Carleton UNIVERSITY

sCO_2 Power Cycle R&D at Carleton University

University R&D Panel Session

5th International sCO_2 Power Cycle Symposium

Henry Saari, Associate Professor
Mechanical and Aerospace Engineering
Carleton University
Ottawa, Ontario, Canada

San Antonio, Texas
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How Can Universities Support the Development of sCO_2 Power Cycles?

- Transferring Knowledge to the Next Generation
  - i.e. education
  - Training engineers (and others)
  - Undergraduates and graduates
- Generation of New Knowledge
  - i.e. research (basic and applied)
  - Develop understanding of fundamentals
    - Test rigs, simulations, models
    - e.g. corrosion, heat transfer, etc.
  - Apply to industrial problems
    - Designs, pilot-scale equipment, etc.

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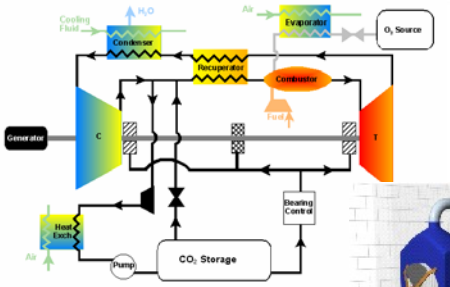
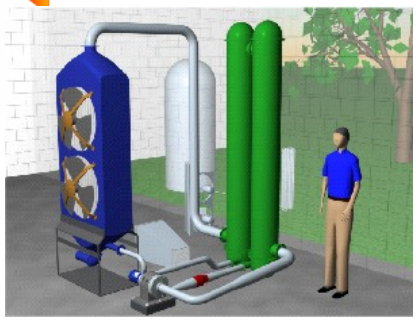
- Mechanical and Aerospace Engineering, Carleton University
  - Strong history of research and teaching in gas turbine technology
- Natural Resources Canada (NRCan), CanmetENERGY
  - Ottawa Research Centre
    - R&D in clean fossil fuel technologies
    - Pilot-scale research facility
- Design and development of advanced semi-closed and closed gas turbine cycles





50 kW Zero-Emission Power Plant

NRCan Vertical Combustor Research Facility (VCRF)

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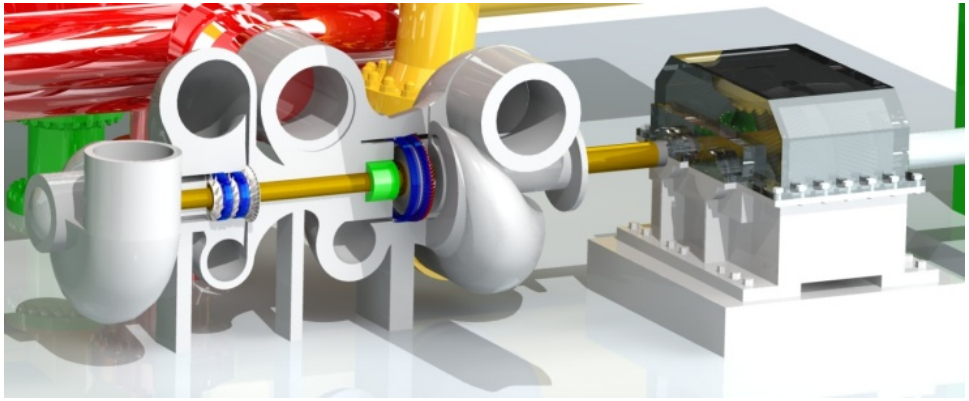
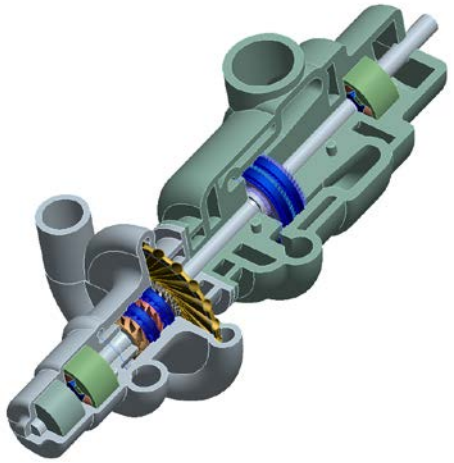
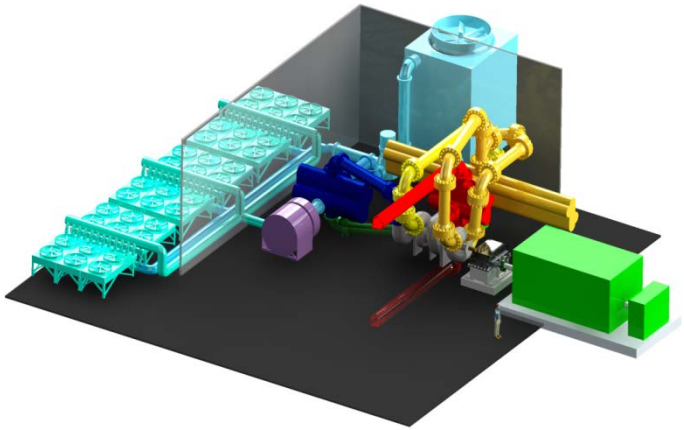
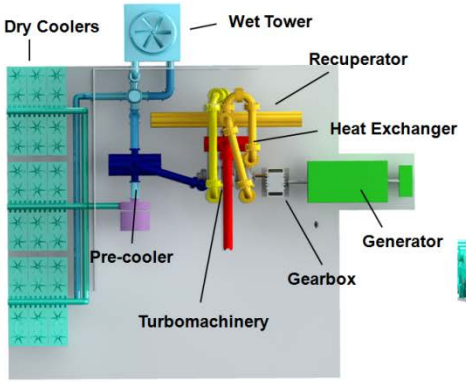
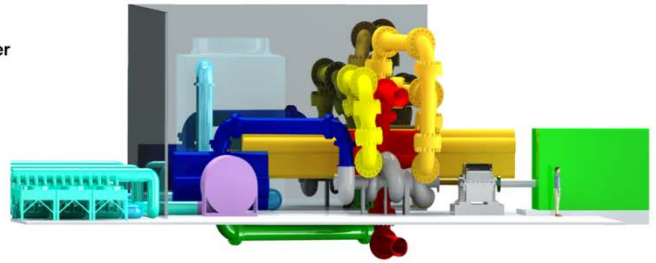




10 MW_e sCO_2 Turbomachinery 2011/12







100 MW_e sCO_2 Brayton Cycle Power Plant (2006/07 to 2010/11)

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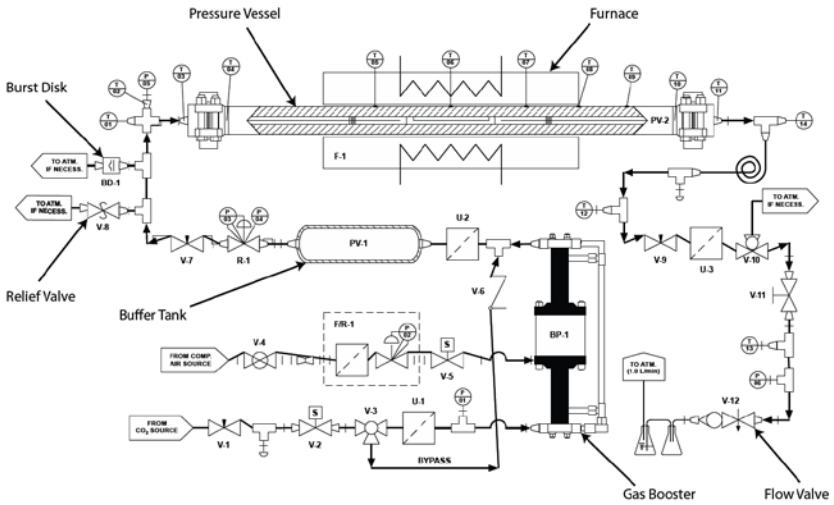

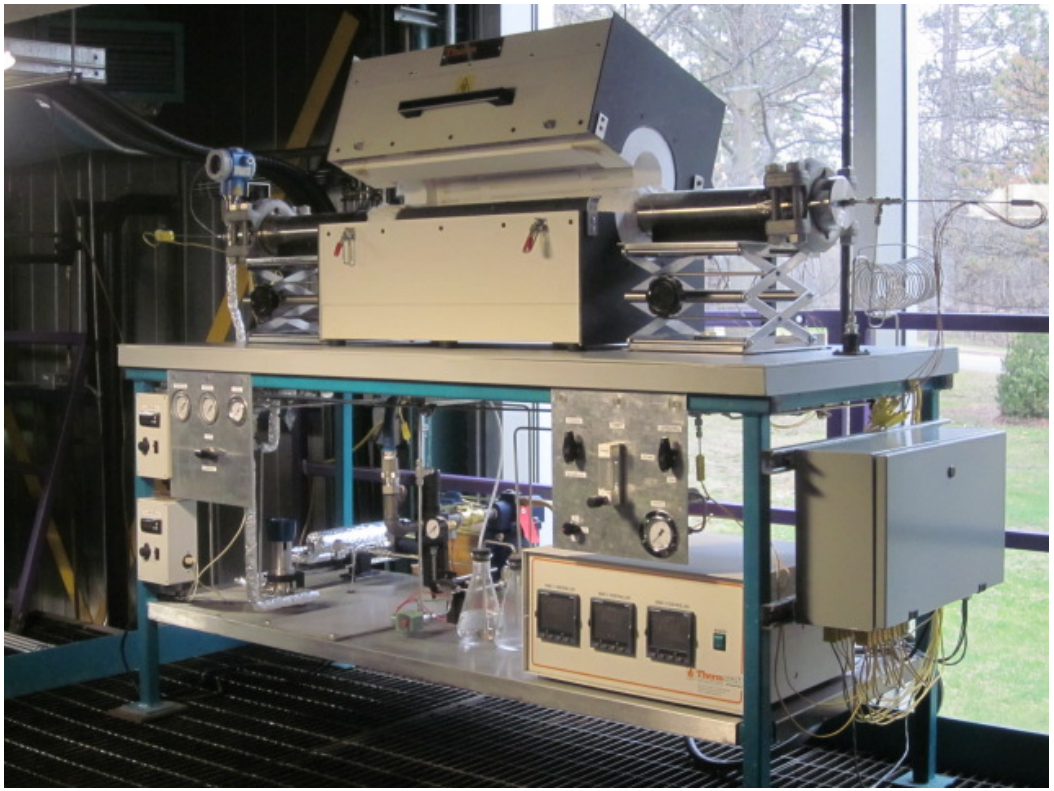

sCO_2 Corrosion Test Rig
Commissioned 2011
Initial testing completed 2013
Current/Planned Work
US DOE NEUP Round Robin Testing
Lower temperature testing – carbon and low alloy steels
Modifications for testing in impurities

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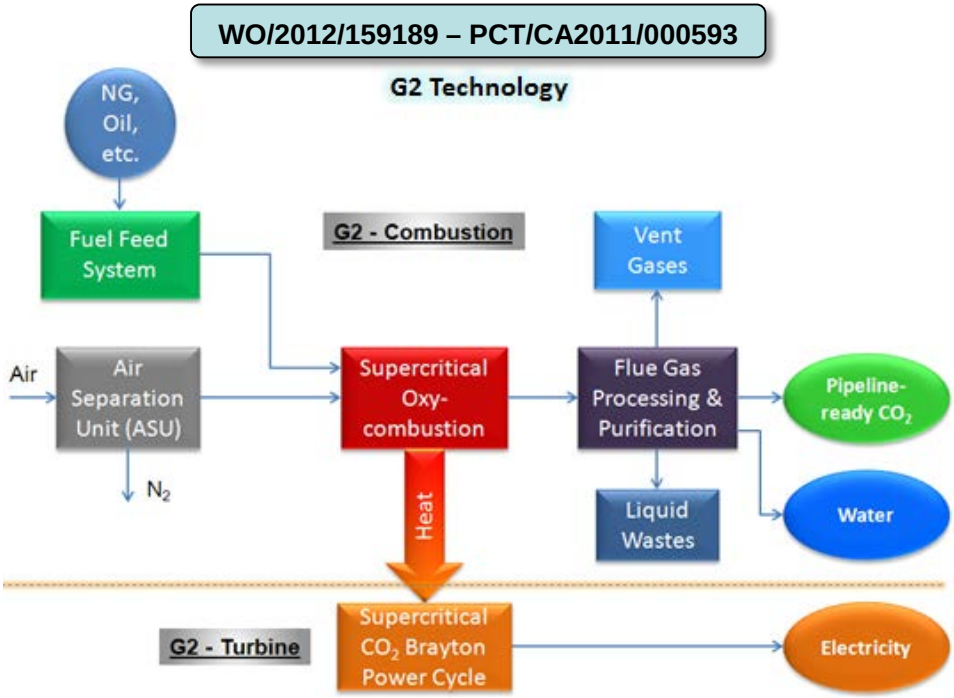
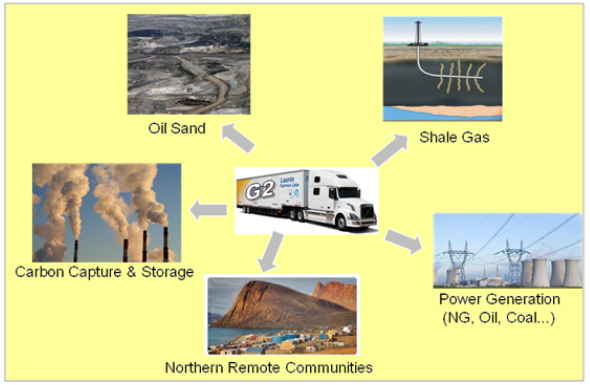
CanmetENERGY G2 Clean Fossil Fuel Technology

WO/2012/159189 – PCT/CA2011/000593



G2 Technology is a unique coupling of an advanced sCO_2 Brayton power cycle (**G2-Turbine**) to an innovative supercritical oxy-fuel combustion loop (**G2-Combustion**)

Stationary Units (> 50 MW_e)	Mobile Units (~ 10 MW_e)
• Electricity generation • Water production • Pressurized CO_2 for EOR	• Oil sands • Shale gas • Remote communities & bases



Various application areas and commercialization options

Attractive capital costs:

G2 NG w/CO_2 Capture ~5-10% over NGCC

G2 Coal w/CO_2 Capture ~22-28% below NGCC w/CO_2 Capture

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250 kW_{th} Brayton Cycle Loop Design (2012-16)

- Funded by NRCan ecoENERGY Innovation Initiative
- Construct a 250 kW_{th} pilot-scale sCO_2 Brayton cycle loop
  - Design/specification of turbomachinery, heat exchangers, piping, balance of plant
  - Manufacture, assembly, and commissioning (later coupling to NRCan combustion loop)
  - Development of models, simulation of loop (and coupled system), and validation testing
- Integrated system
  - Pilot-scale demonstration of G2 Clean Fossil Fuel Technology
  - Study controllability and interoperability

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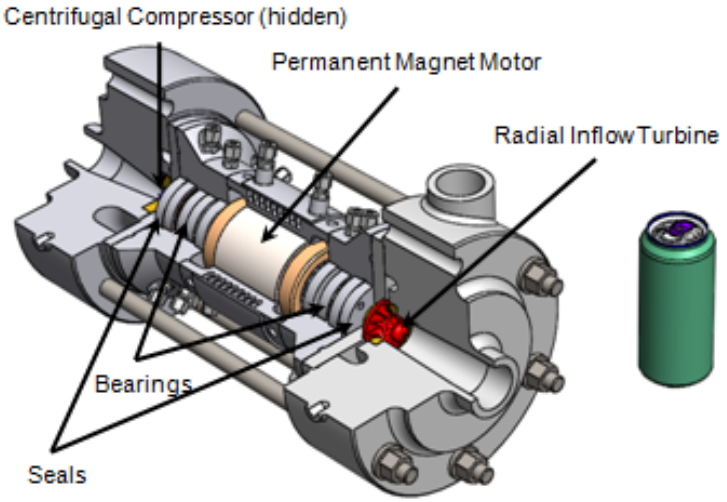
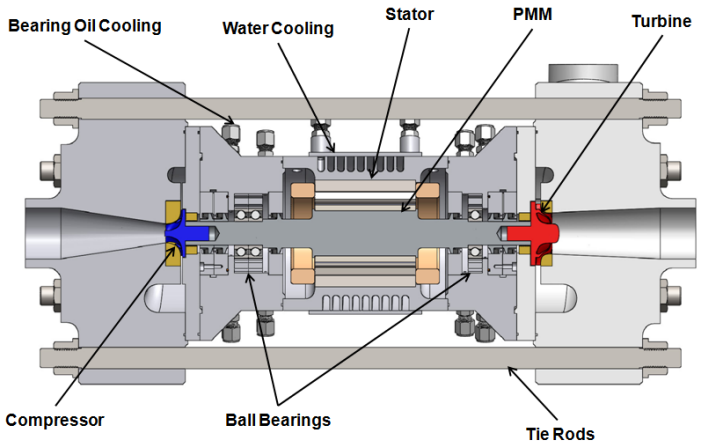
250 kW_{th} Brayton Cycle Loop Design

- Preliminary/detail design completed/underway
  - Turbomachinery
  - Impedance heater
  - Heat exchangers
  - Balance of plant equipment
    - ~250 kW heat input
    - ~35 kW net power output
    - ~14.5% thermal efficiency
- Brayton cycle loop model
  - Steady-state and dynamic
  - Simulate transient operation
  - Control and DAQ design





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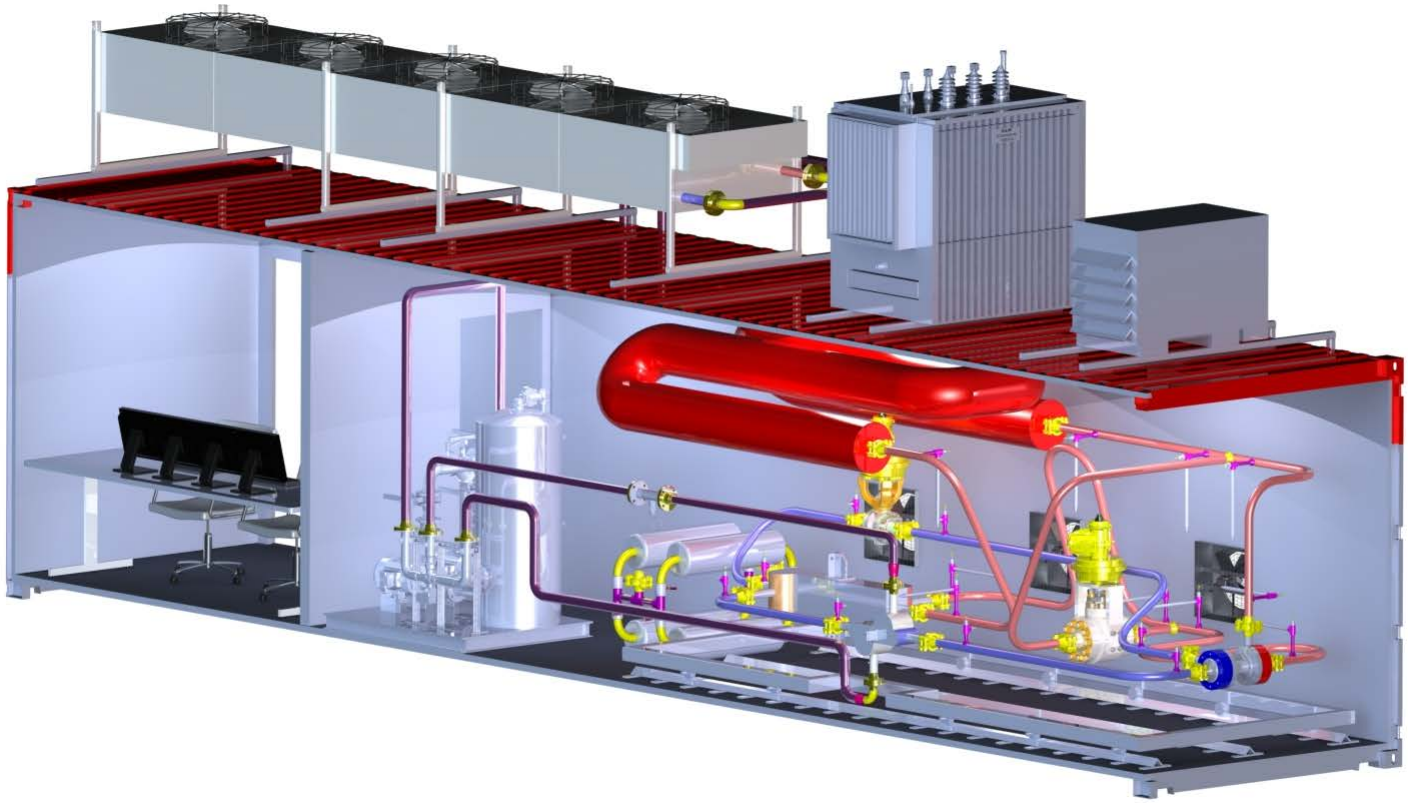

250 kW_{th} Pilot-scale Brayton Cycle Loop (2012/13 to 2015/16)

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250 kW_{th} Pilot-scale Brayton Cycle Loop (2012/13 to 2015/16)