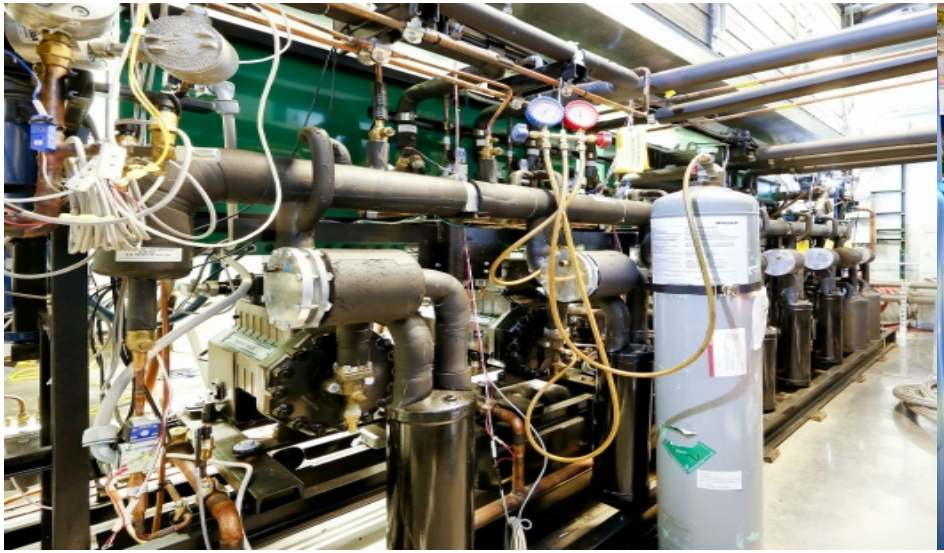
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Impact of Refrigerant Leaks From Zeotropic Refrigerant Based Refrigeration Systems



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Project Summary

Timeline:

Start date: 10/01/2020

Planned end date: 9/30/2023

Key Milestones

1. Leak Characterization and 1st Gas Chromatograph Analysis: 09/30/2021
2. Laboratory Evaluation to determine impact of leakage of blend refrigerant on system performance: 09/30/2022
3. Life Cycle Performance tool development of account impact of refrigerant blend fractionation: 07/30/2023

Budget:

Budget					
FY 2021 (Current)		FY 2022 (Planned)		FY2023 (Planned)	
DOE	Cost-Share	DOE	Cost-share	DOE	Cost-Share
300K	*	300K	*	250K	*

* In-kind contribution from industrial partner- exact total is confidential information

Key Partners:

NASRC	CoolSys
Walmart	
HEB	
Raley's	
Grocery Outlet	

Project Outcome:

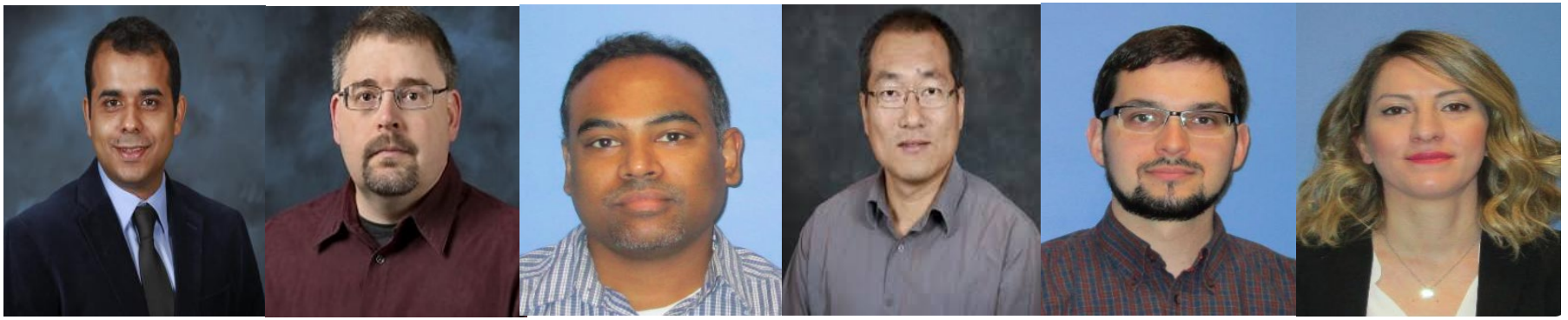
This project focuses on determining impact of leakage of refrigerant blends on refrigeration system performance

At the end of this project:

1. Impact of refrigerant leakage
2. Guidelines for stakeholders/ OEMs/Regulatory bodies
3. Enhance ORNL LCCP tool

Team

- Oak Ridge National Laboratory



Vishal Sharma | Brian Fricke | Praveen Cheektamarla | Bo Shen | Joe Rendall | Tugba Turnaoglu

- Industrial Partners

NORTH AMERICAN SUSTAINABLE REFRIGERATION COUNCIL

Walmart | Raley's | H-E-B | GROCERY OUTLET bargain market

CoolSys

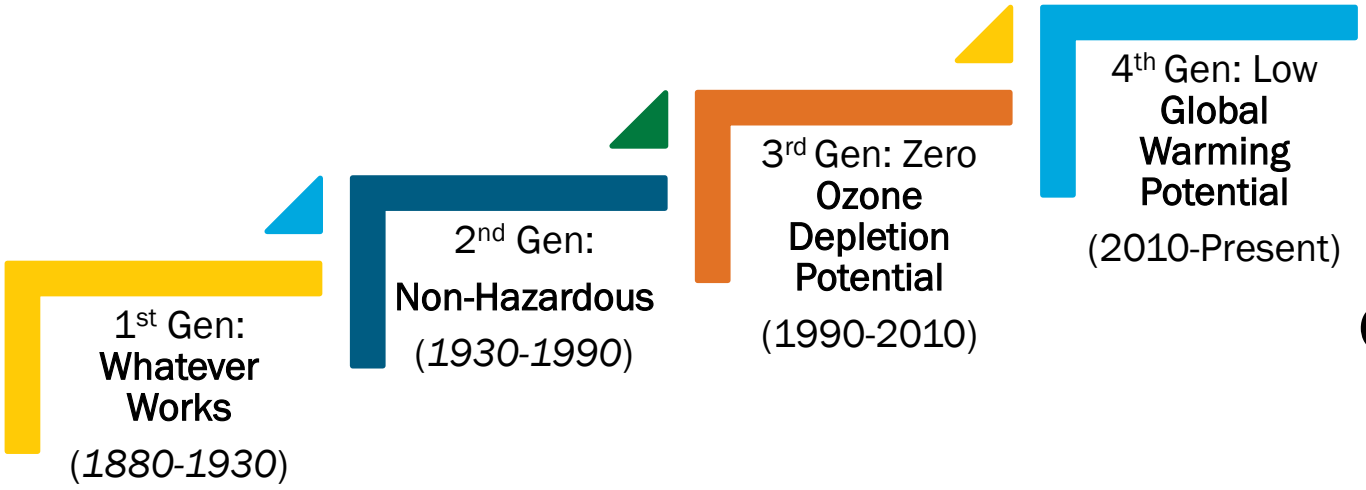
Challenges– Commercial Refrigeration Systems

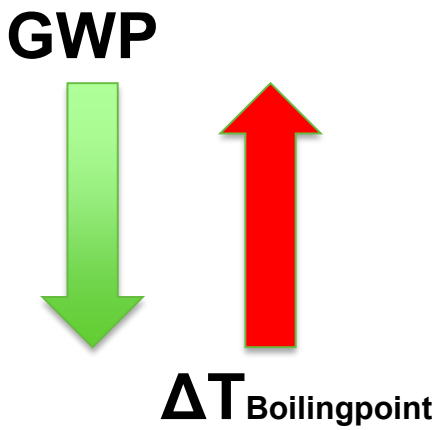
- **38,000 supermarkets,14,000 grocery stores,154,000 convenience stores**
  - 14% of total energy consumption in Commercial Sector
  - High Leakage Rate: 25% (Globally highest)
  - No prior work
- **Current Low-GWP Solution**
  - HFO Blends:

    Pros: Drop-in alternative
    Lower GWP
    Comparable system performance

    Cons: Leaks result in composition changes after recharging
    Top-up method does not maintain system performance

Challenges: Refrigerant Evolution





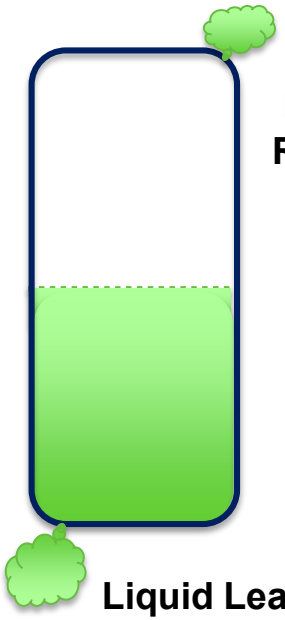
R404A : R125/R143a/R134a

R448A : R32/R125/R1234yf/R134a/R1234ze(E)

R449A : R32/R125/R1234yf/R134a

Challenges: Zeotropic Refrigerant Leak

- R407A : R32/R125/R134a
  - Fractionation



Vapor leak

R32 > $R32_{nominal}$

R125 > $R125_{nominal}$

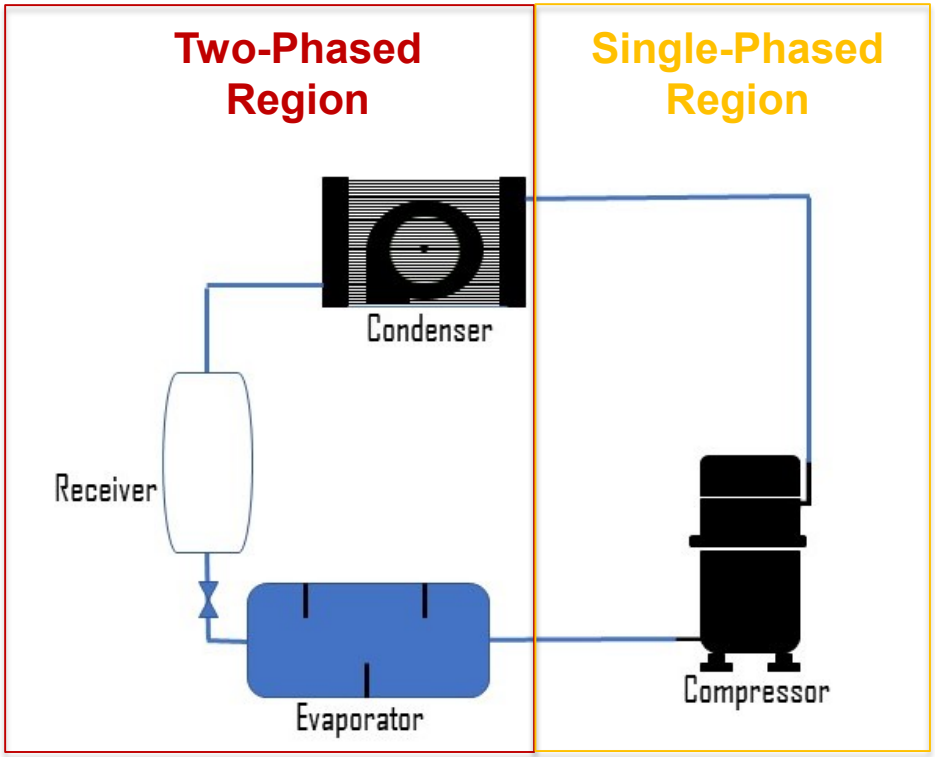
R134a < $R134a_{nominal}$

Liquid Leak

R32 < $R32_{nominal}$

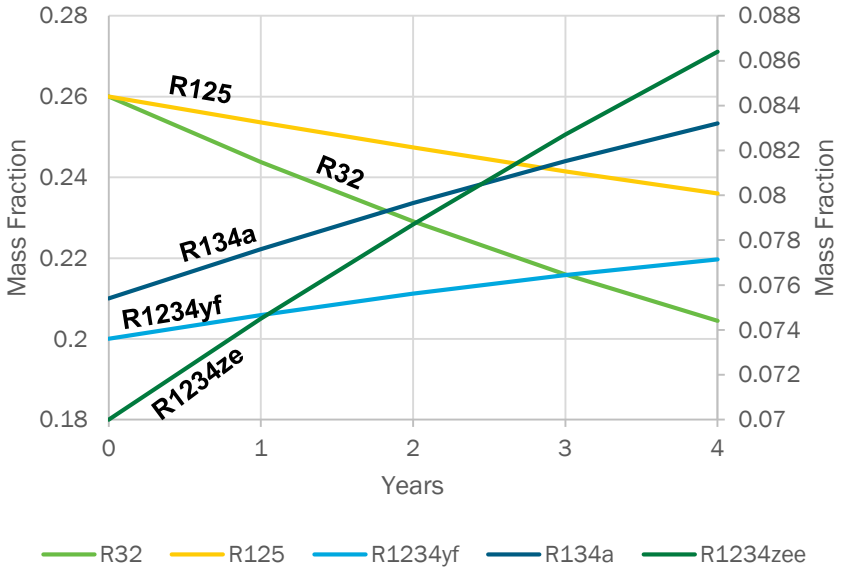
R125 < $R125_{nominal}$

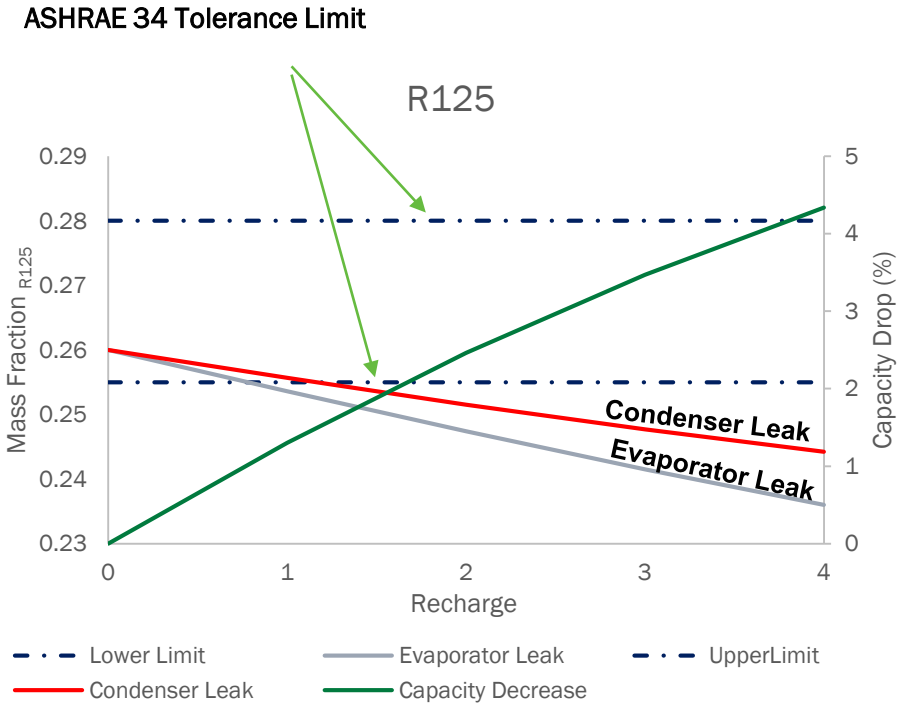
R134a > $R134a_{nominal}$



Direct Expansion (DX) System

Challenges: Zeotropic Refrigerant Leak





Is it really a lower GWP solution?

Approach

- **Characterize refrigerant leaks from commercial refrigeration equipment**
  - Historic refrigerant leak data provided by retailers (**23,000 data points**)
  - Improve our understanding of the likelihood of the location, frequency, and extent of leaks
  - Propose best practices to reduce refrigerant leaks
  - No prior work, anecdotal evidences only

- **Determine impact of zeotropic refrigerant leak on refrigerant composition and systemic performance degradation in commercial refrigeration systems**

- **Study Environmental impact of refrigerant composition change**

Impact

- **Reduce Carbon Footprint of supermarkets**
  - Direct Emission$_{R404A}$: 3.4 million pounds $CO_{2\ eq}$ /year
  - IndirectEmission$_{R404A}$: 3 million pounds $CO_{2\ eq}$/year)
- **Improve Servicing and Charging Methods**
- **Develop advanced leak detection methods**

* Profile of an Average U.S. Supermarket's Greenhouse Gas Impacts from Refrigeration Leaks Compared to Electricity Consumption - EPA

Progress

- **Year 1**
  - Literature and Regulatory Standard Review
    - ASHRAE Standard 34
    - ASHRAE SPC 177P Fractionation Apparatus Evaluation
    - AHRI Standard 700
  - Advisory Committee
    - Retailers, Service Industry and Regulatory bodies
  - Characterization of historic data
    - 2 years data
    - 5351 Retail Stores Nationwide
    - 23,000 leakage data points
    - 1,391,598 pounds of refrigerant added
  - 1st Sample Analysis
    - 12 supermarket sites across the country
    - Gas Chromatograph Calibration
    - Refrigerant Sample Analysis

Stakeholder Engagement

- **Advisory Committee**
  - Walmart
  - HEB
  - Raley's
  - GroceryOutlet
  - CoolSys
  - NASRC
- **Regulatory Bodies**
  - EPA
  - CARB

Remaining Project Work

- **Year 2**
  - Laboratory evaluation of impact of fractionation
  - 2nd Sample Analysis
- **Year 3**
  - 3rd Sample Analysis
  - Life Cycle Climate Performance analysis of refrigerant fractionation

Thank you

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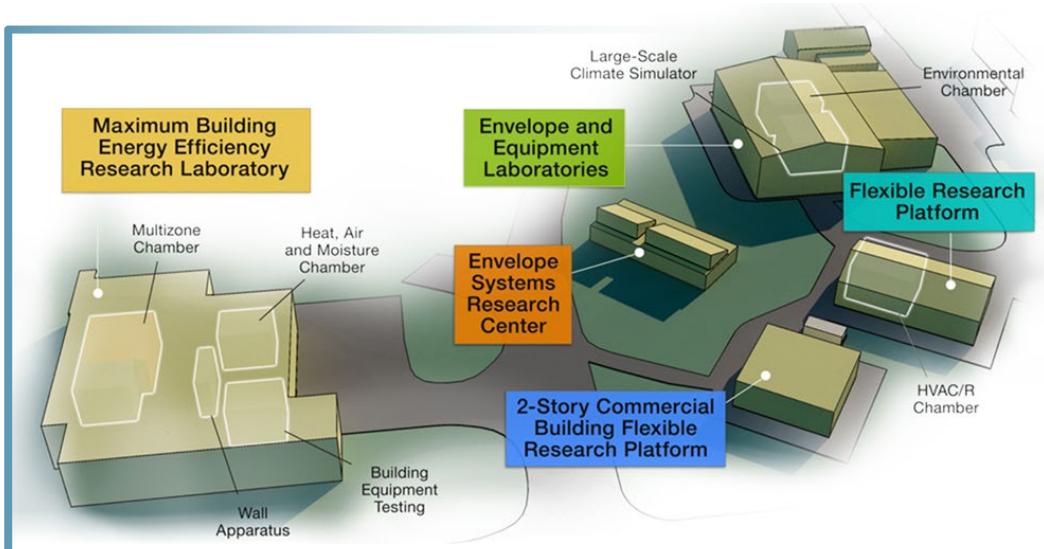

ORNL's Building Technologies Research and Integration Center (BTRIC) has supported DOE BTO since 1993. BTRIC is comprised of 50,000+ ft^2 of lab facilities conducting RD&D to support the DOE mission to equitably transition America to a carbon pollution-free electricity sector by 2035 and carbon free economy by 2050.

Scientific and Economic Results

238 publications in FY20
125 industry partners
27 university partners
10 R&D 100 awards
42 active CRADAs

BTRIC is a DOE-Designated National User Facility

Project Budget

Project Budget: 850K
Variances: No
Cost to Date: $300K
Additional Funding: NO.

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Project Plan and Schedule