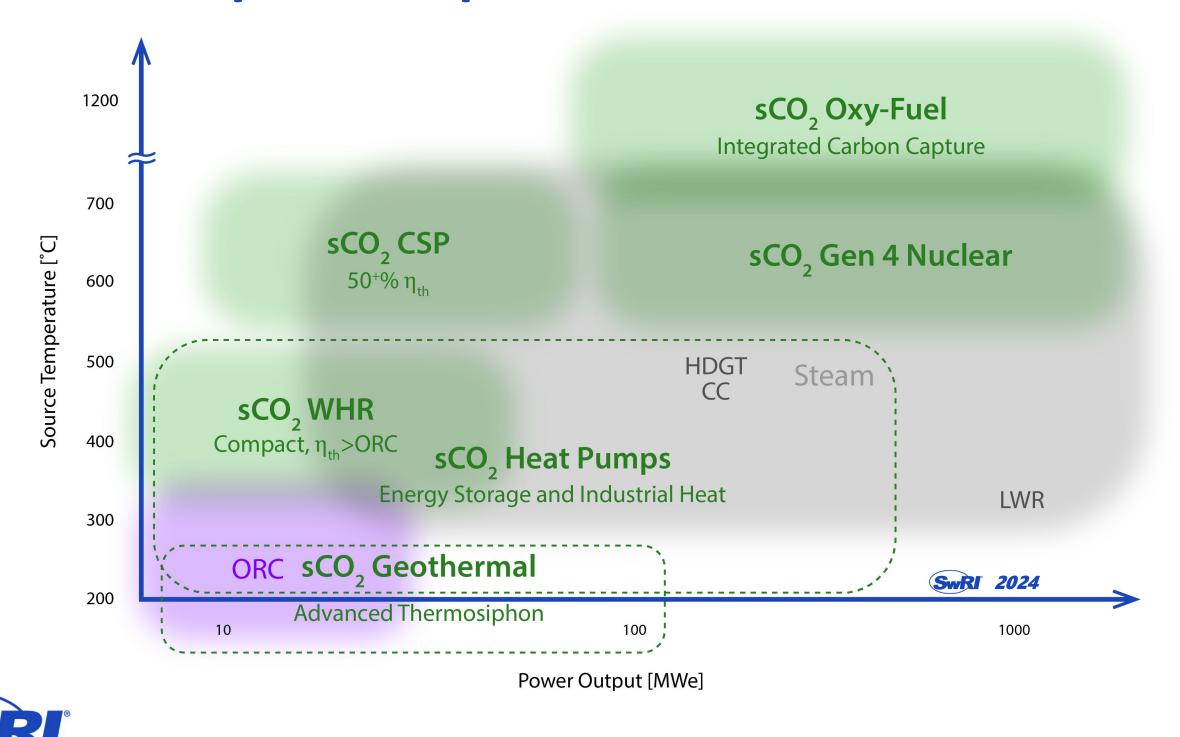
### **Application Space – Updated 2024**



### CO<sub>2</sub> Cycles – Versatile Tool for the Energy Transition

**Potential Impact by 2050** 



10% of Industrial Heat 138  $GW_{th}$  970,000  $GWh_{th}/yr$ 25.6 MM tpa  $CO_2$ 

#### **Small WHR**

25% of SCGT Installed Base  $9.3~\mathrm{GW_e}$   $10,700~\mathrm{GWh_e/yr}$  4 MM tpa

#### **Electro-Thermal Energy Storage**

25% of Total Storage 40.9 GW<sub>e</sub> 89,500 GWh<sub>e</sub>/yr 33.6 MM tpa CO<sub>2</sub>

#### **Concentrated Solar**

5% of Total Solar  $14 \text{ GW}_{e}$   $98,500 \text{ GWh}_{e}/\text{yr}$   $37.0 \text{ MM tpa CO}_{2}$ 

## Path to Net-Zero

#### Next Gen Nuclear

10% of Total Nuclear 8 GWe 62,500 GWh<sub>e</sub>/yr 23.5 MM tpa CO<sub>2</sub>

% = Assumed market penetration  $GW_e$  or  $GW_{th}$  = installed capacity  $GWh_e$  /yr or  $GWh_{th}$ /yr = energy delivered MM tpa = million tonnes  $CO_2$  per annum reduced Primary data source: eia annual energy outlook



#### OxyFuel with CCS

10% of NG fueled generation 13.3 GW<sub>e</sub> 93,100 GWh<sub>e</sub>/yr 35 MM tpa CO<sub>2</sub>

#### **Adv Geothermal**

10% of Geothermal  $8.5 \, \text{GW}_{\text{e}} \quad 60,000 \, \text{GWh}_{\text{e}}/\text{yr}$   $22.5 \, \text{MM tpa CO}_2$ 

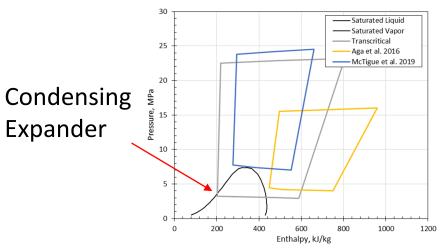
## Total Potential 181.2 MM tpa CO<sub>2</sub>

~12% of Current Electric Power Emissions



# sCO<sub>2</sub> Research Projects at SwRI: Industrial Heat Pumps and Energy Storage

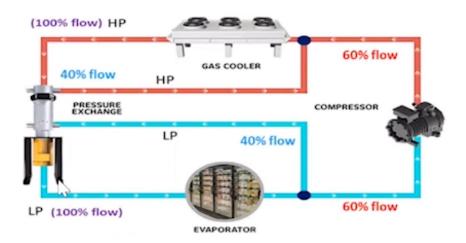
- Condensing expander development for transcritical CO<sub>2</sub> heat pump
  - Higher COP due to additional work extraction
  - Multiphase turbine operation & reliability
  - For DOE SETO with Echogen,
    Flowserve
- Test rig for Pressure Exchanger development
  - Multiphase expansion
  - For Energy Recovery, Inc.



Various CO<sub>2</sub> Heat Pump Cycles



SwRI sCO<sub>2</sub> pump loop



Energy Recovery [1,2]

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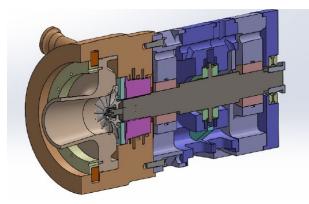
## sCO<sub>2</sub> Research Projects at SwRI: Power

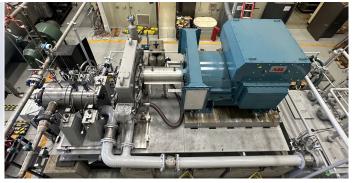
**Generation Applications** 



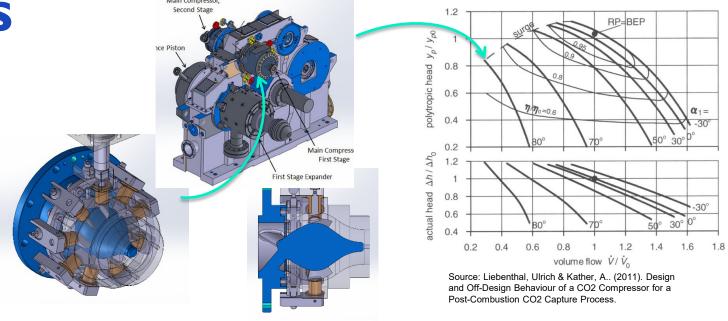


STEP Facility Integration, Turbine Development, Testing

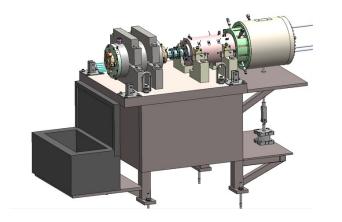


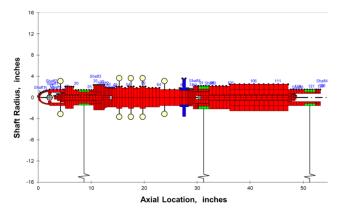


Geothermal Turbine Development with Modular Aero Design, Oil Seals



IGV Testing for Near-Dome or Two-Phase Compressor Operation



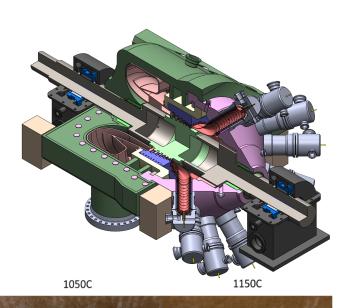


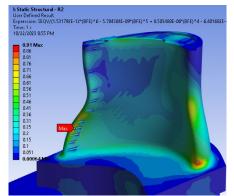
High-Temperature DGS and Magnetic Bearing Development

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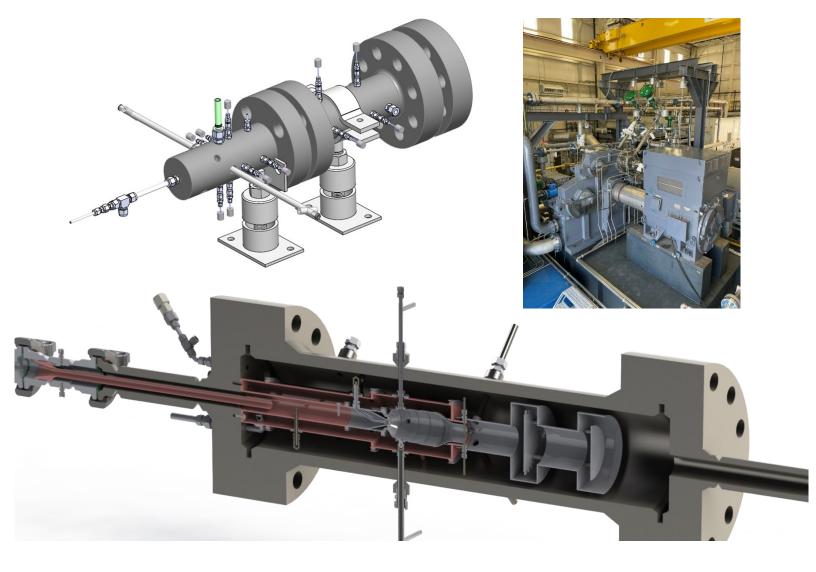
## sCO<sub>2</sub> Research Projects at SwRI: Oxy-

Combustion









Turbine Design, Materials Testing, and Component Testing for sCO<sub>2</sub> Oxy-fuel Turbine

kW-scale (open-loop) and MW-scale (closed-loop) Combustion Test Facilities with Laser Ignition

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