Pricing Refrigerant Emissions at Yale

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1 Abstract

This document outlines the thrust behind pricing emissions of refrigerant gases within the Yale Carbon Charge. Currently, the Carbon Charge applies a price of $40 per metric ton of carbon dioxide equivalent (MTCDE) from energy use in university buildings. This program creates a university-wide price signal that incentivizes energy efficiency. The program currently *does not* cover emissions of other greenhouse gases, such as hydrofluorocarbon refrigerants, which are climate pollutants thousands of times more potent compared with carbon dioxide.

2 Technical Background

Hydrofluorocarbon (HFC) refrigerant gases are among the most potent greenhouse gases in the world. HFCs have Global Warming Potentials (GWP) thousands to tens of thousands of times greater than that of carbon dioxide. In simple terms, one kilogram of HFC has the same atmospheric warming effect as several tons of carbon dioxide.

The table below shows GWPs for the most common refrigerants on campus. R-404A and R-134A are HFCs commonly used in air conditioners and refrigerators, while R-290 and R-600A are climate-friendly hydrocarbon refrigerants commonly used in student mini-fridges. Low-GWP refrigerants are becoming increasingly common in larger HVAC equipment, but the university has not yet widely adopted this technology.

Refrigerant	HFC	GWP-20
R-404A	Yes	6010
R-134A	Yes	3830
R-290	No	3
R-600A	No	3

Refrigerants leak into the atmosphere in two ways: from leaks that occur during its operating life, and from loss of refrigerant at end of life. Refrigerant technicians can manage equipment to reduce refrigerant leakage and to capture refrigerant at end of life. Adherence to best practices can keep HFC out of the atmosphere. It is typical for refrigeration systems (such as those used in the dining hall) to leak up to 10 percent of their total charge each year. Leak rate data are not always available for equipment at Yale, but from speaking with refrigerant technicians, our team learned that technicians typically keep leak rates around 7-8 percent threshold for commercial cooling equipment.

3 Calculating Environmental Impact

In 2020, Yale emitted roughly 147,000 MTCDE. We predict that leakage of refrigerants, currently not accounted for in university climate calculations, accounts for at least 11 percent of university climate impact, if not more. Globally, HFCs have accounted for roughly 11 percent of atmospheric warming, and with Yale's large research centers and dining halls, we have reason to believe that Yale's percentage is higher. A full campus refrigerant inventory will be necessary to determine the true magnitude of this issue.

To begin to assess the scope of this problem, our team conducted a full inventory of refrigerants in the dining halls on campus. Although the dining system is indeed a notable source of refrigerants on campus, it represents only a subset of the total quantity of HFCs at the university. Our inventory allowed us to estimate that from leaks alone (at the estimated annual rate for this equipment), the dining hall system emits 823 MTCDE from HFCs per year. This does account for loss of refrigerant during maintenance or disposal.

It is also worth mentioning that from similar calculations, the 131 ice makers in the Yale New Haven Health system emit an estimated 88 MTCDE from HFCs annually from leakage. This number excludes the massive cryogenic freezers and other cooling equipment in medical laboratories. One can imagine how these numbers add up over many units and many buildings.

The magnitude of this problem merits a well-constructed solution to primarily incentivize better refrigerant management practices on campus, and to secondarily accelerate the adoption of low-GWP HVAC technology.

4 How Refrigerant Pricing Can Work

For now, we will focus on how refrigerants can be priced at the general university level, excluding emissions from student mini-fridges. (The latter emissions would be 238.24 MTCDE over the lifespan of the mini-fridges, collectively). Pricing these emissions would create some political challenges at the student level, which we are dealing with separately).

The easiest way to price refrigerant emissions is to record how much each Yale building spends on refrigerants for recharge each year. We can infer that the amount of refrigerant purchased is equal to the amount of refrigerant leaked into the atmosphere in the given year. The amount of refrigerant for recharge is itemized on bills from refrigerant technicians. We can then calculate carbon dioxide equivalent emissions, and tack on the social cost of these emissions to the existing bill from the Carbon Charge.

One key feature of the Carbon Charge is that it is revenue neutral, meaning that inefficient buildings lose (they end up losing money over the year) and efficient buildings gain (they make money over the year). To preserve this feature of the Carbon Charge with refrigerant pricing, we must first complete a full refrigerant inventory of all buildings on campus.

This full inventory is necessary because we should be able to compare leak rates of a particular building against another building, and also against the university average refrigerant leak rate. If we know how much refrigerant is in each building, we can calculate the leak rate for each building.

The same logic can apply now for revenue neutrality. Buildings with higher than average leak rates will lose over the calendar year, and buildings with lower than average leak rate will gain. This idea should be refined throughout the brainstorming process.

5 Effects

The effects of refrigerant pricing on HVAC equipment would be profound.

First, creating a price signal for refrigerant emissions would shift the priorities of facility managers. If high leak rates will trigger extra costs, it will make economic sense to pay technicians for a few more hours per year to check for and minimize leaks, beyond what is required by law.

Moving back to the dining halls, the 823 MTCDE annual refrigerant emissions would translate to a $32,900 fee for the dining system. Slicing leak rates in half, for example, would be valued at $16,453, savings that may create a slim financial incentive to better manage leaks.

Second, pricing refrigerant emissions will accelerate a campus-wide shift to low-GWP HVAC equipment. This idea is best understood with an energy analogy. Suppose you are a cost-minded consumer using natural gas to warm your home. If the cost of solar energy is higher than natural gas, you likely will not shift to solar. But if the government imposes a carbon tax that makes it more expensive to burn natural gas, solar now becomes a more attractive option.

The exact same logic is true with HVAC equipment. If having an HFC system will cause extra variable costs down the line, you may choose to buy the low-GWP alternative. Low-GWP options are becoming increasingly popular on the market, but are still slightly more expensive than HFC options. Pricing refrigerants will therefore accelerate the transition to this new technology.

All of these effects come at an important time. In December 2020, Congress passed the American Innovation and Manufacturing (AIM) Act, a bill that will phase down HFC over a period of 15 years. This phasedown will affect Yale's equipment and purchasing decisions. Applying the Carbon Charge to refrigerant emissions will facilitate the refrigerant transition required by law with both administrative and economic efficiency.