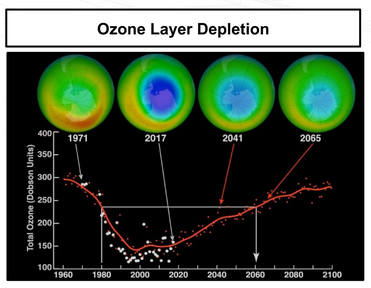
OAK RIDGE National Laboratory | BUILDING TECHNOLOGIES RESEARCH AND INTEGRATION CENTER

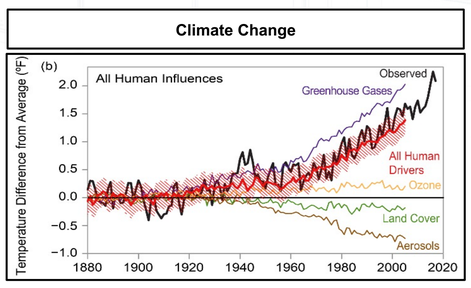
Micro-cascade Supermarket Refrigeration Using Low-GWP Refrigerants

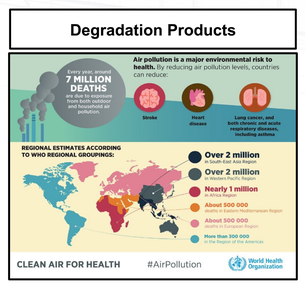
Samuel Yana Motta (PI), Junjie Luo, Vishaldeep Sharma, Bo Shen

Research Challenge

- Over 38,000 stores in the US have significant levels of greenhouse gas (GHG) emissions:
  - 43.8 million tons CO_2eq/year (69.7%) of direct emissions (related to HFC's use)
  - 19.08 million tons CO_2eq/year (30.3%) of indirect emissions (related to energy use)
- Current centralized systems can carry ≈3,500 lb (per store) of high-GWP refrigerant R-404A (GWP = 3,922) and have a high leakage rate
- The environmental impact clearly needs to be reduced using low-GWP refrigerants while maintaining or improving efficiency

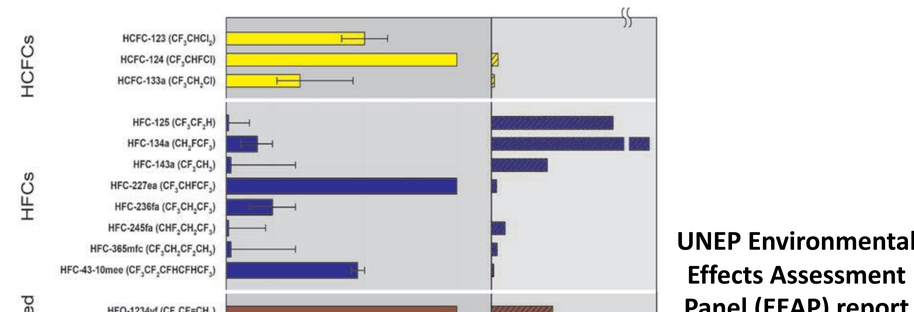




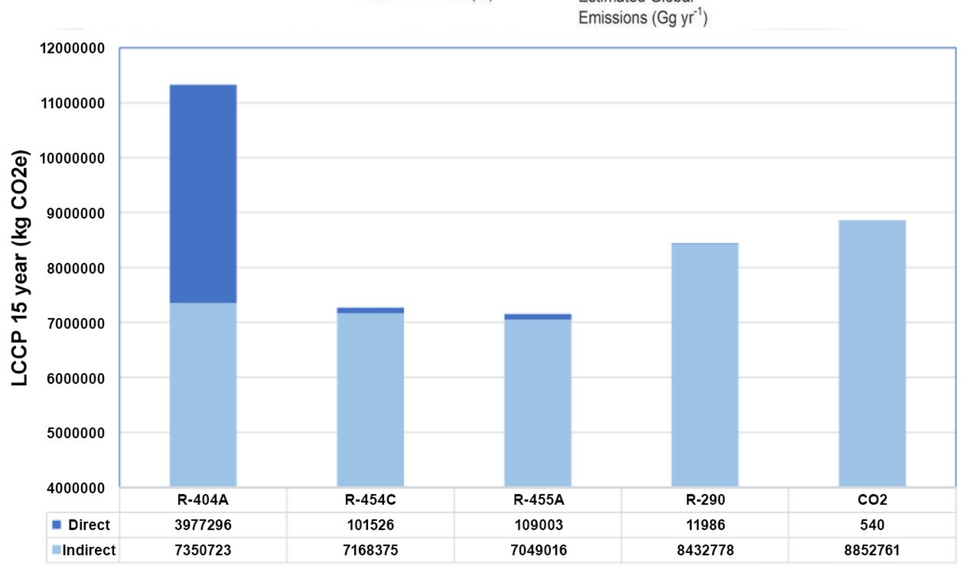


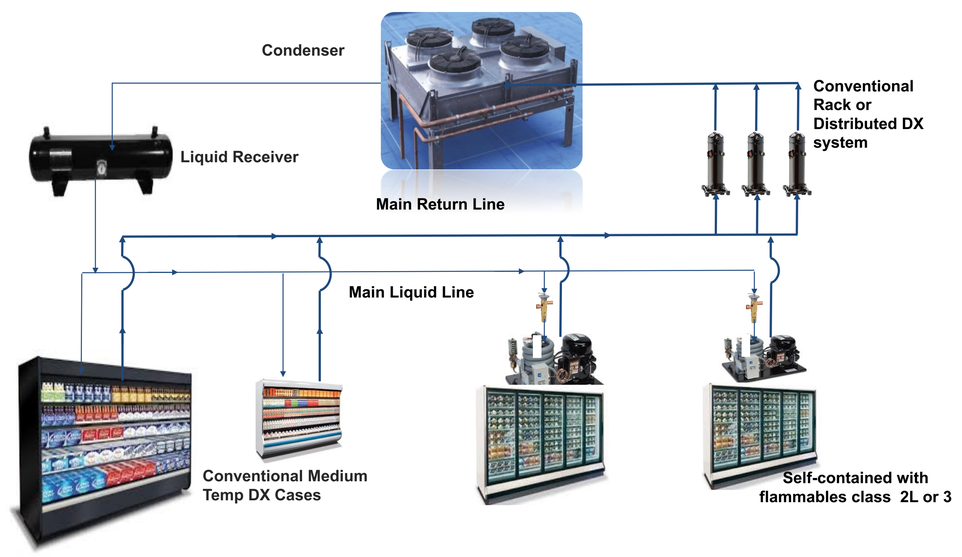
Main Research Efforts (Activities)

- **Critical review of refrigerants' environmental issues**
  - Performed a thorough literature review of refrigerants' environmental effects: ozone depletion potential (ODP), GWP, and formation of pollutants (e.g., trifluoroacetic acid [TFA]).
  - The formation of TFA can affect the selection of refrigerant(s)
  - Current scientific assessments (UNEP EEAP, 2022) report no significant effect on the environment but advises continued monitoring
  - Significant uncertainty still exists regarding the yield of TFA formation, its dispersion in the environment, and the concentration in air, soil, and water.
- **Performance and life cycle climate performance (LCCP) evaluations of current supermarket technologies**
  - Includes current top-performing technologies: 1) distributed systems using HFC/HFO mixtures, 2) Alternatives using the transcritical booster CO_2 and water-cooled propane systems.
  - Fluorinated options (e.g., R-454C, R-455A) reduce emissions significantly because of their acceptable energy efficiency
  - Propane and CO_2 systems have larger emissions because of the higher yearly energy consumption (lower efficiency).
    - Optimized compressors and larger charge can increase propane efficiency
    - Improvements of the CO_2 system may be possible by using additional subcooling and integration with other supermarket systems
- **Preliminary assessment of new supermarket technologies**
  - A micro-cascade configuration was proposed to use a class 1 refrigerant in the medium-temperature loop; the low-temperature loop will be in a cascade configuration using flammables (A2L, A3)
  - Preliminary performance and 15-year LCCP evaluations show significant reduction of energy consumption and GHG emissions



UNEP Environmental Effects Assessment Panel (EEAP) report (2022)





Planned/Future Research

- Conclude literature review of environmental issues of fluorinated materials (HFC, HF) by issuing a final report (CRADA Honeywell)
- Complete the experimental testing of micro-cascade system using synthetic and natural refrigerants (Honeywell CRADA)
- Perform field evaluation of new supermarket technologies in existent and new stores to evaluate energy consumption and GHG emissions (CRADA with supermarket chain - Food City)
- Support the commercialization of refrigeration technologies working with partners (Copeland, Hussmann, Honeywell, Food City)