QUANTIFYING AND REDUCING
HALOCARBON EMISSIONS AT ACADEMIC INSTITUTIONS

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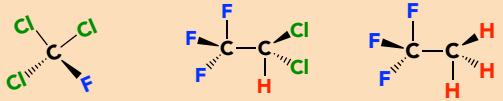
Halocarbons

Halocarbons are among the most potent greenhouse gases ever emitted.

- **Global Warming Potentials** (GWPs) 100 to 10,000 times greater than CO_2 (1).
- Emissions account for 14% of warming.
- An additional 0.5 ˚C of warming by 2100 if emissions are unabated (2).

We examine the **use and emissions** of halocarbons at Harvard University.

- Halocarbon represent ≲ **2% of annual emissions.**
- Total annual emissions: **2770 metric tons of CO_2 equivalents** ($MTCO_2eq$).
- Scaling up to 7 Boston area universities' emissions: ~13,000 $MTCO_2eq\ yr^{-1}$.



Chlorofluorocarbons (CFCs)
- Consist of **chlorine**, **fluorine**, and **carbon**. High ozone depleting potential. Production banned.

Hydrochlorofluorocarbons (HCFCs)
- Like CFCs, but **hydrogen** lowers ozone depletion. Production being phased out.

Hydrofluorocarbons (HFCs)
- No chlorine, very low ozone depletion. Potent greenhouse gases.

U.S. Regulatory Gap

Montreal Protocol
- International treaty to phase out ozone depleting substances (CFCs and HCFCs).

Kigali Amendment
- Update to the Montreal Protocol. Prescribes phase out of HFC production. **Not Ratified by U.S.**

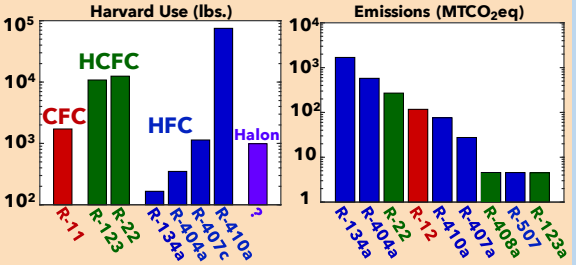
Clean Air Act Section 608
- Regulations prescribing maintenance and leak repair for equipment using HFCs. **Rescission Proposed.**

Lack of Regulation Means Room for Leadership!

Halocarbons at Harvard University

Water Chillers | Air Conditioning | Sample Storage

- Inventory includes units with ≥50 lbs. (3).
- About 100 units use ≥50 lbs.
- Leaks determined from service contracts.
- Average leak rate is 3 to 10% of stock. (Industry average is 15% (4)).



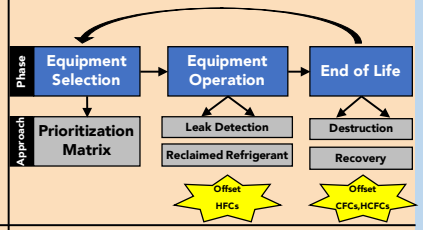
Roadmap to Reduction

Steps to Reduce Emissions

1. Use **our halocarbon manual** to plan phaseout.
1. Create **inventory** of halocarbon use and emissions; identify easy replacements.
2. Minimize **leaks** on existing equipment.
3. Use **reclaimed refrigerant** and **recycle HFCs** until production phase out.
4. Adopt contract language for and **procure non-halocarbon equipment.**
5. Implement **pilot projects** to demonstrate feasibility.
6. Commit to "**Kigali Pledge**."

Equipment Lifecycle Analysis

- Equipment Lifecycle: (1) Purchasing/ Selection, (2) Operation (3) End of life
- Halocarbon emissions can be reduced at each stage.



Prioritization Matrix

Stoplight criteria for upgrading equipment:

Green: Ready for Upgrade

Yellow: Moderate Barriers

Red: Upgrade Unlikely in Near Term

	Green	Yellow	Red
End of Life	< 5 Years	5-10 Years	>10 Years
Refrigerant	Halons, CFCs, HCFCs	Medium and High Pressure	Low Pressure Systems
Ease of Upgrade	Drop-In Replacement	Equipment Change Out	Fire and Building Code Restrictions
Capital Cost	< $50,000	~$250,000	> $500,000
System Criticality	Serves as Back-Up Only	Runs in Parallel with other Units	Single Unit/ Critical System

Pilot Project

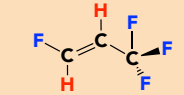
11 individual units servicing cold storage rooms. Collectively, units use 300 lbs. of **HFC-404a.**

Use a more efficient HFC
- Replace HFC-404a with **HFC-442a**. 10% more energy efficient, **50% lower GWP.**
- **10 $MTCO_2eq$** avoided annually!

Halocarbon Alternatives

Drop-in replacements can reduce Harvard's emissions by 336 $MTCO_2eq\ yr^{-1}$.

Hydrofluoroolefins (HFOs)
- Require modifications to existing equipment.
- Next-generation halocarbon refrigerant with low GWP. Mild flammability and environmental toxicity concerns.



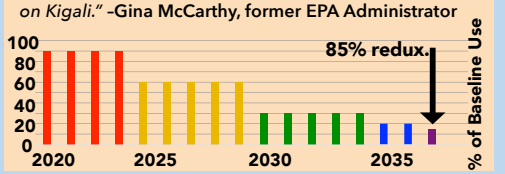
Natural Refrigerants
- Low GWP refrigerants including carbon dioxide, ammonia, and hydrocarbons.
- Often more energy efficient (15-20%).
- Using natural refrigerants can preempt future regulation.

	HFCs	HFOs	Natural Refrigerants
Application	Can be used in all applications	Newer: More common in HVAC and Auto	Currently limited to refrigeration
Energy Efficiency	Baseline	Generally lower	Often more energy efficient
Flammability	Class 1	Generally Class 2L	Varies: Can be Class 3 (C_3H_8) or Class 1 (CO_2)
GWP	High	Medium	Very Low

Policy Recommendations

Internal pledge to reduce halocarbon use.

"Voluntary commitments by Harvard and the Boston GRC Higher Ed group to reduce HFC's could catalyze the momentum needed to show the world we're still in on Kigali." **-Gina McCarthy, former EPA Administrator**



References

(1) IPCC Fifth Assessment Report, 2014. (2) Primer on Short Lived Climate Pollutants, IGSD, 2013. (3) 40 CFR Part 82, Subpart F. (4) Methodology for the Quantification of GHG Emissions from Refrigeration Systems, ACR, 2018).

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