sCO2 Transformational Electric Power "STEP" Project Overview

European Turbine Network Annual General Meeting

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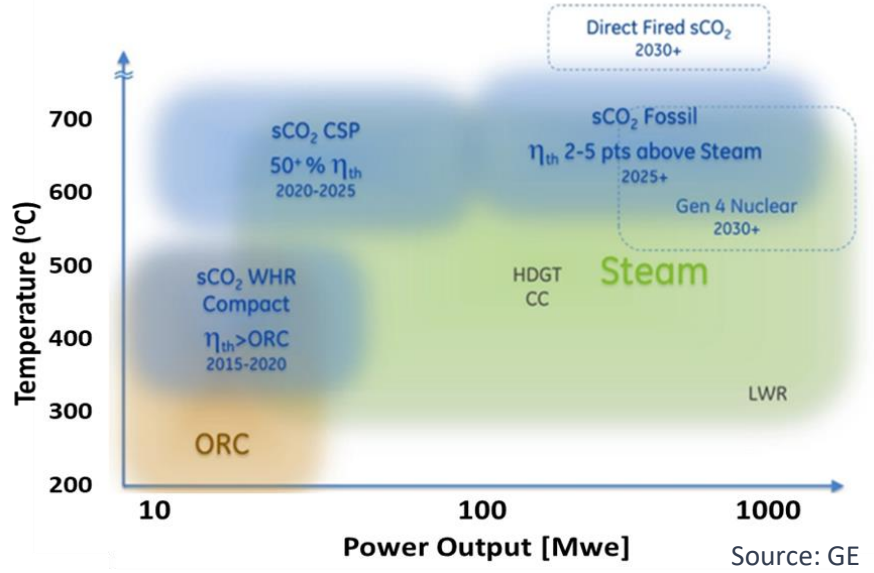
Promise of sCO_2 Power Cycles

Promise:

> Efficient, Compact, Scalable, low water, low-carbon power generation

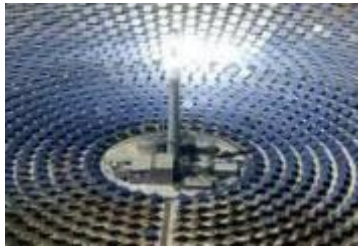
STEP Demo will demonstrate:

> Operability, Turbomachinery, Seals, Heat Exchangers, Durability, Materials, Corrosion, Cost



Source: GE

Versatile Technology – Broad Applicability:


Concentrated Solar


Fossil Fuel


Geothermal


Nuclear


Ship-board Propulsion


Waste Heat Recovery

STEP Program Objectives

STEP Demo will demonstrate a fully integrated functional electricity generating power plant using transformational sCO2-based power cycle technology

Demonstrate pathway to efficiency **> 50%**

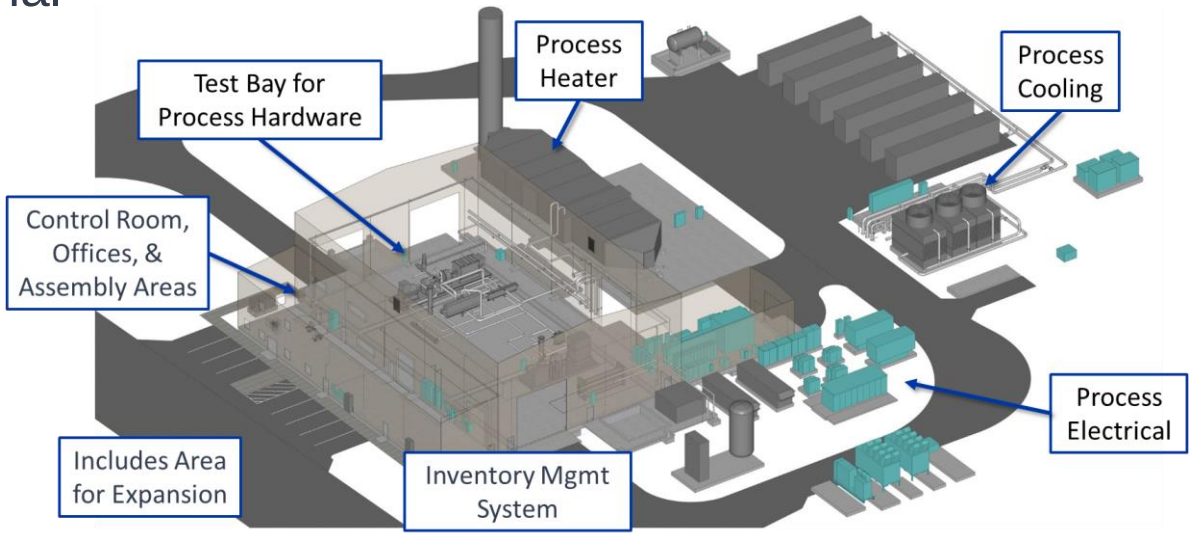
Demonstrate cycle operability **>700°C** turbine inlet temperature and 10 MWe net power generation

Quantify performance benefits:

- 2-5% point net plant efficiency improvement
- 3-4% reduction in LCOE
- Reduced emissions, fuel, and water usage

Demonstrate Reconfigurable flexible test facility

- Available for Testing future sCO2 equipment & systems



STEP will be among the largest demonstration facilities for sCO2 technology in the world

Supercritical Transformational Electric Power (STEP) Project

Scope: Design, construct, commission, and operate **10 MWe sCO_2 Pilot Test Facility**
Reconfigurable to test new technologies in the future

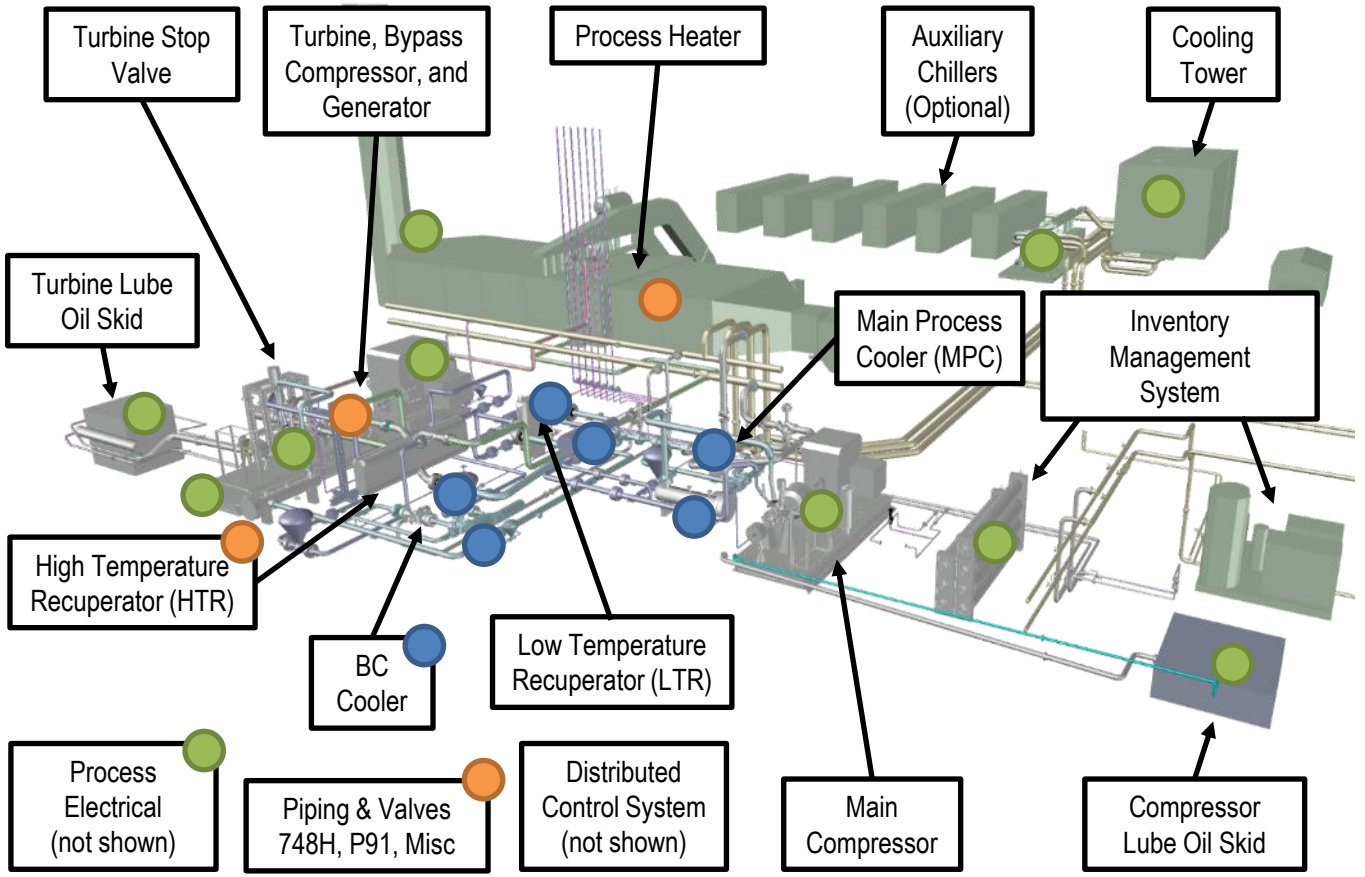
Goal: Advance state of the art for high temperature sCO_2 power cycle performance
Evolve Proof of Concept (TRL3) to operational System Prototype (TRL7)

Schedule: Three budget phases over six years (2016-2022)
Currently in Budget Phase 2 – Fabrication & Construction

Team: U.S. Department of Energy (**DOE NETL**)
Gas Technology Institute (**GTI®**)
Southwest Research Institute (**SwRI®**)
General Electric Global Research (**GE-GR**)

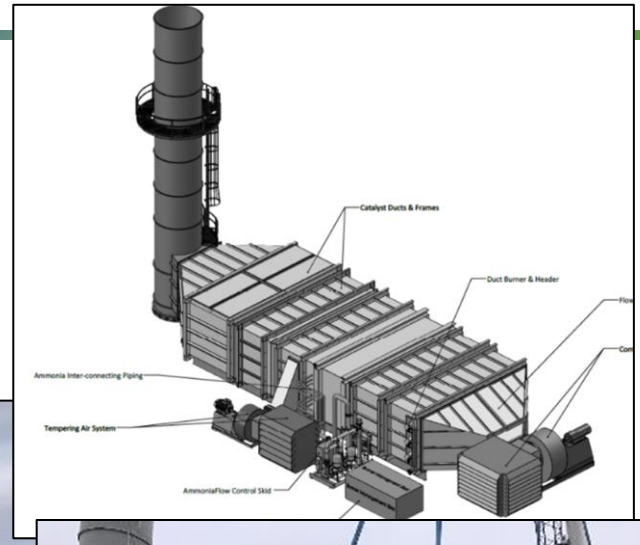
Industry Partners:

Facility Construction Completed at Test Site in San Antonio, Texas, USA



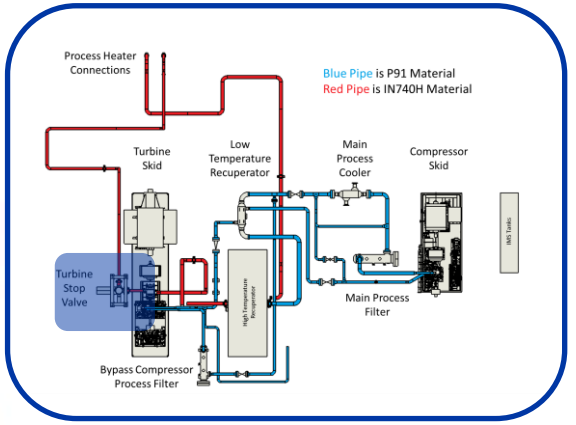
Process Heater construction on going

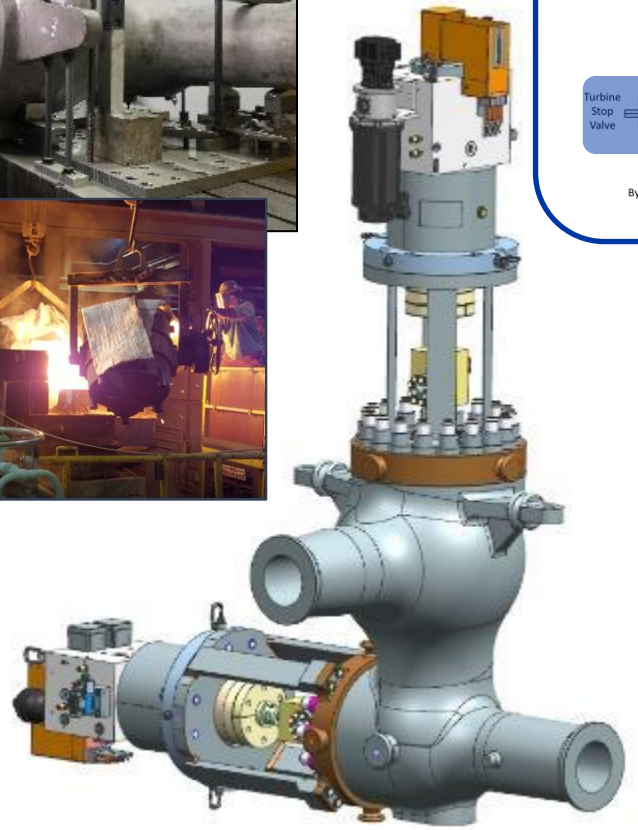
- Heat Recovery Steam Gen (HRSG) style “boiler”
  - Duct NG burner ~ 50 MWth
  - Designed to ASME BPV Section 1
  - Size: 14’W x 133’L x 18’H
- Optimus Industries, LLC



STEP Turbine Stop/Control Valve (TSV)

- Turbine Control and Stop Function
  - Provided by GE Power
  - Based on conventional steam valves with sCO2 specific features
  - Leverages Haynes 282 material development under DOE AUSC program
  - Stem Seal Design Tests Completed
  - First production Haynes 282 Valve

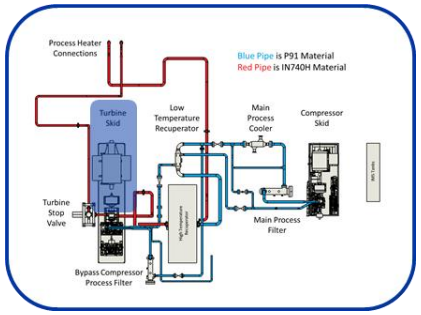


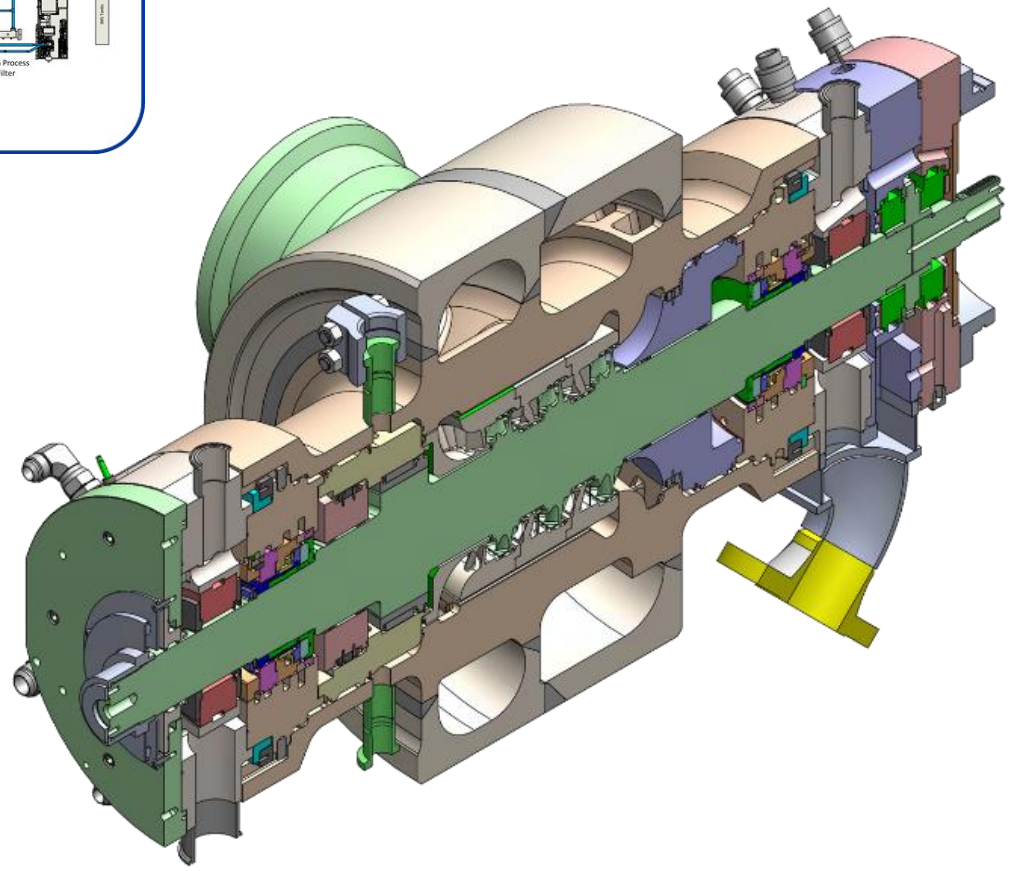


Testing Completed On sCO2 Stem Seals

STEP Turbine - Builds on SunShot success

- Collaboration between GE-RC and SwRI
- Design challenges include high blade loading and large temperature gradients
- Based on frame design demonstrated under the EERE SunShot program
- Fabrication of components on going

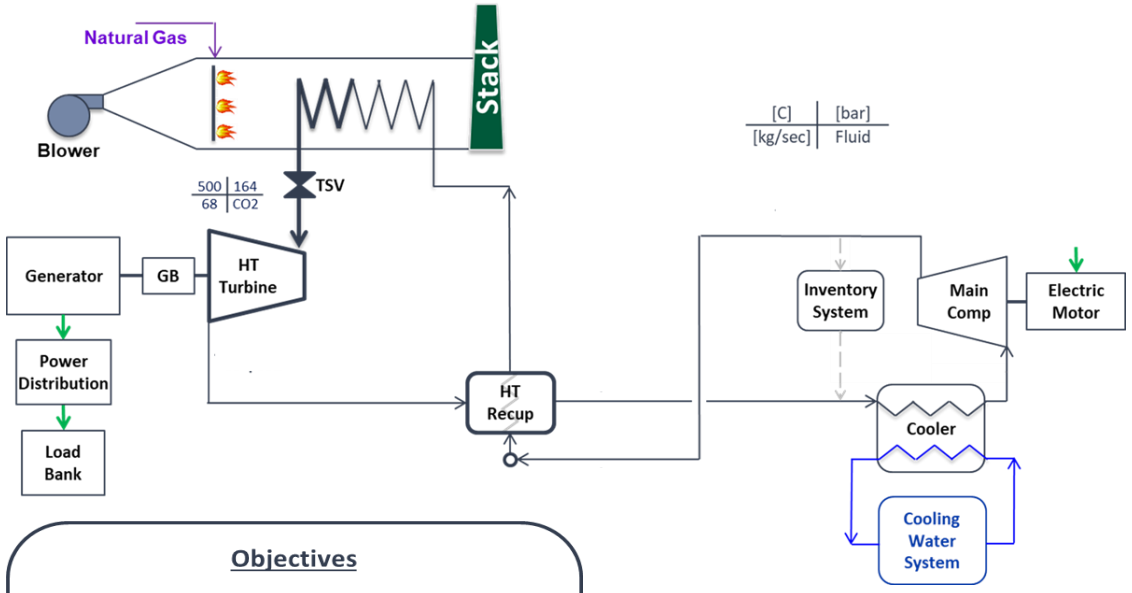




Commissioning to start in 2021.
Simple and Recompression Brayton Cycle test configurations will demonstrate cycle performance.

STEP DEMO

Simple Recuperated Brayton Cycle

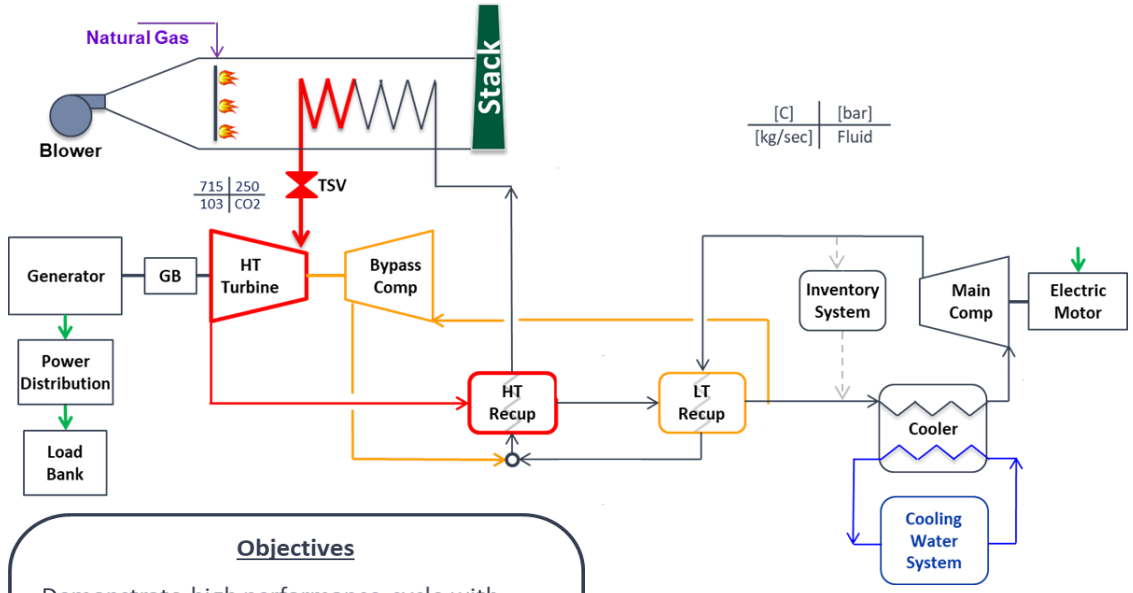


Objectives

Demonstrate initial cycle performance with reduced risk configuration

- Reduced Turbine inlet at 500°C similar to Waste Heat Recovery applications
- Single compressor configuration
- Provides Steady & Transient Cycle Performance Data used to predict RCBC performance and operations

Recompression Brayton Cycle (RCBC)



Objectives

Demonstrate high performance cycle with parallel compressors & multiple HEX

- Increase Turbine inlet to 715°C
- Measure Steady & Transient Cycle Performance Data, evaluate operability
- Demonstrate pathway to 50% thermal efficiency
- Supports application to in-direct coal, HT WHR Industrial sources, and CSP plants

NATIONAL ENERGY TECHNOLOGY LABORATORY gti SwRI

Summary of STEP Project Status

- **Site Construction Progress Excellent**
  - Building Occupancy received in early June 2020 on schedule
  - Process Electrical, Primary Heater, Cooling Water, Compressor Installation progressing
- **Significant Achievements on Major Equipment Design & Fabrication**
  - Most Major Equipment delivered or near completion
  - Equipment deliveries to site started in Nov 2019 and new arrivals every month
- **Challenges with 'first of a kind' equipment impacted schedule**
  - Turbomachinery, High Temperature Recuperator, Primary Heater, and Turbine Stop Valve
  - Resolved technical issues and progressing with final equipment manufacture and delivery
- **Industry investment received during COVID pandemic**
  - 3 new members

STEP Project Status can be followed at *www.STEPdemo.us*

STEP Joint Industry Program

STEP is an open project that seeks to benefit the sCO2 community also through a Joint Industry Program.

Industry participation is critical!

Two levels of participation:

1. Steering Committee
   - Input and advisory recommendations to the project team
   - Direct participation in bi-monthly advisory meetings
   - Attendance at bi-annual technical interchange meetings
   - Receipt of quarterly technical status reports
   - Real time access and use of Project System Data
   - Opportunity for facility visits and training in system operations
   - Period of exclusive access to license system IP

2. Associate Membership
   - Attendance at bi-annual technical interchange meetings
   - Receipt of quarterly technical status reports
   - Opportunity for 2 site visits per year

For more information on opportunities to participate:
www.stepdemo.us

Questions?

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