AIR EQUIPMENT COMPANY

EXPERTS HELPING EXPERTS

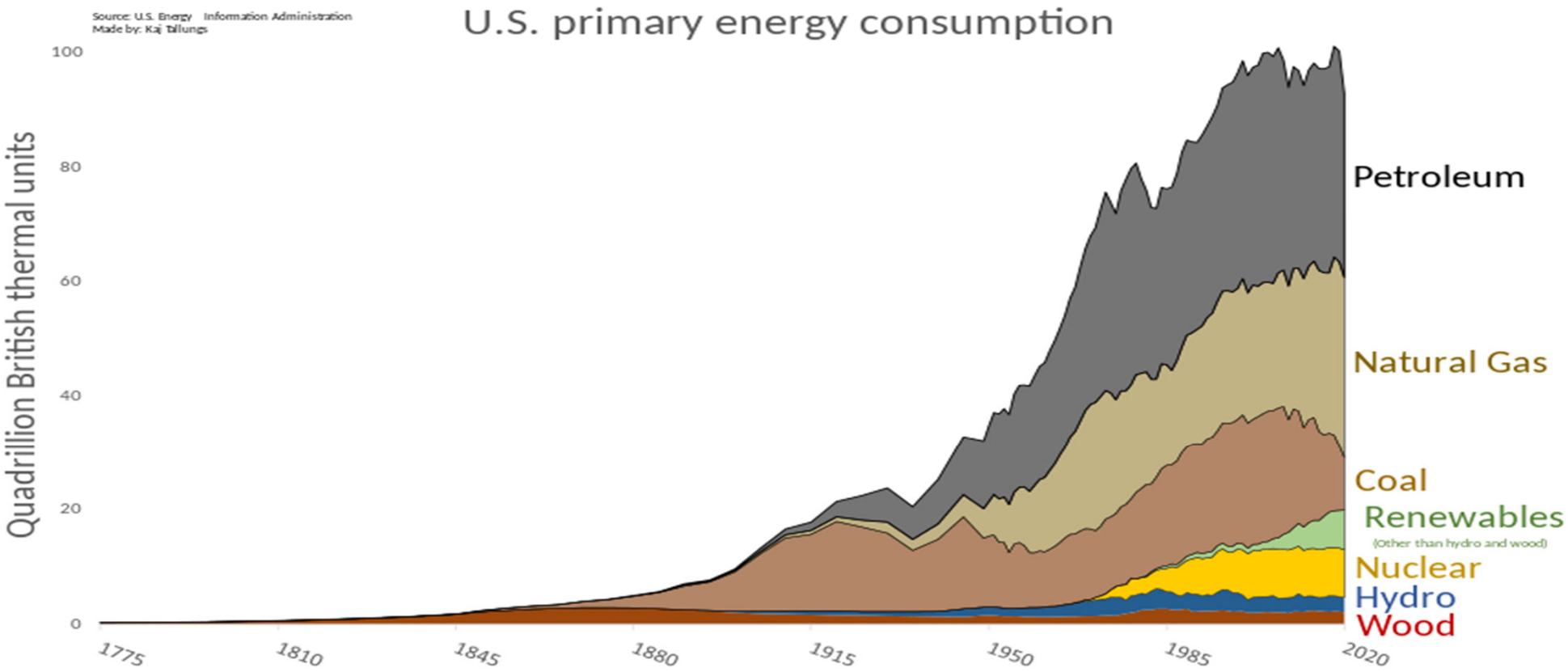
The Experts in Providing and Maintaining Healthy Environments

Serving Kentucky and Southern Indiana for 76 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

The Electric Power Sector will continue to Decarbonize



How will the Building Sector continue to Decarbonize?

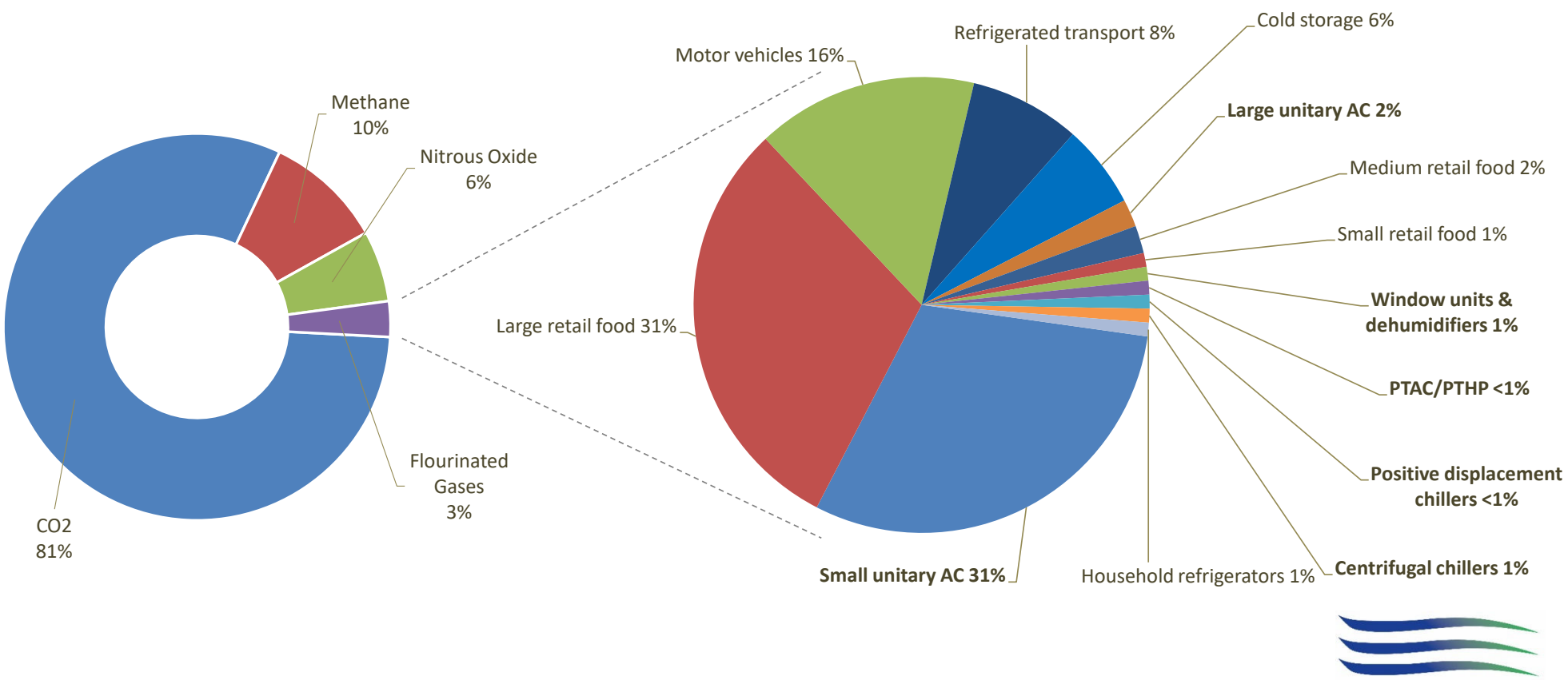
ENERGY EFFICIENCY

CLEAN GRID

ELECTRIFICATION

- Shifting from fossil fuel combustion to electric end-uses
- Can include:
  - Space Heating
  - Water Heating
  - Cooking

Global HFC emissions by application type
% of GWP-weighted emissions



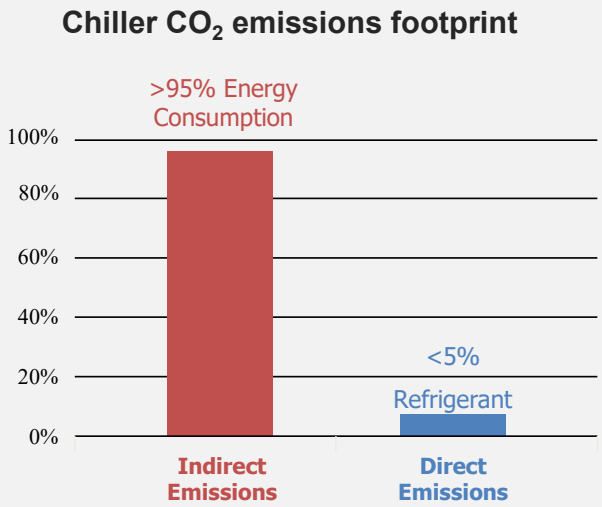
Source: US EPA, Global Mitigation of Non-CO2 Greenhouse gases: 2010-2030. September 2013, EPA-430-R-13-011

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
- CO_2 emissions / kWh generated



Direct emissions

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

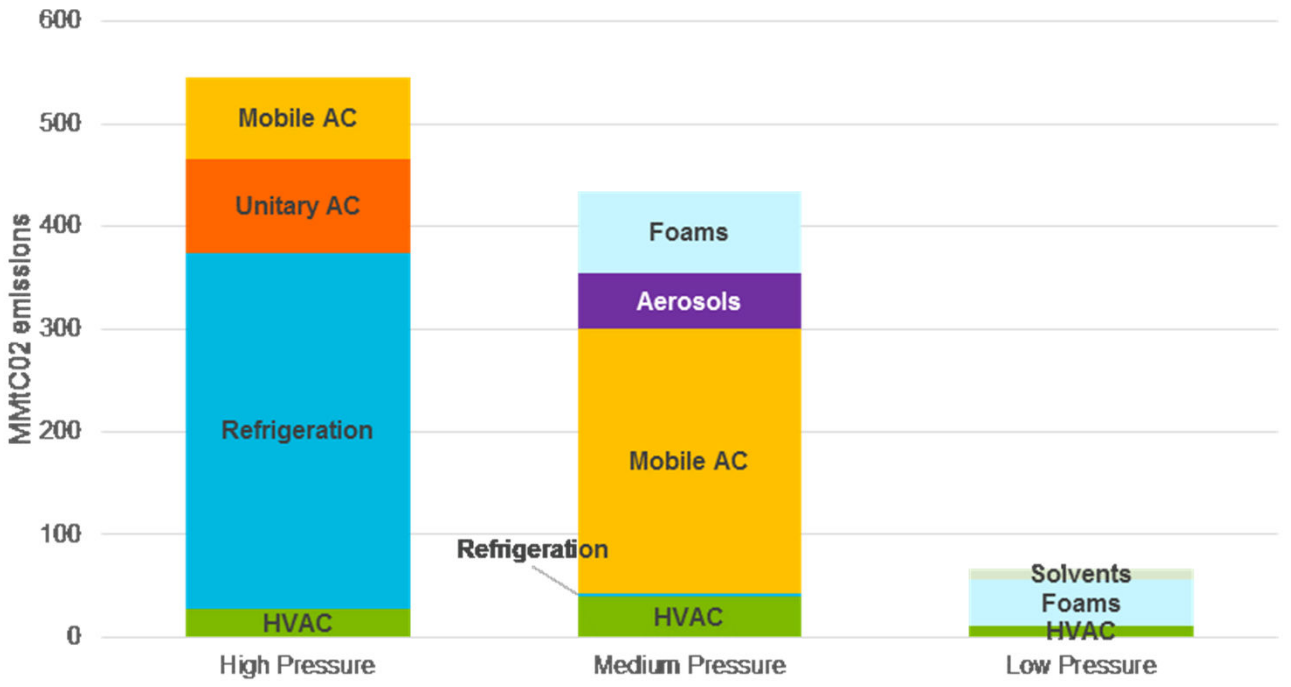
Energy Efficiency

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

Emissions by sector – HFC Consumption

Industry Sector Emissions

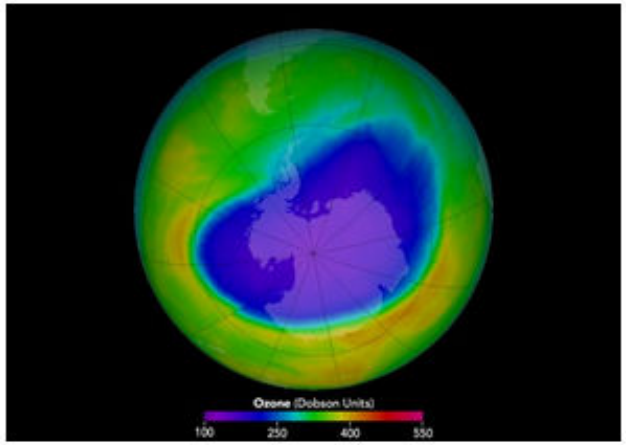
- Regulations focus on the highest emitting industry sectors
- HVAC is a much smaller contributor due to responsible use practices and maintenance



Source: U.S. EPA

Phase *Out* and Phase *Down* History

Ozone Depletion Potential (ODP)

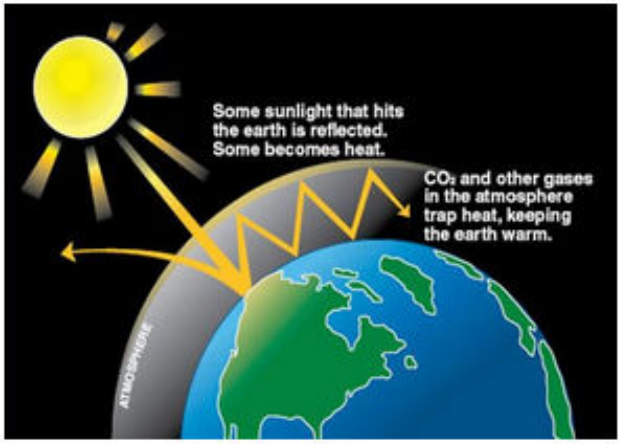


Phase OUT of CFCs & HCFCs

(Ozone Depleting - Higher GWP)

Montreal Protocol

Global Warming Potential (GWP)



Phase DOWN of HFCs

(Non-ozone Depleting – High GWP)

Kigali Amendment

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

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

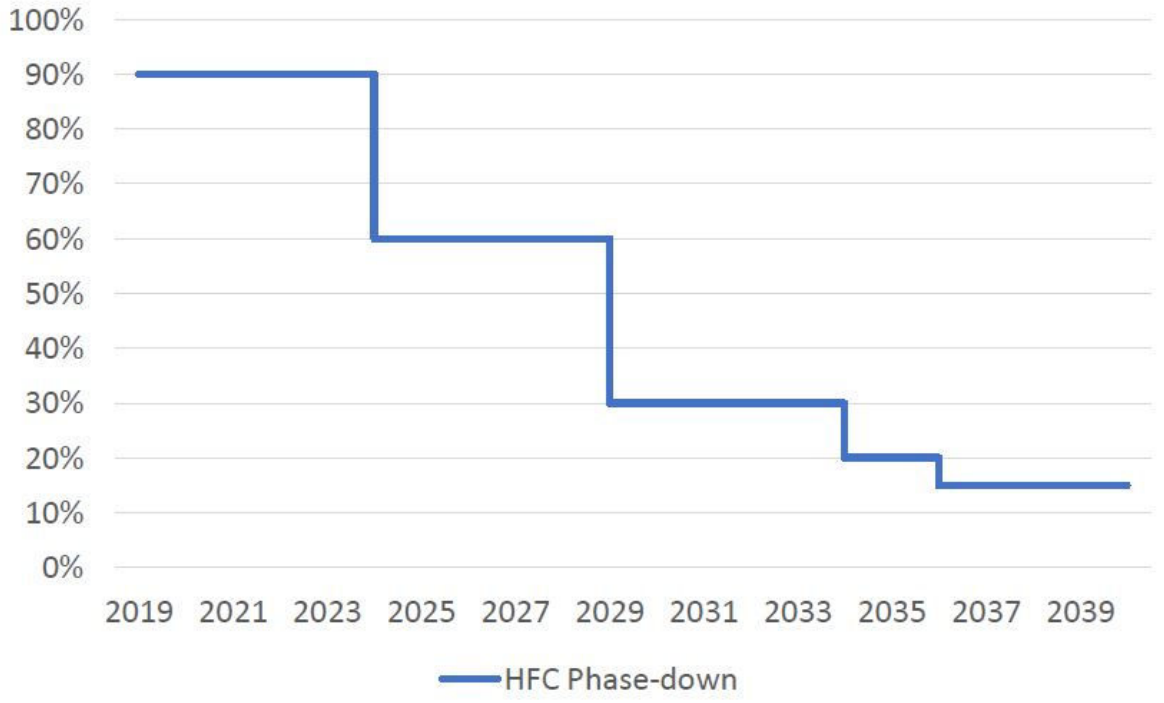
- US: EPA published HFC production and consumption cap
- Canada: Implemented HFC sector-based limitations
  - Ex: no new chillers with GWP > 750 in 2025

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

Driving regulation behind HFC reductions

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.



State HFC activity – United States only

California Air Resources Board (CARB)

- Prohibitions on new higher GWP HFCs in stationary ACR applications finalized
  - Rulemaking is now in effect

CALIFORNIA AIR RESOURCES BOARD

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

- 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 ≤ 1,400 for food retail stores

Other states

- ~10 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

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

HFC activity – United States only

AIM Act Timeline

- 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

North America regulations and legislation

Global Warming Protection

121 countries + the EU have ratified the Kigali Amendment

- Canada ratified in November 2017
- United States has NOT ratified…yet

Kigali Amendment to the Montreal Protocol

- Targets HFC refrigerants and Global Warming Potential (GWP) level of refrigerants
- Defines a 15-year phase-down schedule of HFCs through 2036
  - Includes phase-down of R-134a and R-410A
- Impacts Chiller, Ducted Systems, Industrial Refrigeration and VRF new products
- The United States must ratify before 2033 for international cooperation
- **Biden administration has declared its commitment to ratify the Kigali Amendment**
- Significant industry support for Kigali Amendment ratification

Three factors to reduce HVAC equipment carbon footprint

1

Design, specify or buy high efficiency equipment and systems

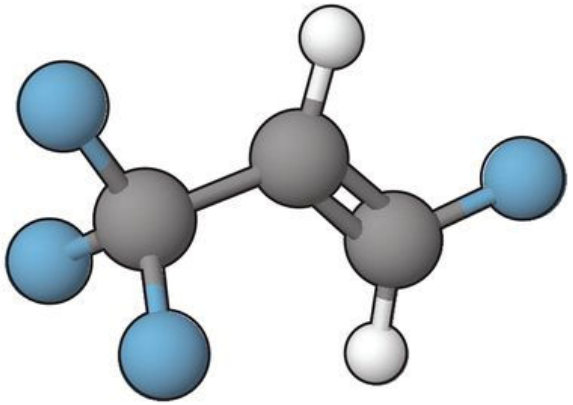
2

Maintain equipment for ultimate performance and leak prevention

3

Choose sustainable refrigerants

Refrigerant Nomenclature



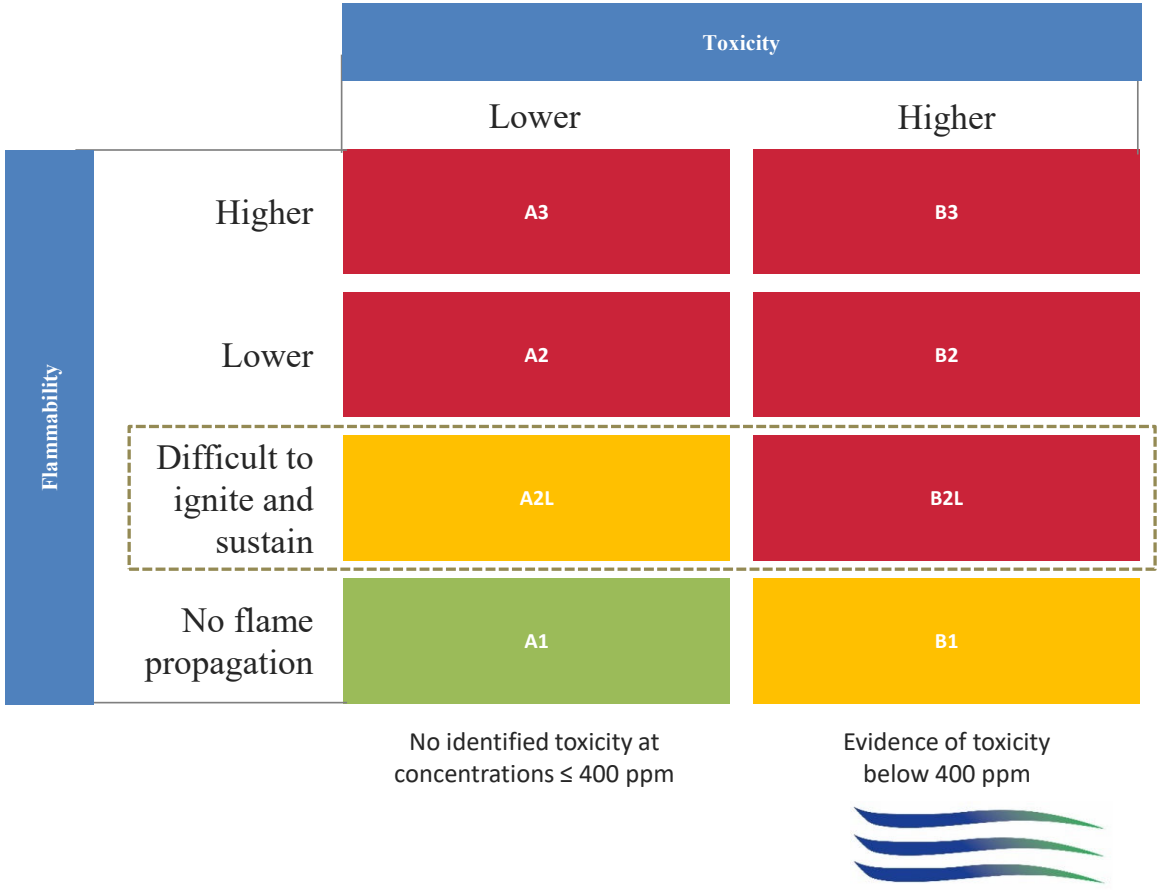
R, refrigerant; composition-designating prefixes also allowed such as CFC, HFC, HFO)

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 ODP > 0*	*A1*
HCFC	*R-123 ODP > 0*	*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



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

GWP versus Density (pressure) of the main refrigerant groups
* No ASHRAE name yet

Legend

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

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

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

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

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

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

R-290

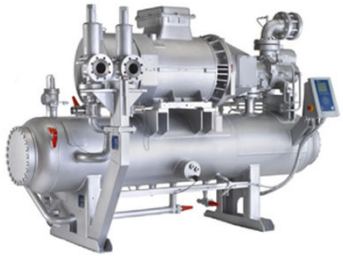
(Propane)

- 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
- 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

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

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
- **Engineers – 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** (when finalized)
  - 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.
- **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 R410A well prior to 2024…**

AHRI
Air-Conditioning, Heating and Refrigeration Institute

ACCA
Air Conditioning Contractors of America

United States Environmental Protection Agency
EPA-608 Certified HVAC Technicians

North America chiller product overview (YORK)

Scroll

R-410A
15 to 230 tons

R-454B – future availability

Screw

R-134a
120 to 500 tons

R-513A as retrofit

Centrifugal

R-134a
125 to 6000 tons

R-513A as retrofit

Absorption

R-718 (water)
30 to 4000 tons

R-1233zd

165 to 2020 tons

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 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-134anwith 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.

Desert Aire has 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.

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.
- 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.
- Refrigerant availability will be limited until the new production facilities become fully operational.
- Contractors must be trained to handle the new low-flammability refrigerants.