STEP SCO2 10 MW Demonstration Plant Update

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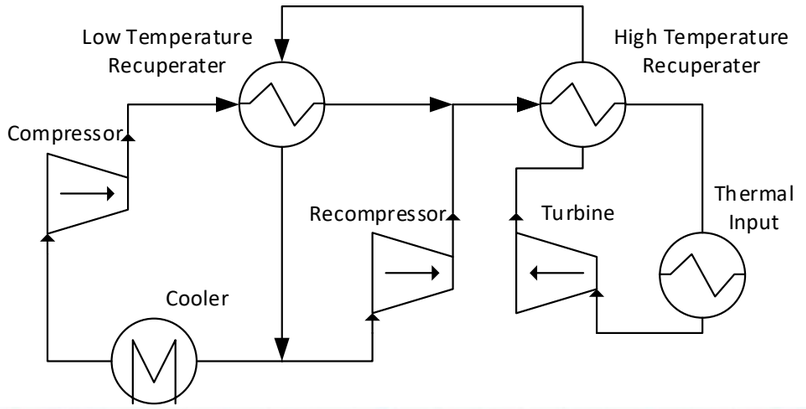
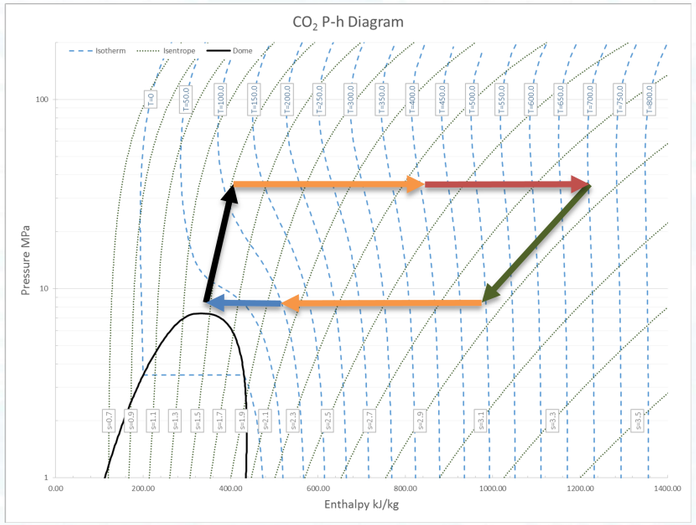
Supercritical Carbon Dioxide (sCO_2) Cycles

- Investigated since early 1900s, revisited since 1999, enabled by new technologies
- Favorable fluid properties:
  - Inert
  - Non-toxic at low concentrations
  - Unfreezable above 5 atm
  - Thermally stable at temperatures up to1700 °C
  - High density → turbine power density ~10x steam turbines
  - High thermal conductivity, low viscosity → compact heat exchangers
  - Critical temperature near ambient
- No "boiler" → eliminates staffing requirements
- Potential for lower $/kW due to higher efficiencies, power densities,
- STEP 10 MWe Demonstration achieved Simple Cycle operation Sep 2024

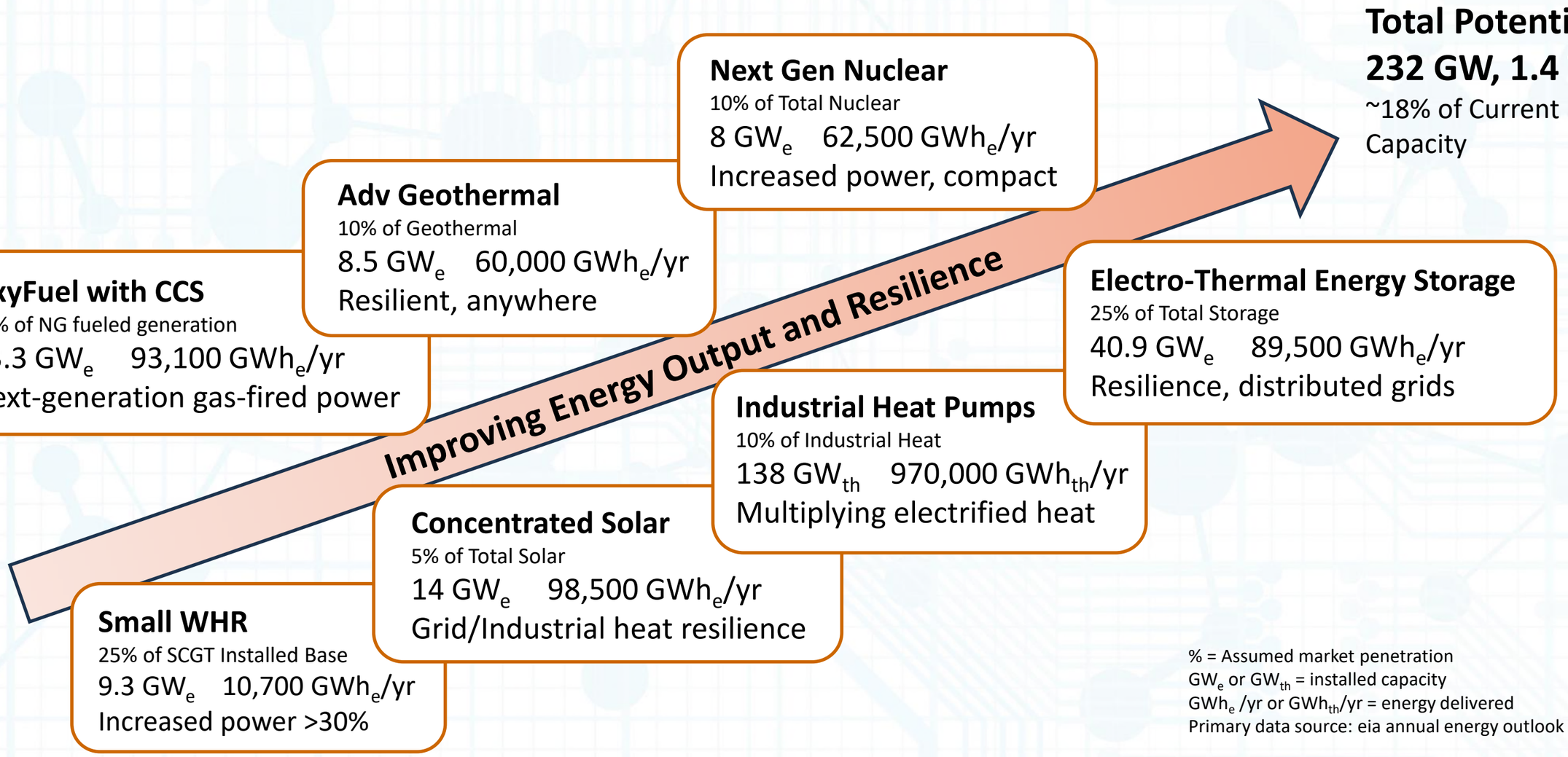


Recompression Brayton Cycle achieving ~50% thermal efficiency over ~700 °C turbine Inlet



sCO_2 Applications – Unleashing Energy Innovation

Potential U.S. Electric and Energy Impacts by 2050



% = Assumed market penetration
GW_e or GW_{th} = installed capacity
GWh_e /yr or GWh_{th}/yr = energy delivered
Primary data source: eia annual energy outlook

STEP Facility Layout & Specifications

STEP DEMO

Test Bay for Process Hardware
- 20k square feet on-5 acre lot
- 30 ton bridge crane
- CO2 inventory, lube oil, shop air

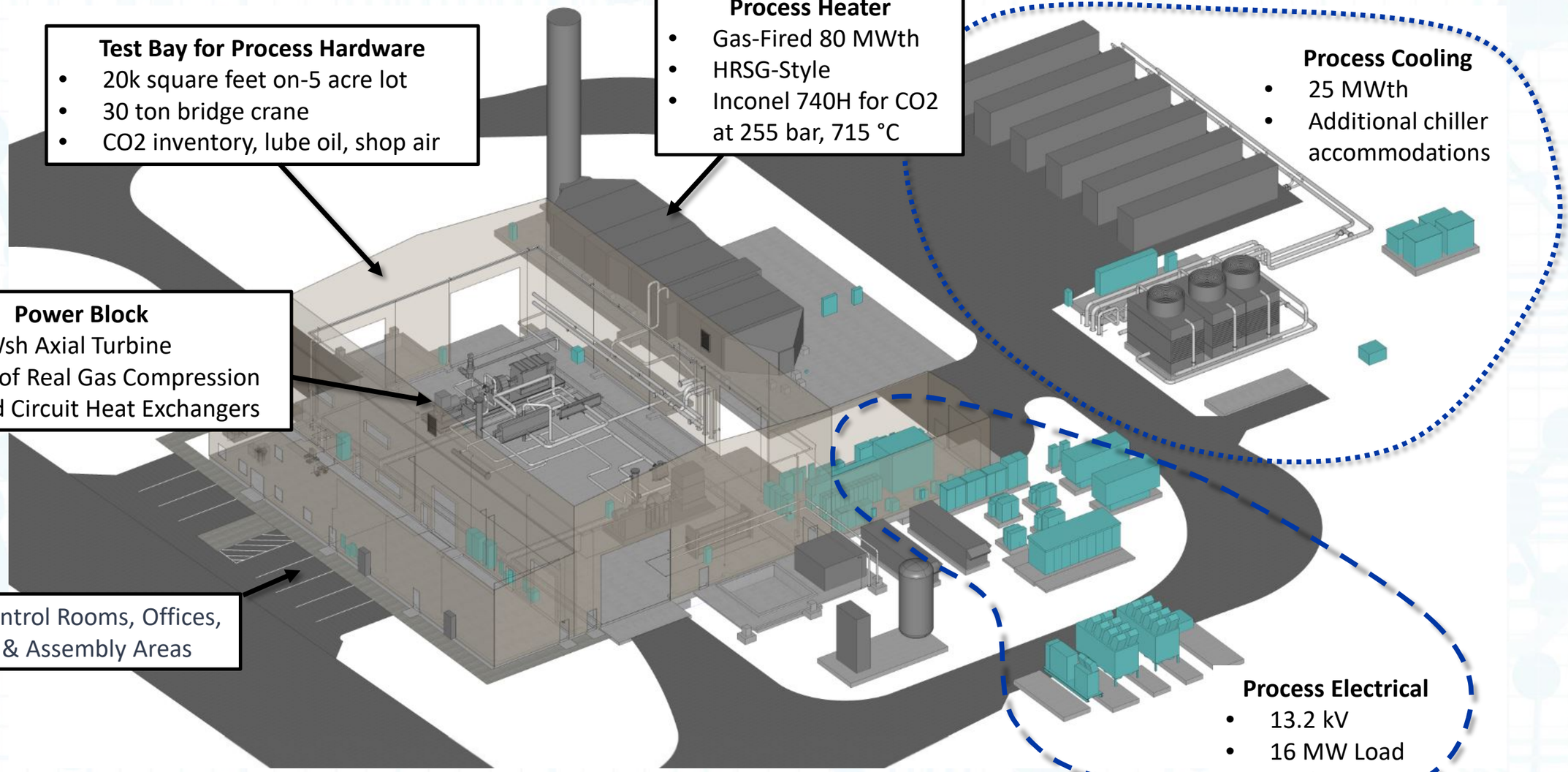
Process Heater
- Gas-Fired 80 MWth
- HRSG-Style
- Inconel 740H for CO2 at 255 bar, 715 °C

Process Cooling
- 25 MWth
- Additional chiller accommodations

Power Block
- 16 MWsh Axial Turbine
- 4 MW of Real Gas Compression
- Printed Circuit Heat Exchangers

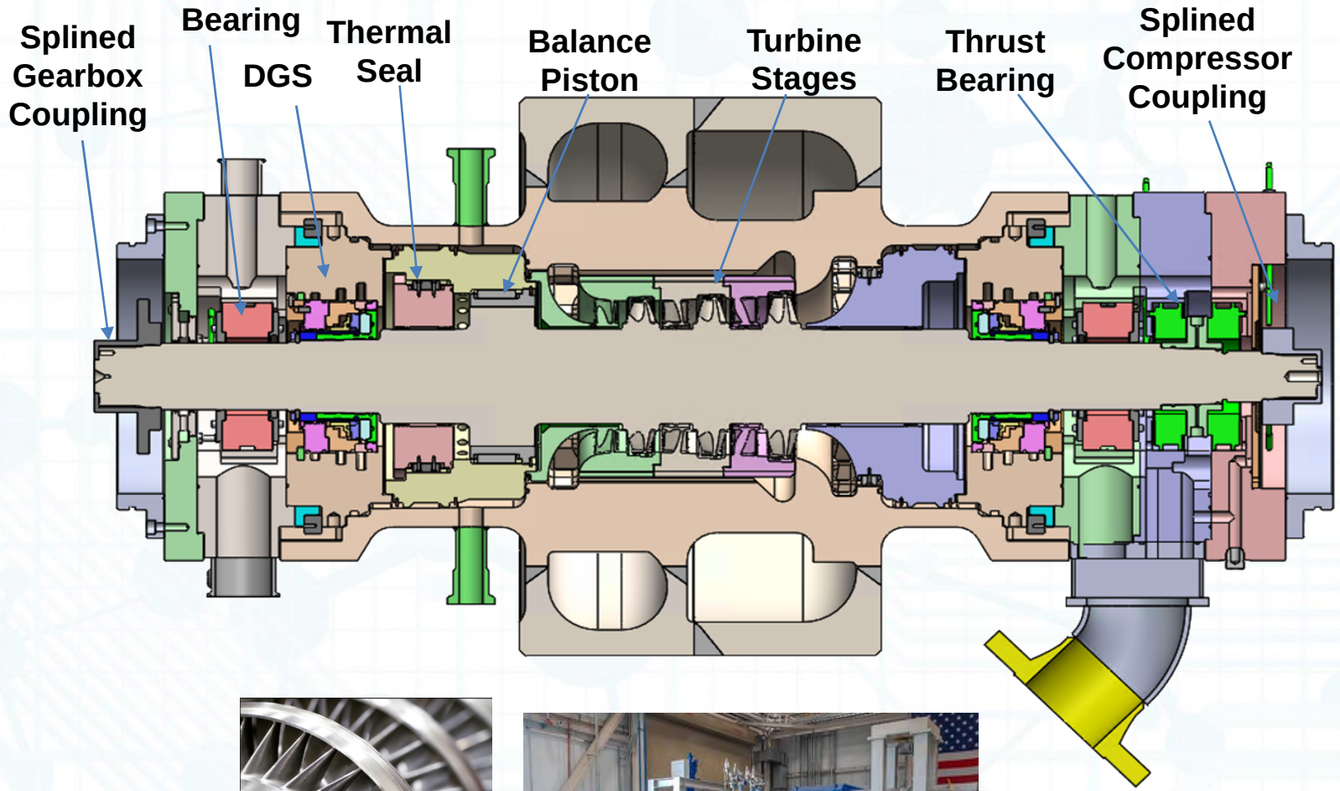
Control Rooms, Offices, & Assembly Areas

Process Electrical
- 13.2 kV
- 16 MW Load Banks



STEP Turbine Achievements

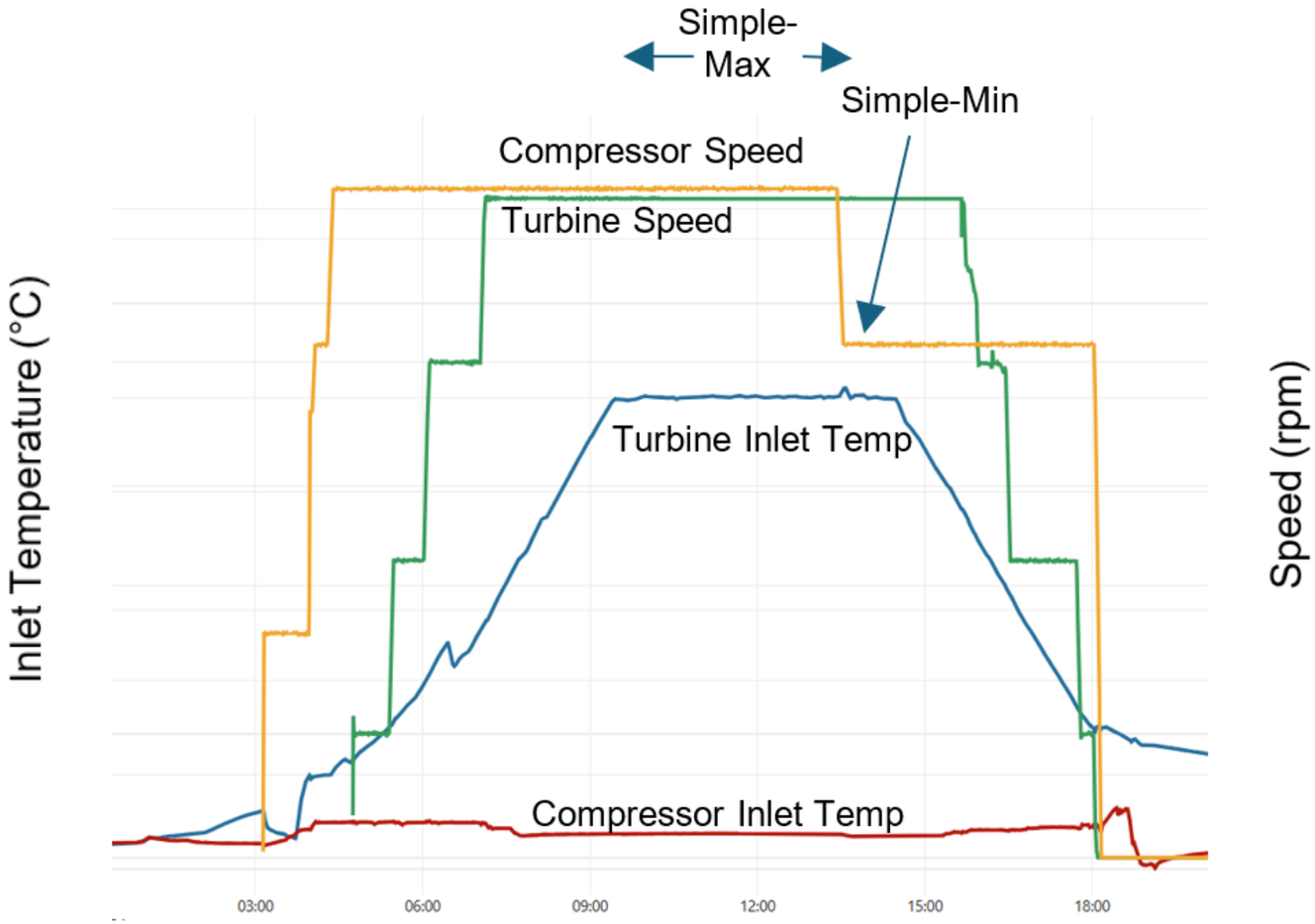
- ~1/10 the size of an equivalent steam turbine
- The world's highest power density industrial terrestrial turbine
- 16 MW (21,000 hp) produced by 86 kg (190 lb) rotor (186 kW/kg)
- Made from Nimonic 105 heat treated forging
- Airfoil shapes cut using a 5-axis electrode discharge machining (EDM) by Baker Hughes



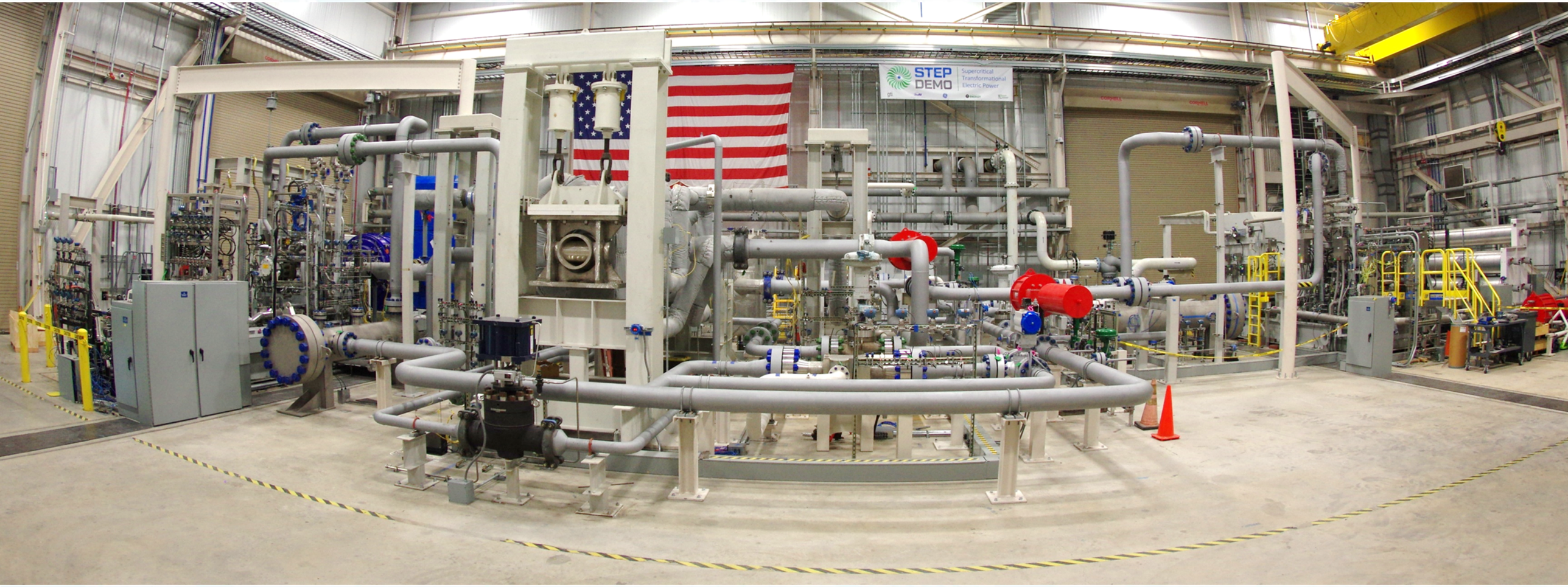
6-hour Performance Test

- NOx emissions test performed
- Both Simple Cycle maximum and minimum power conditions demonstrated
- No trips

Parameter	-	Simple-Min	Simple-Max
Normalized Efficiency		0.874	0.950
Aero Power	MWsh	4.57	8.25
Net Plant Output	MWe	2.26	3.93



Current Photo with RCBC Pipe Installed



Conclusions

- sCO_2 systems have progressed through many component and now system development activities to increase technology readiness level
- STEP 10 MWe demonstration has advanced simple recuperated sCO_2 cycles up to 500°C generating 4 MWe to the Texas grid
- Plant has been reconfigured for RCBC configuration
- RCBC Test goal includes 250 bar, 715°C and 10 MWe output

Achieved Simple Cycle Conditions on Sept 26, 2024

www.STEPdemo.us