Building-Integrated Thermal Energy Systems (BITES)

Professors: Jean Duquette
Cynthia Cruickshank
Ian Beausoleil-Morrison

Industry Partner: Chris Weissflog
Canada is the fifth largest energy producer in the world and the eighth largest consumer of energy.

Buildings account for 28% of secondary energy use in Canada and represent a large source of GHGs.

Approximately 80% of residential use is attributed to space heating and hot water demands.

Current strategies to reduce building loads typically consider heating, cooling and hot water needs separately.

- Hydro 59%
- Nuclear 15%
- Coal 9%
- Natural gas and oil 10%
- Non-hydro renewables 7%

Canada’s Energy Mix
• Overall project focus is on an integrated approach for heating, cooling, ventilation, dehumidification, and domestic hot water heating for low-rise multi-unit residential buildings (MURBs)

• Design and optimization is required, including:
  • Passive solar architecture
  • High-performance envelope
  • Multi-function heat pumps
  • Heat recovery
  • Geothermal storage
  • Control strategies

• Goal is to design a building integrated thermal energy system (BITES) that is replicable and delivers net-zero-energy-ready levels of performance
• Year 1 (2018-19):
  • Analyze performance of BITES prototype (single-family residential scale) and identify opportunities for improving design
  • Size key components (heat pumps, thermal storage, hydronic floor, geothermal field, thermal mass, windows) using simplified models for low-rise MURB

• Year 2 (2019-20):
  • Design, develop and analyze new heat pump cycles for use in heating, cooling and domestic hot water applications
  • Develop heat transfer models of heat pump cycles in EES software
  • Evaluate system feasibility based on seasonal performance, energy and exergetic efficiencies, system economics, environmental analysis, safety, noise, originality, esthetic of design, practicality, etc.
  • Provide overall justification of design and performance, including assumptions and strategies
Group 2: Proposed CO$_2$ (R774) System and Operating Points
• Year 3 (2020-21):
  • Measure performance of a CO$_2$ heat pump prototype in laboratory setting
  • Optimize heat pump design based on preliminary results; optimize design to balance performance with cost
  • Investigate opportunities for effluent waste heat recovery in MURB utilizing current heat pump design
  • Develop detailed heat transfer model of waste heat recovery unit using energy simulation tool, and assess techno-economic benefits
Thank you for your interest in BITES!
For more information, contact: Jean.Duquette@Carleton.ca