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Serving Kentucky and Southern Indiana for 77 years



Agenda


1. Regulatory Drivers and HVAC Impact on Climate

2. Regulatory Updates

3. Alternative Refrigerant Choices

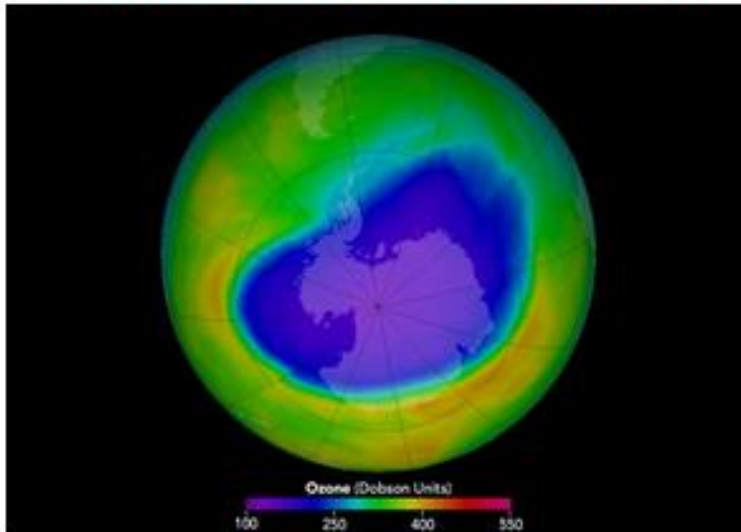
4. What Manufacturers are Doing

5. Challenges To Consider



Phase *Out* and Phase *Down* History

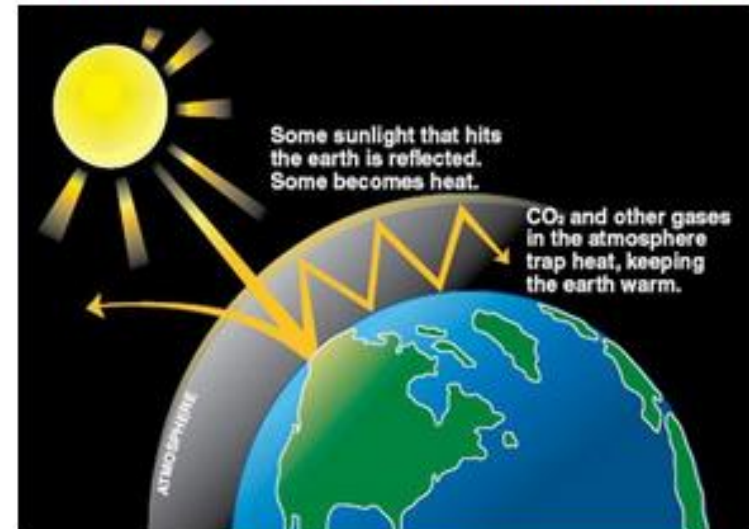
Ozone Depletion Potential (ODP)



Phase OUT of CFCs & HCFCs
(Ozone Depleting - Higher GWP)

Montreal Protocol

Global Warming Potential (GWP)



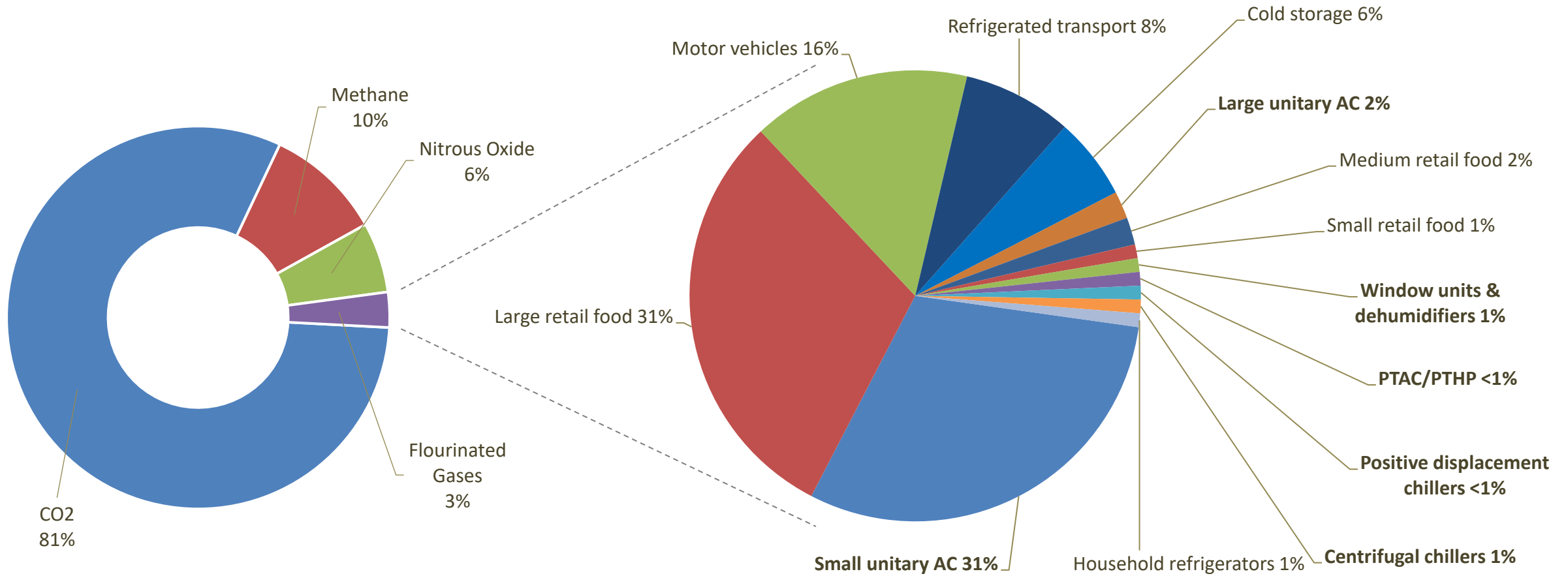
Phase DOWN of HFCs
(Non-ozone Depleting – High GWP)

Kigali Amendment



Global HFC emissions by application type

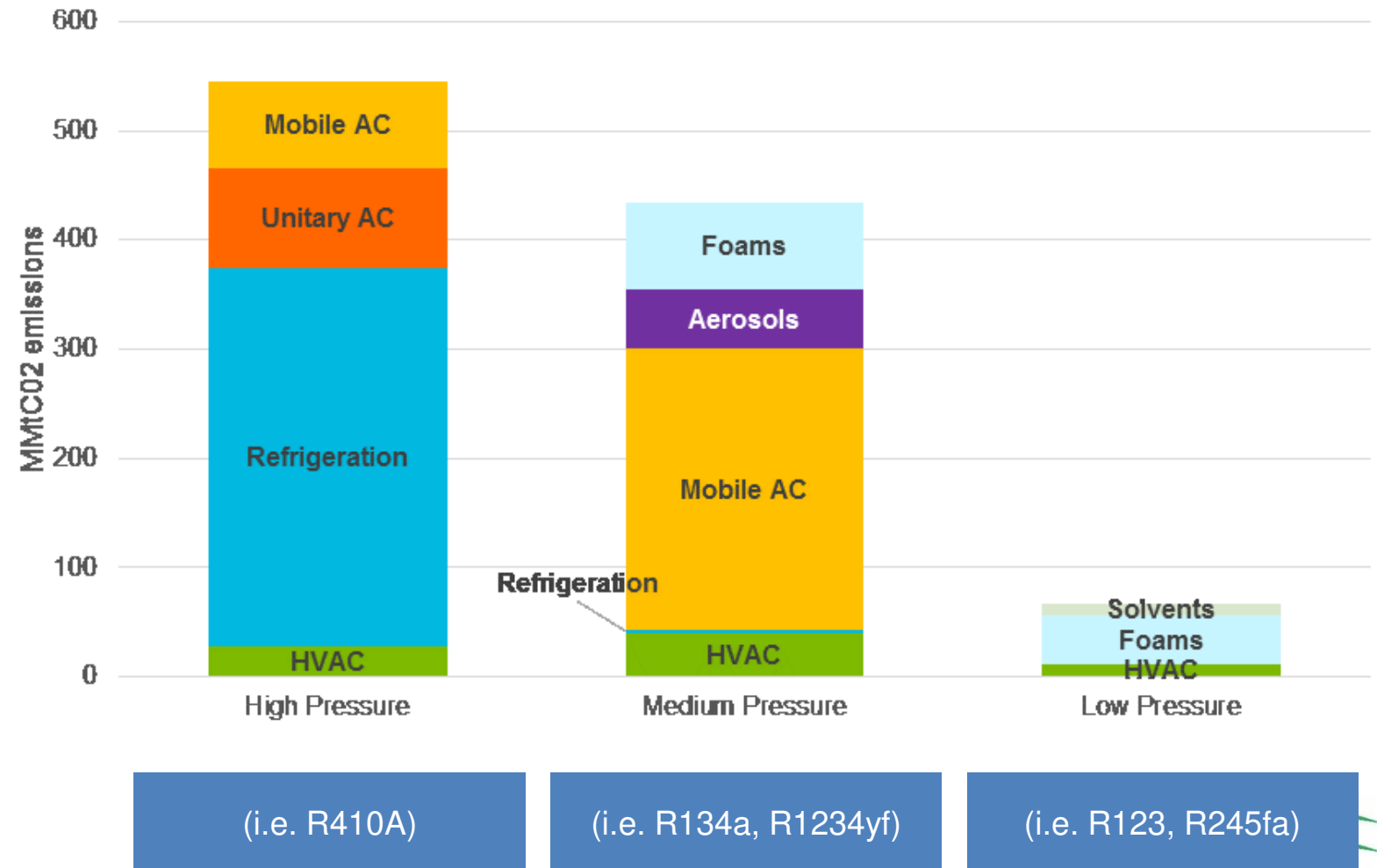
% of GWP-weighted emissions



Emissions by sector – HFC Consumption

Industry Sector Emissions

- Regulations focus on the highest emitting industry sectors
- HVAC is a much smaller contributor due to responsible use practices and maintenance

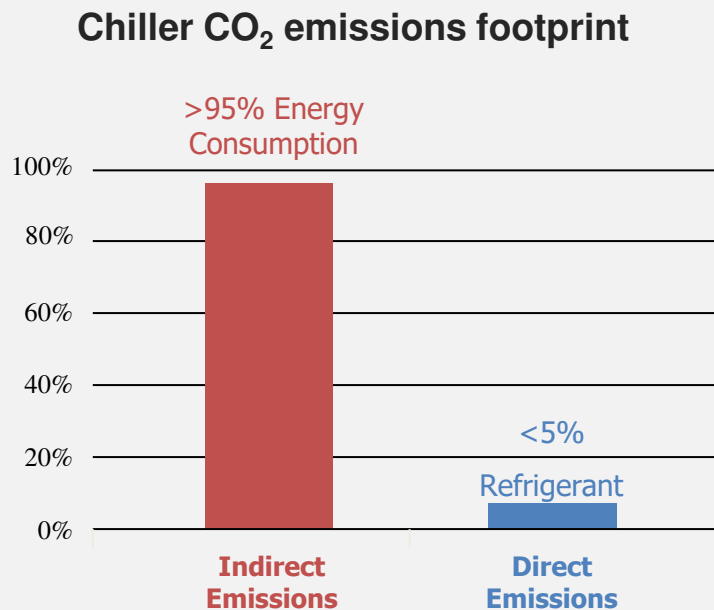


HVAC Equipment Carbon Footprint

- Refrigerant emissions are insignificant when compared to the indirect emissions from energy production needed to power HVAC equipment

Indirect emissions

- Annual kWh used
- CO₂ emissions / kWh generated



Direct emissions

- Refrigerant leaks
- Escape during servicing
- Refrigerant not recovered at end-of-life

Energy Efficiency

has the greatest impact on total cost of ownership and environmental impact when it comes to HVAC equipment

Regulations and Legislation

Climate Protection Regulations

EPA SNAP Rules (US only)

- Publishes acceptable and unacceptable refrigerants by end-use

AIM Act (US only)

- HFC phase-down and sector-based mandates

Montreal Protocol

- Ratified in 1987 – addresses Ozone depleting substances (CFCs, HCFCs)

EPA SNAP Rules

- 2015-2016 – Looks at Ozone depleting substances and alternates

Kigali Amendment

- Targets Global Warming and HFCs (85% reduction by 2047*)

Paris Accord

- Limits global warming to <2°C (preferably <1.5°C) by end of century
- Canada ratified in 2016
- The United States formally rejoined on February 19, 2021

HFC Phase Down

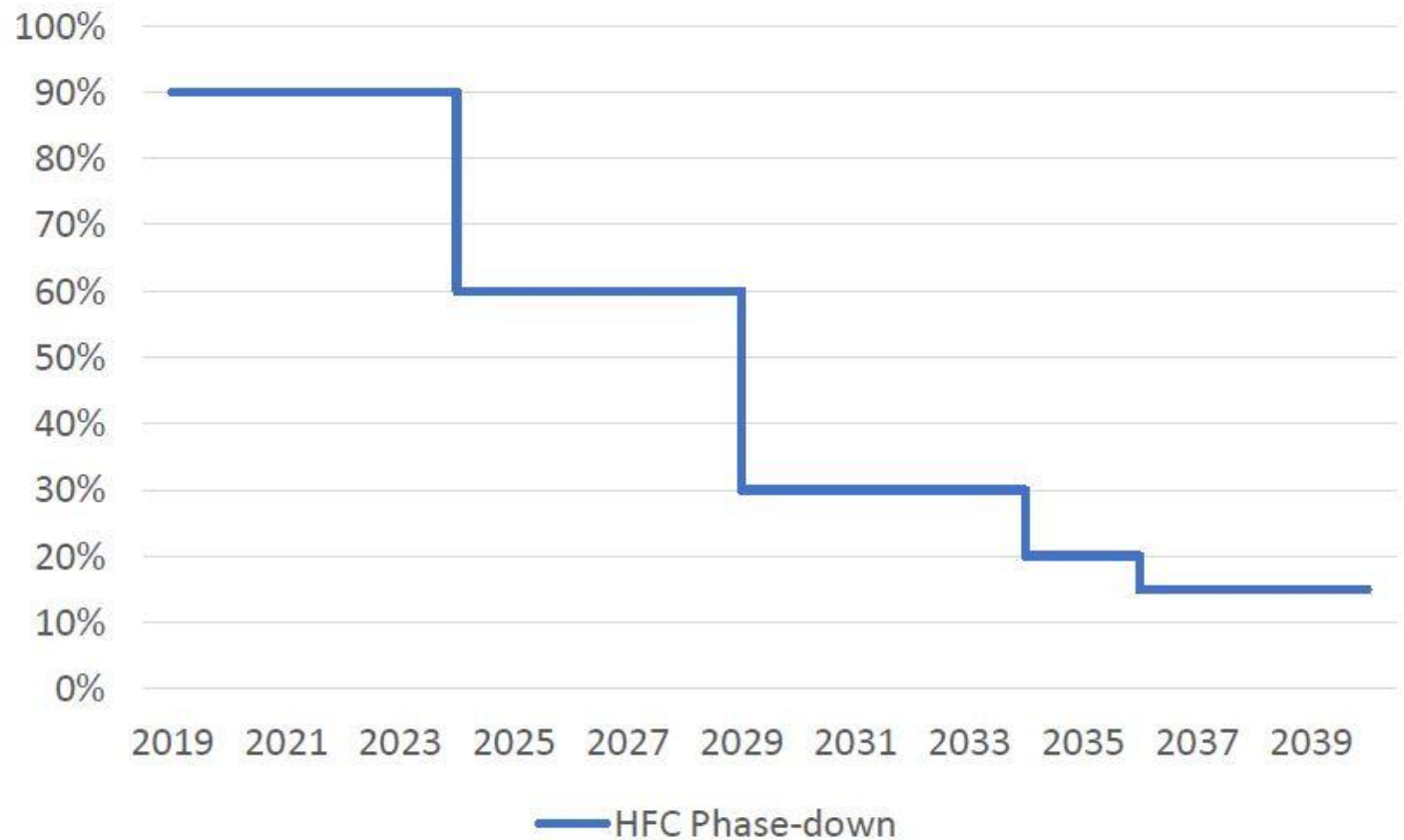
- US: EPA rule: prohibit new manufacturing by 1/2025, sale of equipment 1/2026
- Canada: Implemented HFC sector-based limitations
 - Ex: no new chillers with GWP > 700 after 2024

* 85% HFC reduction by 2036 for Developed Countries, including CAN and USA

HFC Reduction Timeline

The Kigali Amendment to the Montreal Protocol is the driving regulation behind HFC reductions globally based on schedules for developed and developing countries.

Unlike ozone depletion, the Kigali Amendment and Montreal Protocol **allow for continued use and production** of HFCs for beneficial purposes indefinitely where refrigerants **R-22 and R-123 are subject to bans** from future production.



HFC Activity – United States

AIM Act Timeline (passed in 2020)

- EPA now has authority to regulate global warming (only ozone depletion prior)
- The AIM Act's goal is to phasedown 85% of annual HFC production and consumption by 2036. The AIM act HFC phasedown officially began in January 2022
 - January 2022: 10% phasedown
 - January 2024: 40% phasedown
 - January 2029: 70% phasedown
 - January 2034: 80% phasedown
 - January 2036: 85% final phasedown
- HFC Refrigerants: **R-32**, R-125, R-134a, R-410a (composed of equal parts R-32 and R-125), R-143a, and R-152a

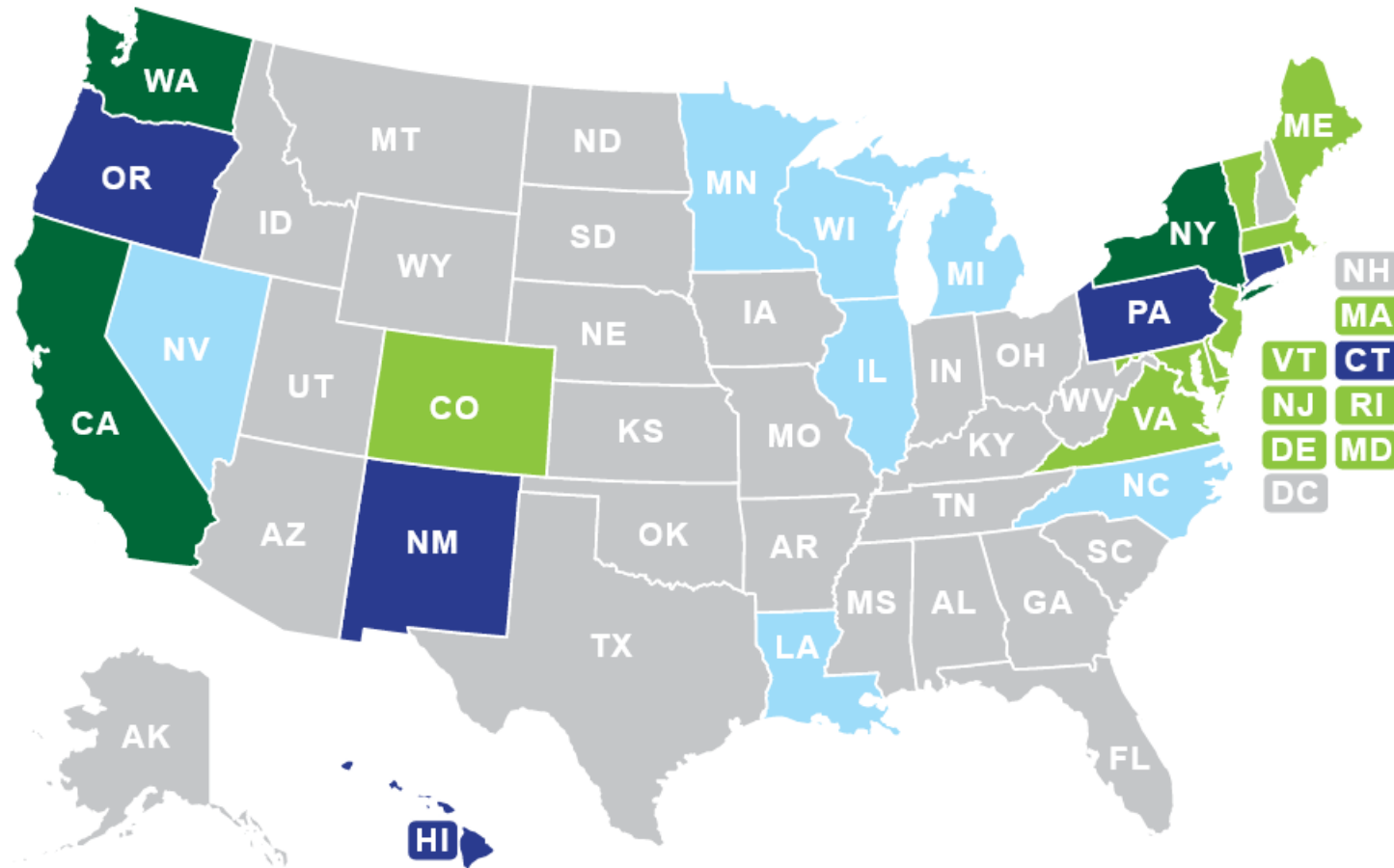


EPA Rule

EPA NOPR (Notice of Public Rulemaking) – Dec. 2022

Sectors and Subsectors	Proposed GWP Limit	Compliance Date
Refrigeration, Air Conditioning, and Heat Pumps		
Residential refrigeration systems	150	January 1, 2025
Chillers – industrial process refrigeration	700	January 1, 2025
Chillers – comfort cooling	700	January 1, 2025
Residential and light commercial air conditioning and heat pump systems	700	January 1, 2025
Residential and light commercial air conditioning – variable refrigerant flow systems	700	January 1, 2026

State HFC Activity – United States



■ SNAP + Additional GWP Limits ■ SNAP 20/21 Signed Into Law ■ SNAP 20/21 Pending
■ US Climate Alliance Member



Map source: nasrc.org

State HFC Activity – United States

California Air Resources Board (CARB)

- Prohibitions on new higher GWP HFCs in stationary ACR applications finalized
 - Rulemaking is now in effect
- A/C – 750 GWP limit for new systems
 - Jan 1, 2023 – Window units and dehumidifiers
 - Jan 1, 2024 – Chillers
 - Jan 1, 2025 – Residential & light commercial systems
 - Jan 1, 2026 – VRF
- Commercial & Industrial Refrigeration
 - Jan 1, 2022 – 150 GWP limit on new systems over 50-lbs
 - Jan 1, 2030 – average GWP of $\leq 1,400$ for food retail stores



Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols-Propellants, and Foam End-Uses Regulation

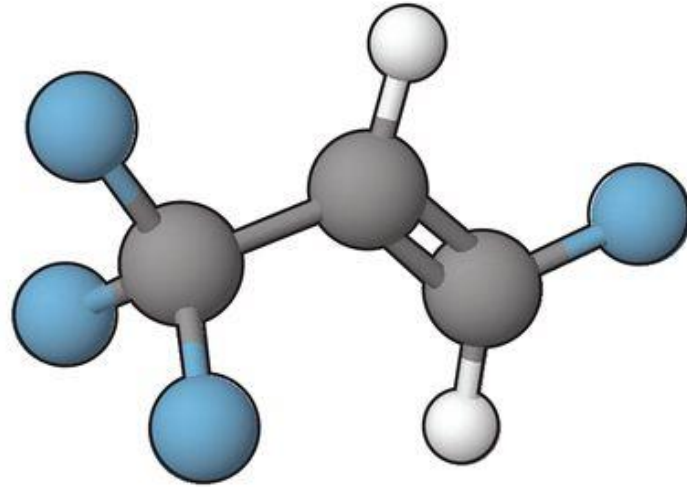
<https://ww2.arb.ca.gov/rulemaking/2020/hfc2020>

Other states

- ~12 other states have finalized or pending HFC regulations
- Some states do not allow storage or pass-through of 'prohibited' substances
- Most states are converging around SNAP Rules from 2016

Refrigerant Nomenclature

R, refrigerant;
composition-designating
prefixes also allowed
such as CFC, HFC, HFO)



R-1234ze (E)

Number of double bonds
(omit for saturated
compounds)

Number of
carbons – 1
(omit if Nc = 1)

Number of
hydrogens + 1

Number
of
fluorines

Isometric
designation
(if applicable)

Conformation
(if applicable);
E, trans; Z, cis

Refrigerant classifications – Safety

Designation		Classification
HCFC	R-22 <small>ODP > 0</small>	A1
HCFC	R-123 <small>ODP > 0</small>	B1
HFC	R-410A	A1
HFC	R-134a	A1
HFC	R-32	A2L
Blend	R-514A	B1
Blend	R-513A	A1
Blend	R-454B	A2L
HFO	R-1233zd	A1
HFO	R-1234ze	A2L

		Toxicity	
		Lower	Higher
Flammability	Higher	A3	B3
	Lower	A2	B2
	Difficult to ignite and sustain	A2L	B2L
	No flame propagation	A1	B1

No identified toxicity at concentrations ≤ 400 ppm

Evidence of toxicity below 400 ppm



Main Refrigerants in Play

GWP

< 4000			■ R404A		
< 2500			▲ R452A ■ R22 ▲ R407A/R407F	■ R410A	
< 1500		■ R134a	▲ R449A ▲ R448A ▲ N20*		
< 750		▲ R450A/N13 ▲ R513A/XP10 ▲ R515	▲ R454A/XL40/DR7 ● L40* ▲ R444B/L20	▲ R32 ▲ R454B ▲ R452B/DR55	
< 150	▲ R514A ▲ R1233zd	▲ R1270 ▲ R1234yf ▲ R1234ze	▲ R454C/XL20/DR3 ▲ R455A/HD110 ▲ R290		■ R744/CO ₂ ■ R717/NH ₃
	R123 like	R134a like	R404A / R22 like	R410A like	Other

Density

Legend

- A1 – Non flammable
- A2L – Mildly flammable
- A3 – Highly flammable
- B2L – Toxic lower flammable
- Old reference refrigerant
- ▲ New and on the market
- Not yet on the market

GWP versus Density (pressure) of the main refrigerant groups

* No ASHRAE name yet

Refrigerant Comparison

	Low Pressure Centrifugal (vs. R-123)	
	R-1233zd	R-514A
GWP	✓ 4.5	✓ 2
Toxicity classification	✓ Low	✗ Higher
Flammability classification	✓ None	✓ None
Efficiency	✓ Highest	✗ Lower
Cost	✗ Higher	✗ High
Footprint	✗ Largest	✗ Largest
Refrigerant producers (global)	✓ Multiple	✗ One
Chiller manufacturers (global)	✓ Multiple	✗ One
Adjacent industry use	✓ Foam blowing	✗ None



Refrigerant Comparison

	Low Pressure Centrifugal (vs. R-123)		Medium Pressure Centrifugal and Screw Chillers, Packaged Units, Splits (vs. R-134a)			
	R-1233zd	R-514A	R-134a	R-513A	R-1234ze	R-515B
GWP	✓ 4.5	✓ 2	✗ 1430	✓ 631	✓ 7	✓ 293
Toxicity classification	✓ Low	✗ Higher	✓ Low	✓ Low	✓ Low	✓ Low
Flammability classification	✓ None	✓ None	✓ None	✓ None	✗ Mild	✓ None
Efficiency	✓ Highest	✗ Lower	✓ Highest	✗ Lower	✗ Lower	✗ Lower
Cost	✗ Higher	✗ High	✓ Lowest	✗ Higher	✗ Higher	✗ Higher
Footprint	✗ Largest	✗ Largest	✓ Smaller	✓ Smaller	✗ Larger	✗ Larger
Refrigerant producers (global)	✓ Multiple	✗ One	✓ Multiple	✓ Multiple	✗ One	✗ One
Chiller manufacturers (global)	✓ Multiple	✗ One	✓ Multiple	✓ Multiple	✓ Multiple	✓ Multiple
Adjacent industry use	✓ Foam blowing	✗ None	✓ Industrial AC, foam, refrigeration	✓ Industrial and commercial refrigeration	✓ Heat pumps, vending machines, refrigerators	✓ Heat pumps, vending machines, refrigerators



Refrigerant Comparison

	Low Pressure Centrifugal (vs. R-123)		Medium Pressure Centrifugal and Screw Chillers, Packaged Units, Splits (vs. R-134a)				High Pressure Scroll Chillers, VRF, Packaged Units, Splits (vs. R-410A)		
	R-1233zd	R-514A	R-134a	R-513A	R-1234ze	R-515B	R-410A	R-454B	R-32
GWP	✓ 4.5	✓ 2	✗ 1430	✓ 631	✓ 7	✓ 293	✗ 2088	✓ 466	✓ 675
Toxicity classification	✓ Low	✗ Higher	✓ Low	✓ Low	✓ Low	✓ Low	✓ Low	✓ Low	✓ Low
Flammability classification	✓ None	✓ None	✓ None	✓ None	✗ Mild	✓ None	✓ None	✗ Mild	✗ Mild
Efficiency	✓ Highest	✗ Lower	✓ Highest	✗ Lower	✗ Lower	✗ Lower	✓ High	✓ High	✓ High
Cost	✗ Higher	✗ High	✓ Lowest	✗ Higher	✗ Higher	✗ Higher	✓ Lowest	✗ Higher	✗ Higher
Footprint	✗ Largest	✗ Largest	✓ Smaller	✓ Smaller	✗ Larger	✗ Larger	✓ Smaller	✓ Smaller	✓ Smaller
Refrigerant producers (global)	✓ Multiple	✗ One	✓ Multiple	✓ Multiple	✗ One	✗ One	✓ Multiple	✓ Multiple	✗ One
Chiller manufacturers (global)	✓ Multiple	✗ One	✓ Multiple	✓ Multiple	✓ Multiple	✓ Multiple	✓ Multiple	✓ Multiple	✓ Multiple
Adjacent industry use	✓ Foam blowing	✗ None	✓ Industrial AC, foam, refrigeration	✓ Industrial and commercial refrigeration	✓ Heat pumps, vending machines, refrigerators	✓ Heat pumps, vending machines, refrigerators	✓ Industrial AC, foam, refrigeration	✓ Heat pumps, vending machines, refrigerators	



GWP values are per the Fourth Assessment Report (AR4) of the IPCC

Natural refrigerants



R-717

(Ammonia)

- Toxicity restricts where it can be used – leaks would be a problem (PPE, insurance requirements. etc.)
- It's corrosive to copper!



R-290

(Propane)

- Highly flammable
- Outdoor application
- Site use or acceptance limitations



R-718

(Water)

- Great when using waste energy
- Higher cost
- Physical dimensions can limit use



R-744

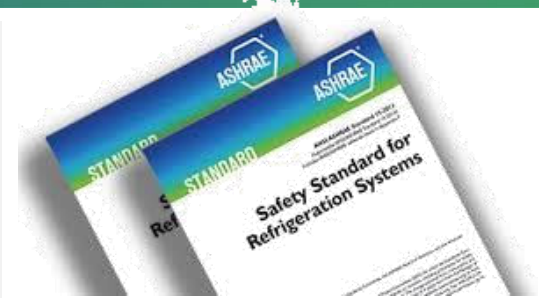
(Carbon Dioxide)

- Low-temp two-stage freezer systems
- Higher cost (2-3x more)
- Condensing temperatures not practical for comfort cooling
- High energy consumption

Natural refrigerants sound like a great solution, but also come with challenges or barriers to entry (or limitations) into commercial applications

What Owners, Engineers, Distributors and Contractors can do

- **Support A2L Code Adoption at the local, state level & national levels**
 - Facilitate a single, national transition on 1/1/2025
- **Designers - Review UL 60335-2-40 (3rd edition) – look at 4th edition proposals**
 - Be prepared for customer questions regarding Low GWP, R410A “drop-ins” (there aren’t any...)
- **Become familiar with ASHRAE 15 & 15.2P** (released Oct. 2022)
 - Engineers & Contractors must calculate conditioned space volumes and total charge sizes for A2L’s
- **[Review AHRI Safe Refrigerant Transition Task Force \(SRTTF\) materials](#)**
 - <https://www.ahrinet.org/saferefrigerant>
 - A2L research and test results, best practices, etc.



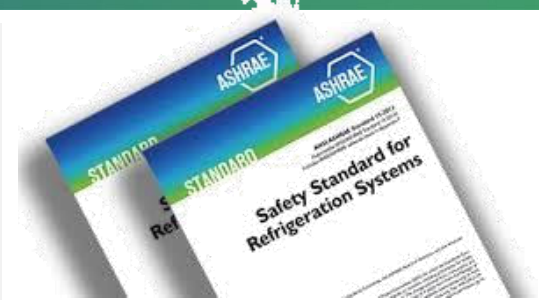
Equipment safety standard UL 1995 will be replaced with UL 60335-2-40

- **UL 1995** sunsets in 2024
 - Does not address A2L refrigerants
 - Existing products without changes remain under UL 1995
- **UL 60335-2-40** addresses the inclusion of A2L fluids for new buildings
 - Used in conjunction with ASHRAE 15, industry can piece together how A2L fluids are to be used within building.
 - Implications to equipment design, testing and validation are complicated
 - Standard addresses leakage, flammability tests



What Owners, Engineers, Distributors and Contractors can do

- **Ensure training occurs on the safe use and handling of A2L's**
 - [ACCA A2L Refrigerant Training](#)
- **Strengthen current refrigerant management practices**
 - [Ensure EPA 608 certification](#)
 - Implement a cylinder exchange program that will specifically address A2L's
 - Avoid mixing recovered refrigerants in the same cylinder; mixed fluids have less value...
 - Confirm your paperwork / documentation processes (systems < 50 lbs charge will ultimately fall into scope)
- **Establish suppliers for reclaim R-410A well prior to 2024...**



North America chiller product overview (York)

North America Johnson Controls Equipment Next Generation Refrigerants

SCROLL CHILLERS, DUCTED	SCREW	CENTRIFUGAL
R-410A ➔ R-454B	R-134a ➔ R-1234ze R-515B R-513A	R-134a ➔ R-1234ze R-515B R-513A
		
VRF R-410A ➔ R-32	ABSORPTION R-718 (water)	YZ R-1233zd
		

North America Manufacturers

LG does not have an official statement on the refrigerant change.

However, they are using R-32 in Europe currently and are designing the next generation of VRF systems so that it will start out as R-410a and be able to be converted to R-32.

Multistack is transitioning in 2024 to multiple refrigerants dependent on chiller type.

- MagLev (magnetic bearings)
 - R-1234ze (30% derate from R-134a)
 - R-513A (R-1234yf / R134a blend) - drop in for R-134an with no capacity reduction
 - R-515B
- Scroll
 - R-454B

Johnson Controls has selected R-454B to replace R-410A in its ducted residential and commercial unitary products as well as air-cooled scroll chillers.

AAON & Desert Aire have decided to move to R-454B as well.



North America Manufacturers

Trane will introduce R-454B across the entire scroll compressor portfolio.

Depending on the product portfolio and compressor technology, Trane will offer units with R-513A, R-514A, R-1234ze and R-1233zd(E).

Daikin makes R-32 – and have now applied it to air conditioners and their single zone, ductless systems and VRF.

Carrier has identified R-454B, to be known commercially as Puron Advance™, as its primary solution to replace R-410A in all of its ducted residential and light commercial packaged solutions sold in North America.

R-32 Refrigerant will replace R-410A for Carrier Commercial Scroll Chillers.



Conversion Challenges

- **Building codes** must adopt the use of these low-flammability refrigerants. They are not eligible to be revised until 2024 (they are on 3 year cycle and were revised in 2021)
- A new **UL safety standard** (UL 60335-2-40) is required for the new refrigerant as the previous standard UL1995 does not address the requirements around refrigerant flammability and it has been determined that units containing A2L refrigerants cannot be listed under this standard.
- Component OEMs will be **introducing their new products in steps**, so not all component sizes will be available at the same time.
- Individual model's **performance and efficiency ratings** will be slightly different.



Conversion Challenges

- **Refrigerant availability** will be limited until the new production facilities become fully operational.
- Contractors must be **trained to handle** the new low-flammability refrigerants.
- US DOT still creating rules around **hazmat drivers** (based on lbs of refrigerant) and placards on all units



Summary

- **The Transition is Underway** – Lower GWP Refrigerant Options Available & Expanding
- **Smooth Transition Likely:** Phasedown Successfully Underway in Other Countries (EU & Japan)
- Remember – Flammables are Flammable No Matter the ASHRAE Classification (Class 2L, 2 and 3)
- **Standards and Building Codes** must be ready by 2024 to support the transition
- Expect more product fragmentation by refrigerant. A single refrigerant may not be used from small to large capacity products.
- Reaching final GWP goals (>85%↓) requires more refrigerant technology innovation.



Resources around Refrigerant Regulation and Updated Standards

- EPA Final Rule for Phasedown of HFCs
<https://www.epa.gov/climate-hfcs-reduction/final-rule-phasedown-hydrofluorocarbons-establishing-allowance-allocation>
- ASHRAE Higher-Flammability Refrigerants Addressed in Updated Standards
<https://www.ashrae.org/news/esociety/new-refrigerants-higher-flammability-refrigerants-addressed-in-updated-ashrae-standards-15-34>
- ASHRAE Position Document on Climate Change
<https://www.ashrae.org/file%20library/about/position%20documents/ashrae-position-document-on-climate-change.pdf>
- AHRI Fact Sheet on AIM Act
https://ahrinet.org/App_Content/ahri/files/Resources/AHRI_AIM_Act-one_pager.pdf
- Climate Alliance States map - <https://nasrc.org/hfc-policy>