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Change & Risk: Refrigerants in Equipment on the road to a Decarbonized Future

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What we'll try to cover...

Tom Kacandes with Jake Marin, VEIC

• What are refrigerants?

- How are they regulated and how does that affect equipment choices and program administration?
- What market dynamics might affect each of these?

Climate Leadership and Community Protection Act (2019)

New York State is required to reduce GHG emissions:

- 40% by 2030, from 1990 levels (40x30)
- 85% by 2050, from 1990 levels (85x50)

Using a 20-year Global Warming Potential

To achieve a goal of:

Net zero emissions by 2050

...but HFC refrigerants are the fastest growing GHG emissions per NYS

Reference: NYS Environmental Conservation Law Article 75 NY's Climate Change Scoping Plan: <u>www.climate.ny.gov</u>

le create a cooling

Mathappens

when we turn

he heat up?

Hawai'i also reports rising emissions from hydrofluorocarbons (HFCs), largely driven by the growing number of units using HFC refrigerants over the past four years, making them **the state's secondlargest GHG contributor.**

HFC Uses Today

Refrigeration



A/C and Heat Pumps



Foam, Propellants, and Solvents





Naturally occurring refrigerants R-290 propane and Ammonia have always been used. Low-charge, outdoor applications of these with glycol/hydronic heat transfer to inside buildings is a "new" option.

"RISK" from Refrigerants

Comes from more than one source

- What's allowed and for how long? Will I be able to get more in 2031?
- Is it PFAS? Does it "make" PFAS?
 - Ex. R-32 vs. R-454B
- Where and how is it used?
- What (really) happens if it leaks?

Examine presumptions about the next 20 years

			IPCC AR4 (2007)		IPCC AR6 (2021)		PFAS
Refrigerants / Brand Name	Туре	Composition	GWP 100 years	Real GWP 20 years	GWP 100 years	Real GWP 20 years	Yes/No
R143a	HFC	100% R143a	4470	5890	5810	7840	Yes
R125	HFC	100% R125	3500	6350	3740	6740	Yes
R134a	HFC	100% R134a	1430	3830	1530	4140	Yes
R32	HFC	100% R32	650	2330	771	2690	No
R404A Freon 404A	HFC	44% R125 / 4% R134a / 52% R143a	3922	6010	4728	7208	Yes
R407A Freon 407A	HFC	20% R32, 40% R125, 40% R134a	2102	4538	2262	4890	Yes
R410A Freon 410A	HFC	50% R125 / 50% R32	2075	4340	2255	4715	Yes
R407C Freon 407C	HFC	23% R32 / 25% R125 / 52% R134a	1768	4115	1908	4457	Yes
R452A Opteon XP44	HFC/ HFO	11% R32 / 59% R125 / 30% R1234yf	2137	4003	2292	4273	Yes
R449A Opteon XP40	HFC/ HFO	24.3% R32 / 24.7% R125 / 25.7% R134a / 25.3% R1234yf	1390	3119	1504	3383	Yes
R448A Solstice N40	HFC/ HFO	26% R32 / 26% R125 / 21% R134a / 7% R1234ze / 20% R1234yf	1379	3062	1494	3321	Yes
R449C Opteon XP20	HFC/ HFO	20% R32 / 20% R125 / 29% R134a / 31% R1234yf	1245	2847	1346	3087	Yes
R452B Opteon XL55	HFC/ HFO	67% R32 / 7% R125 / 26% R1234yf	681	2006	779	2275	Yes
R454B Opteon XL41	HFC/ HFO	68.9% R32 / 31.1% R1234yf	448	1606	531	1854	Yes
R513A Opteon XP10	HFC/ HFO	44% R134a / 56% R1234yf	629	1686	673	1823	Yes
R450A Solstice N13	HFC/ HFO	42% R134a / 58% R1234ze	601	1611	643	1742	Yes
R454C Opteon XL20	HFC/ HFO	78.5% R1234yf / 21.5% R32	140	502	166	580	Yes
R455A Solstice L40X	HFC/ HFO	75.5% R1234yf / 21.5% R32 / 3% R744	140	502	166	580	Yes
R744	Natural	CO2	1	1	1	1	No
R600a	Natural	Isobutane	<1	<1	<1	<1	No
R290	Natural	Propane	<1	<1	<1	<1	No
R1270	Natural	Propylene	<1	<1	<1	<1	No
R717	Natural	NH3	0	0	0	0	No



Grant Kovac of Vilter with the new VQ95 ammonia heat pump at Chillventa 2024.

Copeland Debuts Ammonia-Based Industrial Heat Pump for Decarbonization of Heating

The Vilter-branded water-to-water, single-screw unit offers 1 to 5MW on a single skid.

10-15-2024 Today's example:

"Natural" refrigerants open up literally ZERO Global Warming Potential options for very large ammonia-based heat pumps for industrial and district heating applications.

How would it be possible to specify a very large fgas industrial heat pump and ignore a zero or near-zero GHG option?

Our footprint

National reach, local approach



Innovative clean energy expertise to move us forward

Over 370 employees across 6 offices

Consultants, engineers, policy experts, M&V specialists, program designers, project managers, marketing experts, consumer insights specialists, researchers, and analysts

EE Utilities = Program Implementers

Consulting for Utilities, Corporate, Government, Foundations, Not For Profit Clients

As the planet warms and we drive "decarbonization,"

heat pump and refrigeration installations are **skyrocketing** Reduce fossil fuel use for **heating**

Reduce fossil fuel use in **newer niches** e.g. drying clothes and heating water

Increased **cooling** needs as climate warms

Reducing global **food waste**

More heat pumps & refrigeration

More f-gas = More GHG

Trading CO2 for CO2e?

Takeaways

Refrigerants are regulated air emissions.

New rules impose new costs to your equipment choices and operating policies.

We must pay attention NOW

because **NYS or WA** rules are different from new **US EPA** rules and EPA rules have just changed, a lot. New refrigerant-bearing HVAC or Commercial Refrigeration *equipment may <u>not</u> have service gas available before end of life*.

There are unaddressed, urgent opportunities

to avoid bad investments and fines for emissions from refrigerant sources along with using the new regs to drive best operating practice into your site operations.



New Work to Do...

Owners/Mgrs / Engineers

- Ensure Compliance
 - Avoid Risk & Fines
- Manage Operation and Maintenance
 - Vendors / Contracts
 - Staff procedures
- Planning and Cost Control
 - Future-proof sites

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Install / Supply Chain

- Understand how regulation and technology will change the market
- Support customer compliance and operating success
- Codes compliance



Replacing equipment? Things to think about

VS.

Keep older, leaky equipment

- Ongoing cost of repairs
- Escalating price of legacy refrigerants
- Environmental impact
- Compliance concerns

Replace with new, lower-GWP

- Increased efficiency
- Improved reliability
- Reduced service calls
- New features

Even if not required, automatic leak detection might save money

HVAC & Commercial Refrigeration (CR) Regulation

Federal – AIM Act

- Reduced Supply of HFC
- Further reductions (phase down, not out)
- Regulation of new refrigerants allowed in all equipment
- Eq. charge size of 15 lbs or more, not residential

NYS / "Your State Here"

- Large Refrigeration and HVAC focus
- Natural refrigerants
 become no regrets choice for future proofing
- Best practice like asset tracking & refrigerant info signs on equipment become required

Codes & Standards

- ASHRAE 15 sets the application standard for what can be used and where / how it is used
- Mechanical code and fire code implications from lower-GHG mildly flammable refrigerants like fire chase for line sets

American Innovation & Manufacturing (AIM) Act

HFC Production & Consumption Phasedown

2 Technology Transitions Program

3 Management of HFC Use and Reuse

American Innovation & Manufacturing (AIM) Act

Production & Consumption Phasedown

- Reduces <u>HFC supply</u>
- Step-downs starting in 2024 (40% reduction compared to baseline)
- Impacts highest GWP refrigerants first
- Began in 2022

Technology Transition Program

- Reduces <u>HFC demand</u>
- EPA set GWP limits for new equipment
- Regulations finalized 10/23
- Restrictions begin 01/25

Emissions Reduction and Reclamation Program

- Reduces HFC demand
- EPA set compliance requirements for refrigerant leak mediation and reclamation requirements
- Regulations finalized 09/24
- Compliance begins 01/26

Protecting Our Climate by Reducing Use of HFCs | US EPA

American Innovation & Manufacturing (AIM) Act 1. HFC Production & Consumption Phasedown



https://www.epa.gov/climate-hfcs-reduction/final-rule-phasedown-hydrofluorocarbons-establishing-allowance-allocation

The American Innovation and Manufacturing (AIM) Act

AIM Act Requires Production/Consumption Reductions through Allocations Following the Montreal Protocol Kigali Schedule for Developed Countries



Reduced Refrigerant GWP Production Allocations + Reduced GWP in New Products



2024 HFC Production Allowances

Individual Firms Decide how to use their AIM Act allowances

As firms manage their profitability within total GWP caps they



Mfgrs manage total GHG within Aim Act

Each Manufacturer has an allocation for total GHG effect of HFCs they sell from EPA that steps down over time: They then manage what refrigerants "use up" that allocation. They are motivated to sell lower GHG refrigerants to maintain \$ volume. Result: some refrigerants will disappear

Nvidia stock heads for record, eyes title of most

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Chemours Discontinues U.S. Sales of Legacy Freon™ Refrigerants 404A and 507



Cost of refrigerants goes up when ...

Price of R-22, Refrigerant Phase out



Total Refrigerants in Buildings and HVAC Systems*

*This is not leaked refrigerant. This is total refrigerants estimated to be in NYS

48,560,979 lbs. refrigerant = 95,682,610 MT CO2e



Where is your 2030 "service gas" coming from? Will it even be available at any price?

Looks like a lot But it is not:

50% of all refrigerant Manufactured each Year goes to replace Leaked refrigerant

Less than 3% is reclaimed



The data displayed above is reported Section 608 data as of November 28, 2023.

Chart credit: www.epa.gov

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Our market assessment calculated 3-10 Million MTCO2e* associated with refrigerant leaks in existing commercial HVAC systems across NYS

"

*depending on 3.5%, 5% or 10% leak rate

Tech Transition Rules and Deadlines

Refrigeration, Air Conditioning, and Heat Pump Systems*							
Subsector	Global Warming Systems Potential Limit or Prohibited Substance		Installation Compliance Date⁵				
Stationary air conditioning and	Residential and light commercial air conditioning and heat pump systems	700	January 1, 20256				
near pumps	Variable refrigerant flow systems	700	January 1, 2026				
Chillers	Industrial process refrigeration with exiting fluid below -50 °C (-58 °F)	Not covered	Not covered				
	Industrial process refrigeration with exiting fluid from -50 °C (-58 °F) to -30 °C (-22 °F)	700	January 1, 2028				
	Industrial process refrigeration with exiting fluid above -30 °C (-22 °F)	700	January 1, 2026				
	Comfort cooling	700	January 1, 2025				
Ice rinks	Ice rinks	700	January 1, 2025				
Data centers, computer room air conditioning, and information technology equipment cooling	Data centers, computer room air conditioning, and information technology equipment cooling	700	January 1, 2027				

There are many more, review them online:

https://www.epa.gov/system/files/documents/2023-10/technology-transitions-final-rule-fact-sheet-2023.pdf

Self-contained Refrigeration, Air Conditioning, and Heat Pump Products*							
Subsector	Products	Global Warming Potential Limit or Prohibited Substances	Manufacture and Import Compliance Date ¹				
Stationary residential and light commercial air conditioning and heat pumps	Stationary residential and light commercial air conditioning and heat pumps (e.g., window units, portable room air conditioning)	/ residential and light al air conditioning and ps (e.g., window units, 700 oom air conditioning)					
Residential dehumidifiers	Residential dehumidifiers	700	January 1, 2025				
Household refrigerators and freezers	Household refrigerators and freezers	150	January 1, 2025				
Chillers (as a stand-alone product)	Industrial process refrigeration with exiting fluid below -50 °C (-58 °F)	Not covered	Not covered				
	Industrial process refrigeration with exiting fluid greater than or equal to -50 °C (-58 °F) and less than -30 °C (-22 °F)	700	January 1, 2028				
	Industrial process refrigeration with exiting fluid equal to or above -30 °C (-22 °F)	700	January 1, 2026				
	Comfort cooling	700	January 1, 2025				
	Ice rinks	700	January 1, 2025				
Data centers, computer room air conditioning, and information echnology equipment cooling		700	January 1, 2027				

TT: What do these restrictions apply to?

<u>The Technology Transition Program</u> applies to **ALL** new RACHP equipment that uses HFCs and is manufactured, imported, and installed across **ALL** sectors after the compliance date for each subsector listed on EPA's website.

Headline: Starting 1/2025 GWP ceiling is <700 and final date will be 2028.

Current exemption for niche markets/use: e.g. Military refrigerant-containing equipment used in deployable and expeditionary situations, including space vehicles as defined.

Emissions Reduction and Reclamation Program

Leak Repair

- Systems ≥15 lb. charge of refrigerant with GWP ≥53.
- Residential & light commercial AC & HPs <u>are exempt</u>.

Automatic Leak Detection (ALD)

- C&I process refrigeration appliances with charge ≥ 1,500 lbs.
- Required 30 days 1 year after final rule publishing

Use of Reclaimed HFCs for HVAC/R equipment

- Beginning 2029 rule of reclaimed rule applies to services and/or repair of existing and initial charge of new equipment.
- Covers all HFC-based products and systems.

What about the ER&R: Who do these restrictions apply to?

The Emissions Reduction and Reclamation Program (ER&R) applies to ANYONE who owns, operate, service, repair, recycle, dispose, or install equipment containing HFCs or their substitutes, as well as those that recover, recycle, or reclaim HFCs or their substitutes.

Headline: Reporting rule applies to any system with a charge >15lbs. ALD required for refrigeration/IP system >1500lbs. Record keeping requirements for 3 years. Servicing/repair of any RACHP must be done with reclaimed beginning 1/2029.

Current exemption: Residential market and light commercial AC, HP subsector

Reminder Subsection (h) final rule highlights

Refrigerant leak mediation

Recordkeeping and reporting requirement

Refrigerant reclamation requirements

Who is responsible for leak mediation?

Owners or operators of applicable* refrigerant-containing appliances are responsible for compliance with the leak repair requirements of the final rule.

An owner or operator can be any person who **owns**, **leases**, **or operates** any refrigerant-containing appliances or **who controls or supervises any practice**, **process**, **or activity** that relates to any refrigerant-containing appliance.



What do you need to know, do and by when?

January 1, 2026, owners or operators and certified technicians must comply with leak repair requirements for all applicable refrigerant-containing appliances with a full charge size of 15 lbs. or more that contain an HFC or substitute for an HFC (HFOs) with a global warming potential GWP > 53.

Required to conduct a leak rate calculation **EVERY TIME** refrigerant is added to an appliance – determines if your equipment is within the comfort cooling threshold limit of 10% leak rate or if you are required to repair.



What does this mean? Do the Math!

EPA allows 2 types of calculations – annualized or rolling average.

Annualized: Leak rate $\binom{\%}{yr} = \frac{pounds \text{ of refrigerant added}}{pounds \text{ of refrigerant}} \times \frac{365^{\text{ days}}/\text{yr}}{\text{shorter of: days since}} \times 100\%$

Rolling average: Leak rate $\binom{\%}{yr} = \frac{pounds \ of \ refrigerant \ added \ over \ past \ 365 \ days}{pounds \ of \ refrigerant \ in \ full \ charge} \times 100\%$

An owner operator must use the **SAME** calculation method for all equipment at a facility.

If you find you are leaking above 10% you must **identify and repair the leak within 30 days** and then **perform and document** a follow-up verification test within 10 days to demonstrate repairs were successful. If you want to retrofit/retire vs. repair you must create a **retrofit plan in 30 days** and **complete within 1yr.**

Recordkeeping steps to support requirements

- **3.** Ensure your service technicians are aware of the records they must provide you for successful data entry and record keeping
- **4.** Avoid easy violations like missing leak inspections. Create a schedule for all your reporting requirements incorporate tracking, monitoring and record keeping of all leaks across all HVACR.
- **5. Create a prioritized investment strategy for equipment upgrades** and identify what of your high-GWP systems can be retrofitted or replace with systems that use natural refrigerants or refrigerants under the EPA HFC phasedown.



Who do I have to report to and when?

There is no 1-800 number for EPA subsection (h). Like any compliance rule, EPA officers can request your records at any time to ensure you are following the requirements as written under the law.

You only need to report directly to EPA if any of the following occur:

- You found you have a chronically leaky appliance/system (125% in a full calendar year)
- You found a leak, but need more time to fix it
- You are looking to retire/retrofit your equipment but need more time to complete a plan



Brief word on reclamation and ALDs

In the proposed rule, use of reclaim refrigerant was required for initial charge in residential and light commercial AC and heat pumps. This was removed in the final rule.

Reclaimed refrigerant requirements only apply to servicing/repair of any existing RACHP equipment starting 1/2029.

EPA only issues required guidance on ALDs for commercial refrigeration and industrial process equipment with 1500lbs+ a GWP > 53.

ALD requirements for HVAC with A2Ls are covered by ASHRAE due to safety considerations.

Refrigerant Management Impact in Vermont (2019-2021 only)

- 50 projects: 25 large custom, 25 through Prescriptive Leak Repair Program
- GHG Impact/Year: 2450 MTCO2e/year
- MWh claimed equivalent: 4,900
- Average annual estimated energy savings per project: 25,000 kwh or \$2,500 at \$0.10/kWh
- Average leakage rate reduction: 12%
- General Store in rural VT: permanent leak monitoring system prevented multiple catastrophic leaks in 2020



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A2L Local Impacts

Do You Know?

ASHRAE 15 (2019) & the International Mechanical Code chapter 11 (2021) requires refrigerant piping for split system projects featuring A2L refrigerants to be installed in a single use, fire rated chase in multi-floor projects?





How are we designing our buildings and systems?

Thermal balancing of the loop with air/water heat pump









Cost considerations for A2Ls & MEPs / building owners

Safety Advanced safety – ALD (20-30% premium), added ventilation requirements, insurance

Architectural implications added fire suppression and fire rated assemblies (chases for VRF)

Ease of installation and ongoing maintenance goal is to simplify! Minimize addition cost associated with compliance reporting, technician training and compliance with A2L

Refrigerant reclaim availability R32, R454B, and R1234yf? Can you get it?



2019:

"... program administrators should require manufacturer certification in the installation of VRF to increase confidence in system performance and reduce risk of refrigerant leaks."

p.3 Market Transformation Strategy 5.b



2023:

CA program administrators should suspend R-410A VRF incentives to review under Total System Benefit metric

No clear evidence of efficiency: VRF real system performance M&V is very difficult No clear path to ultra-low GWP No low-cost effective leak detection Alternative lower net GWP technologies becoming available, AWHPs in particular

New term: "refrigerant efficiency"

Collision of energy mindset with environmental regulation to control HFCs as high impact GHG was noted by Daikin VP Rusty Tharp at CEE's May 2023 meeting



Variable Refrigerant Flow (VRF) Refrigerant Management Market Assessment

Final Report

ET22SWE0020



Prepared by: Katey Beaton VEIC JT Coneybeer VEIC Lead Author, Tom Kacandes VEIC

September 17, 2023

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Safety – Refrigerant Volume





A typical 10T VRF system (1 floor of a hotel) will have ~70 lbs of refrigerant, circulating throughout the rooms/floor An equivalent floor of a hotel (10T)with inroom VPAK will have 13 units and ~30 lbs of refrigerant total...With only 2.3 lbs max circulating / contained per room



Emerging trend: GHG reduction goals for utilities

Maryland HB 864

A bill recently passed by the Maryland legislature (HB 864) directs the state's public service commission to establish greenhouse gas (GHG) emissions reduction targets for utilities. Electric utilities will need to achieve at least the GHG emissions reduction equivalent of annual electricity savings of 2% in 2024, 2.24% in 2025 and 2026, and 2.5% for each year after that. Directly connecting Maryland's EmPOWER energy efficiency programs to its decarbonization goals strengthens the case for future investment in energy efficiency. – ACEEE 5/9/24

Non-energy GHG reduction via refrigerant management can help meet EE program goals

VT and DCSEU experience remain unique

There are opportunities to improve operations while reducing future GHG emissions from refrigerant sources



Minimize Refrigerant







Use Natural Refrigerant



Problem 1. Systems with Lots of Refrigerant

Example: VRF (variable refrigerant flow)

VRF is viewed by many as a "gold standard" in HVAC in large buildings, **yet**

- Results in 100s to 1000s of feet of refrigerant lines
- Each bend and joint is a leak risk (and there will be leaks)
- This infrastructure is expensive, locked into a building from the start, and **cannot be retrofitted** to use natural refrigerants. R-410A systems cannot be retrofitted to use A2L
 - Is it "the CFL of HVAC"? Will it last 15 years?





Solutions, 1. Minimize Refrigerant

Air or water distribution (#pumpwaternotrefrigerant)

Monobloc equipment (factory sealed, no field connections)

Minimize refrigerant amount (charge size) – choose alternative designs that reduce required refrigerant





Problem 2. Too Many Leaks

Example: Food retail

Supermarkets each have 1000s of pounds of refrigerant and on average lose 20% of it per year

Refrigerant lines corrode over time

Leaks are hard to find

Example: HVAC

Mini-splits and VRF equipment have technician-installed connections, each of which is a potential leak site

Leaks are hard to find

"Gas and go" refills (recharges) are common



Solutions, 2. Minimize Leaks

Refrigerant leak repairs

Permanent **refrigerant leak detection** systems

Outreach and contractor training on installation and maintenance **procedures** for leak prevention

Design systems to **reduce or eliminate pipe bends and field-made connections** (they're leaky)



Problem 3. End of Equipment Life – How to Dispose?

Example: Appliance end-of-life

Even in Vermont, it is **almost impossible** to dispose of an appliance and **know for sure** that the refrigerant <u>will not end up in the</u> <u>atmosphere.</u>

We must think about **all of the new appliances** that contain refrigerants being installed **as part of electrification efforts**, e.g.:

- Minisplits/cold climate heat pumps
- Heat pump dryers
- Heat pump water heaters
- VRF systems



If vented (intentionally or over time in a landfill), the relatively small 295 grams of R-134A in this heat pump dryer equate to 422 kg CO2e (about 1100 miles driven by the average gas-powered car)

Solutions, 3. Recover and Reclaim

Refrigerants must be reclaimed at the end of equipment life to prevent ineffective disposal

- Contractors and Technicians need skills & access to specialized tools to do reclamation
- Reclaimed Refrigerant Resellers need connection to customers + contractors to buy phased-out reclaimed refrigerant



Source: A-Gas, <u>Rapid Recovery</u> <u>New York</u>



Problem 4. High-GWP Refrigerants

Locking In Future Emissions

Systems installed in new construction and retrofit situations may build in huge amounts of infrastructure supporting refrigerant that will one day be banned – this is **not easily undone**



Source: Supermarket News, <u>CO2 refrigeration on the rise</u>

Solutions, 4. Use Natural Refrigerant

Pilot demonstration projects and case studies

3rd party guidance on natural refrigerant-based technologies and systems

Cutting-edge modeling tools

for natural refrigerant systems quantify energy and GHG savings to help companies meet carbon goals and obtain incentives



clients & results case studies

How can grocery stores save money and future-proof operations through refrigeration management?

4 min read







Thank you!

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