BUILDINGENERGY BOSTON

ASHPs & VRF: How About These HFC Refrigerants?

Thursday, May 21, 2020

The webinar will begin at 11:00am.

Brought to you by:

NESEA

Sponsored by:

DAIKIN

ASHPs & VRF

A discussion on refrigerants

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Economics

Environment

Health & Safety

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Pre-reqs

- **OK with doing a bit of follow-up research**
- **Desire to create your own <u>educated</u> opinion**
- **Don’t let a little high school chemistry scare you**

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Agenda

- Why do we care
- Carbon, CFCs, HCFCs, ODP & the Montreal Protocol
- HFCs and refrigerant classification
- Global, Federal and State level HFC phasedowns
- The ‘Low GWP A1’ challenge & LCCP impacts
- Getting A2L into buildings codes
- R-32: the original and the future A2L low GWP refrigerant

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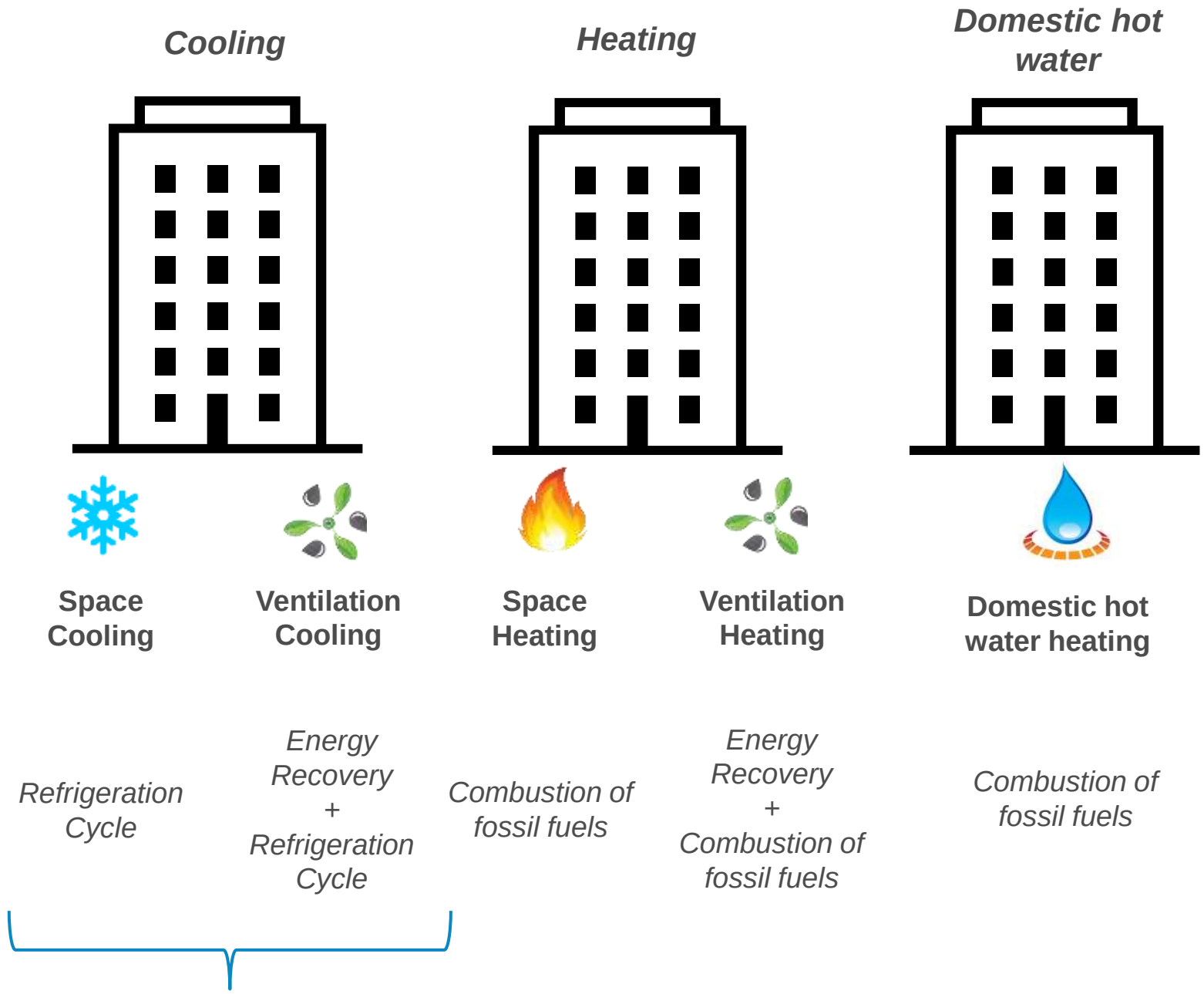
Buildings Today (yesterday)



Refrigerants are already used in most buildings.
If a building has AC, it has refrigerants somewhere.

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Why do we care?

As energy efficiency, sustainability and climate activists, why do we care about refrigerants?

1

Refrigerants can have environmental, health & safety and economical impacts.

We care about rules and regulations around them, including timely phase downs when required.

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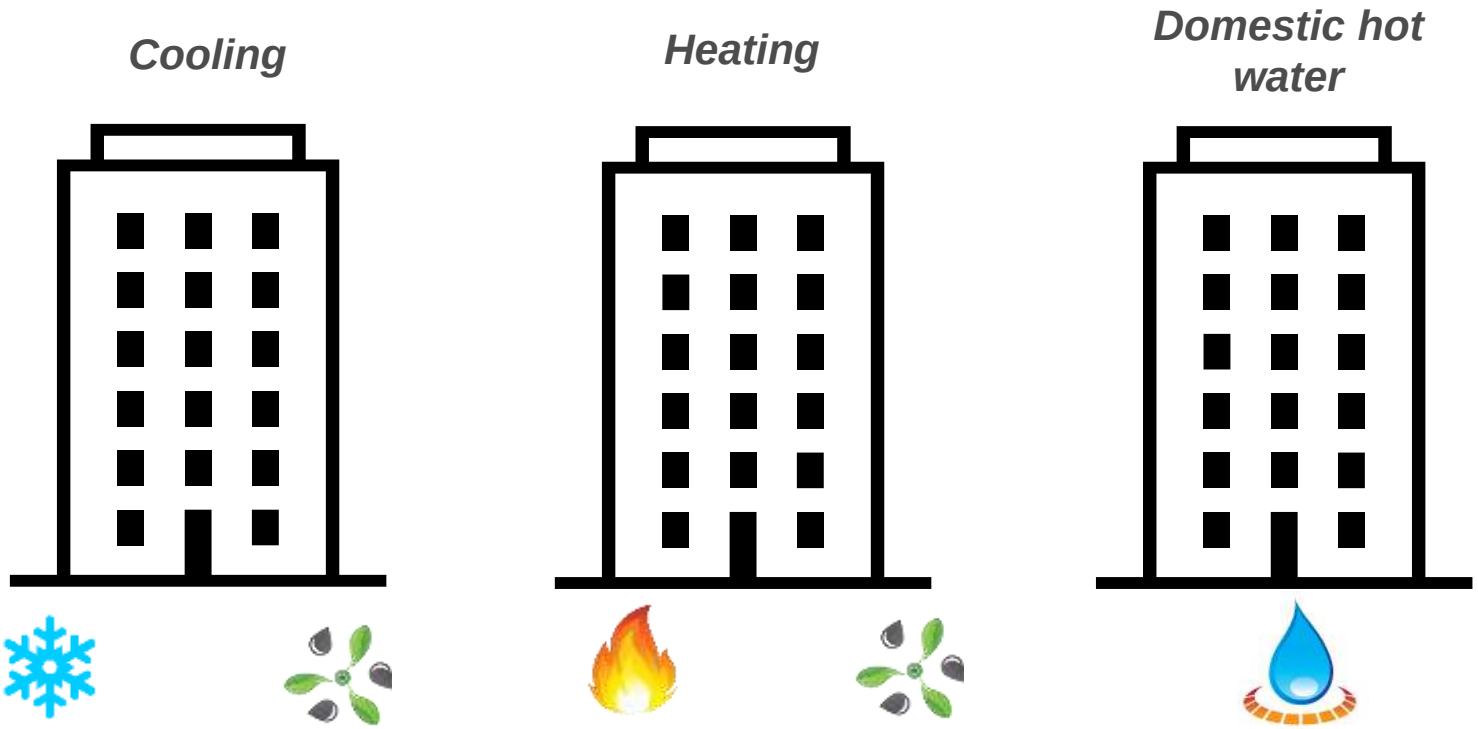
Buildings Tomorrow



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Why do we care?

As energy efficiency, sustainability and climate activists, why do we care about refrigerants?

1

Refrigerants can have environmental, health & safety and economical impacts.

We care about rules and regulations around them, including timely phase downs when required.

2

Leading technologies to electrify buildings (ASHPs, VRV) now introduce refrigerant throughout the building.

We care about ensuring phase down plans leave sustainable options for refrigerants that can be run through buildings.

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Carbon

Atomic no. 6
4 valence electrons
Looking for 4 bons

CO_2

O = C = O

Carbon Dioxide
R-744

GWP: 1

The Global Warming Potential metric (GWP)

- How much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to 1 Ton of CO2.
- The time period used is usually 100 years.
- GWP is NOT a measure of efficiency

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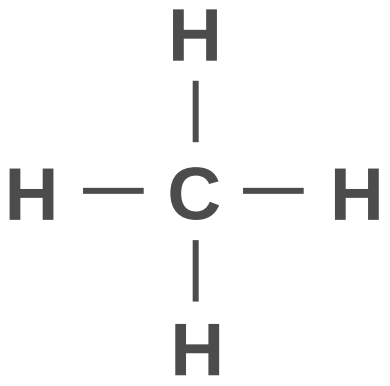
Carbon based chemicals

CO_2

Carbon Dioxide
R-744

GWP: 1

CH_4

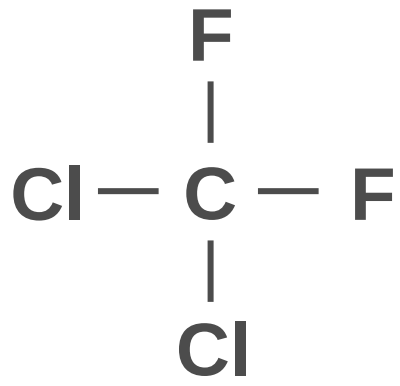


Methane
Natural Gas
R-50

GWP: 28 [AR5[1]]

Estimates up to 105[2]

CCl_2F_2



Di Chloro Fluoro Methane
Freon
R-12

GWP: 10,200 [AR5[1]]

Combustion of methane

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

117 lbs of CO_2 per mmBTU

1. GPW values from the IPCC 5th assessment report, 2014 [AR5 values]. https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf
2. Improved Attribution of Climate Forcing to Emissions. *Science* 30 Oct 2009: Vol. 326, Issue 5953, pp. 716-718 Drew T. Shindell*, Greg Faluvegi, Dorothy M. Koch, Gavin A. Schmidt, Nadine Unger, Susanne E. Bauer https://science.sciencemag.org/content/326/5953/716

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Refrigerant Naming Convention

Series

Series	Description
000	Methane Based
100	Ethane Based
200	Propane Based
300	Cyclic Organic Compounds
400	Zeotropes
500	Azeotropes
600	Organic Compounds
700	Inorganic Compounds
1000	Unsaturated Organic Compounds

R-50: Methane

R-290: Propane

R-410a: Mixtures

R-718: H_2O

Rule of 90 (add 90)

R-12

12 + 90 = 102

1 0 2

1 x Carbon atom

0 x Hydrogen atoms

2 x Florine atoms

CCl_2F_2

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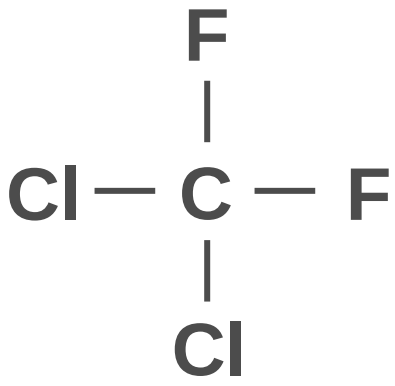
CFCs
HCFCs

Evil Chlorine

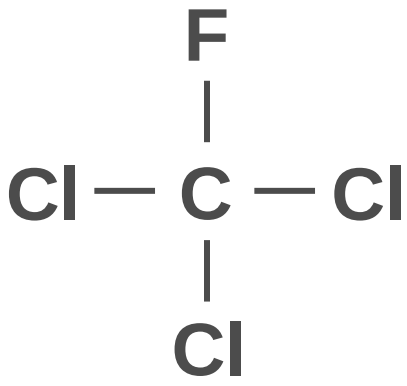
CCl_2F_2



Di Chloro Fluoro Methane
R-12

GWP: 10,200 [AR5[1]]

CCl_3F

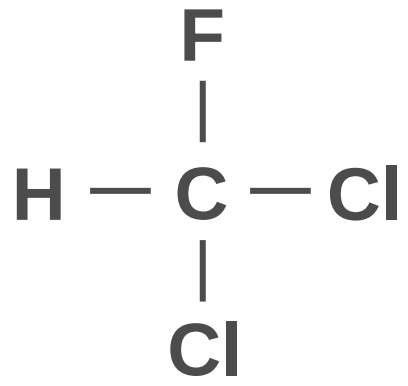


Tri Chloro Fluoro Methane
R-11

GWP: 4,660 [AR5[1]]

Chloro Fluoro Carbons [CFCs]

$CHClF_2$

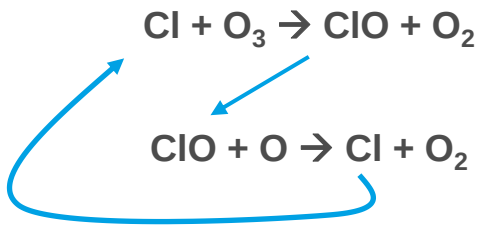


Chloro Di Fluoro Methane
R-22

GWP: 1,760 [AR5[1]]

Hydro Chloro Fluoro Carbons [HCFCs]

Stable molecules with long life cycles.
Carbon-Chlorine bond is broken up by sunlight radiation.
Chlorine molecule reacts with ozone (O_3)



Repeat up to 100,000 times

1. GPW values from the IPCC 5th assessment report, 2014 [AR5 values]. https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

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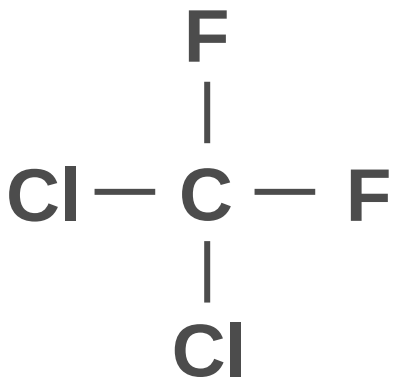
ODP

CCl_2F_2

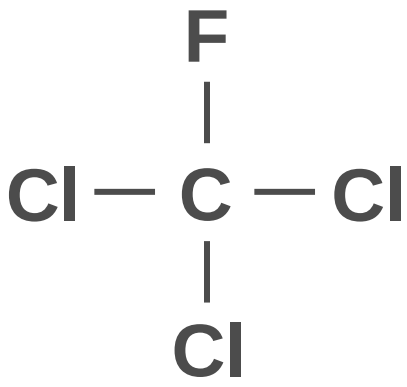


Di Chloro Fluoro Methane
R-12

GWP: 10,200 [AR5[1]]

ODP: 1

CCl_3F

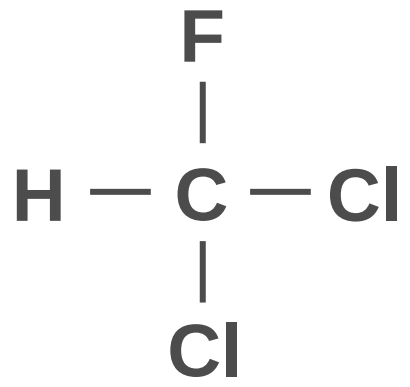


Tri Chloro Fluoro Methane
R-11

GWP: 4,660 [AR5[1]]

ODP: 1

$CHClF_2$



Chloro Di Fluoro Methane
R-22

GWP: 1,760 [AR5[1]]

ODP: 0.055[2]

Ozone Depletion Potential (ODP) – Effectiveness of a given compound in removing ozone, relative to R-11, at steady state.

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1. GPW values from the IPCC 5th assessment report, 2014 [AR5 values]. https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

The Montreal Protocol

(ODS)

"The Montreal Protocol to protect the Earth's ozone layer is to date the only United Nations environmental agreement to be ratified by every country in the world. It is also one of the most successful".[1]

1985

- Atmospheric ozone over Antarctica's Halley Bay dropping precipitously
- NASA analyzing an 'ozone hole' the size of the US over Antarctica

1987

- Montreal Protocol on Substances that Deplete the Ozone Layer was adopted
- Large US involvement (Reagan) in encouraging other countries to adopt
- Goal: Phase out CFC and HCFC refrigerants (containing Chlorine)

1996

- 100% Phase out of CFCs (and other chemicals) [R-11] [R-12]

2010

- No production or import of R-22 (except for equipment built before Jan 1, 2010)

2020

- No production or import of R-22
  - Recycled only
  - Drop-ins available such as Bluon R-458a

1. https://www.unenvironment.org/news-and-stories/story/thirty-years-what-montreal-protocol-doing-protect-ozone

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Illegal trade of R-22

iPIC system helps prevent an illegal shipment of 72 tonnes of HCFC-22

NEWS / 22 APRIL 2020

An information sharing platform known as the informal Prior Informed Consent (iPIC) system is helping countries enforce the work of the Montreal Protocol. Recent collaboration between China and Thailand using the iPIC system, for example, has resulted in the prevention of a huge consignment of ozone-depleting and climate damaging hydrochlorofluorocarbons (HCFCs). iPIC is a voluntary and informal mechanism of information exchange on intended trade between countries in controlled substances. This case shows that iPIC can be an important tool to weed out any unauthorised trade (intentional or unintentional) to support the licensing system for import and export of ozone depleting substances and hydrofluorocarbons (HFCs) and mixtures containing these substances. To find out more click here

https://ozone.unep.org/ipic-system-helps-prevent-illegal-shipment-72-tonnes-hcfc-22

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Refrigerant Classification

ASHRAE 34

ASHRAE Standard 34 – Designation and Safety Classification of Refrigerants

Higher Flammability	A3	B3
Lower Flammability	A2	B2
	A2L*	B2L*
No Flame Propagation	A1	B1
	Lower Toxicity	Higher Toxicity

Toxicity

- Toxicity “A” & “B”
- “B” not generally accepted
- Occupational Exposure Limit (OEL) > 400 ppm by volume is classified as “A”

Flammability

- All refrigerants can be combusted when put into a high-energy situation such as a fire

- Class 1: no flame propagation (at testing standard of 140F)
  - Class 2 & 3 have flame propagation
- Class 2: lower flammability
- Class 3: higher flammability (LFL < 0.10 kg/m3 or Heat of Combustion HOC > 19 kJ/g)

*New flammability subclass for A2 refrigerants that burn very slow
A2L have slow velocities; <10 cm/sec ~ 20ft/minute

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Refrigerant Classification

ASHRAE 15

ASHRAE Standard 15 – Safety Standard for Refrigeration Systems

- Application standard with a focus on health & safety
- Version currently followed by U.S. building codes includes:

> **7.5.2 Applications for Human Comfort**. Group A2, A3, B1, B2, and B3 refrigerants shall not be used in high-probability systems for human comfort.

refrigerant coils in air stream = 'high probability systems'

What can we use for VRV / ASHP systems?

A1

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Refrigerant Classification

ASHRAE 15

RCL

- Introduces Refrigerant Concentration Limit (RCL) to ensure safety in case of a complete refrigerant discharge in the smallest occupied space
  - Analyzes toxicity, oxygen deprivation and flammability
  - Worse case maximum concentration determines the RCL

- R-410a
  1. Low toxicity
  2. No flame propagation at 140F
  3. Oxygen deprivation determines the RCL
  - RCL of R-410a = 26 lbs / mcf

Oxygen Percentage Available	Symptoms	Altitude equivalent [ft] Of effective oxygen %
21	Normal conditions, no effect.	0
19.5	OSHA oxygen-deficient atmosphere.	2,000
17	Muscular impairment, rapid breaths.	5,500
12	Dizziness, headache, rapid fatigue.	14,500
9	Unconsciousness.	22,000
7 to 6	Death within a few minutes.	29,000

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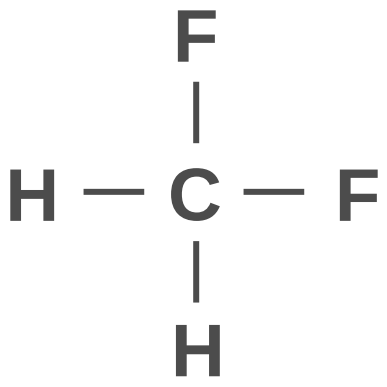
Introducing: HFCs

CH_2F_2



Di Fluoro Methane
R-32

GWP: 677 [AR5[1]]

ODP: 0

Hydro Fluoro Carbons

- No Chlorine
- Relatively low GWP: 677
- Zero ODP

1. GPW values from the IPCC 5th assessment report, 2014 [AR5 values]. https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

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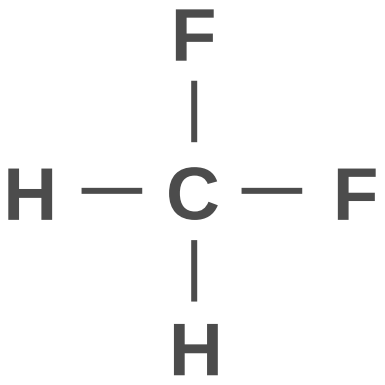
HFCs

CH_2F_2



Di Fluoro Methane
R-32

GWP: 677 [AR5[1]]

ODP: 0

- Increasing Hydrogen atoms increases flammability
- R-32 is NOT an A1 refrigerant (A2L)
- Therefore, since 1991, we've been mixing R-32 with a fire suppressant called R-125…

Introducing R-410a

- 50% R-32 / 50% R-125
- 400 series Zeotropic mixture
- ODP of 0 (no Chlorine)
- But, GWP of our fire suppressant R-125 is 3,170
- Therefore GWP of R-410a = **1,924**[1]

Solve our ODP issue with HFCs

Created another problem with GWP

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1. GPW values from the IPCC 5th assessment report, 2014 [AR5 values]. https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

Overview

- CFCs & HCFCs are officially out (Montreal Protocol)
- HFCs solved the Ozone issue (no more Chlorine)
- HFCs tend to be flammable and need to get mixed with some sort of flame retardant to remain A1's
  - Ie. Mixing R-32 with R-125 to create R-410a
- This results in high GWP refrigerants
- Current U.S. building codes only allow A1 refrigerants to be run through buildings (ASHPs & VRV)

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The Kigali Amendment

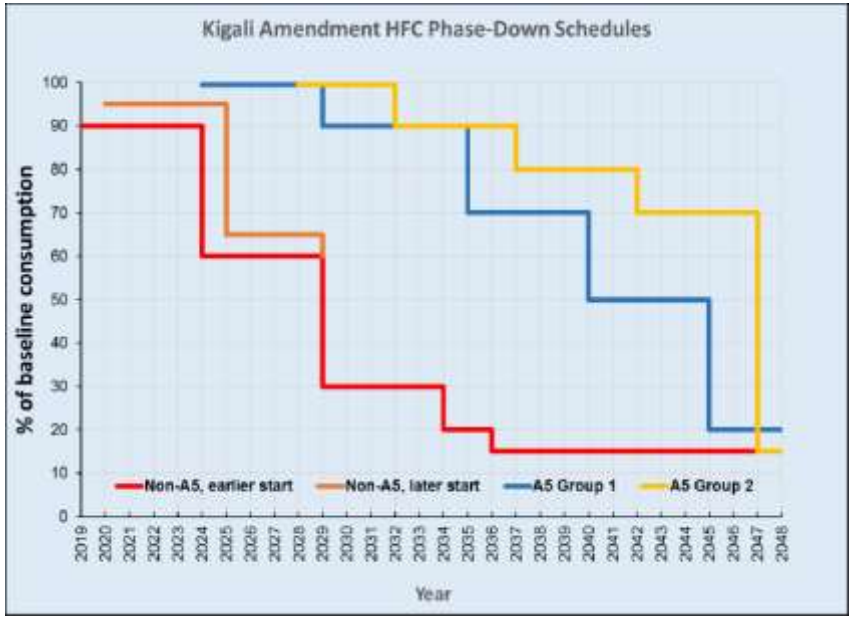
Amendment to the Montreal Protocol to globally phase down HFC's (85% reduction in CO_2 tons equivalent)

2016
- Signed October 15th 2016 (28th meeting of the Montreal Protocol)

2019
- Start of the phase down for developed countries (including USA) by 15%

2036
- Phase down of developed countries (including USA) by 85%

2047
- Phase down of developing countries by 85%



3%	Solvents, Aerosols, etc.
5%	Foams
1%	Residential refrigeration
7%	Mobile AC
32%	Stationary AC
52%	Ind/Comm refrigeration

Estimates that a successful phase down could prevent up to 0.5C increase in global temperatures by the end of the century

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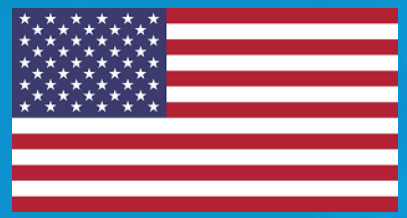
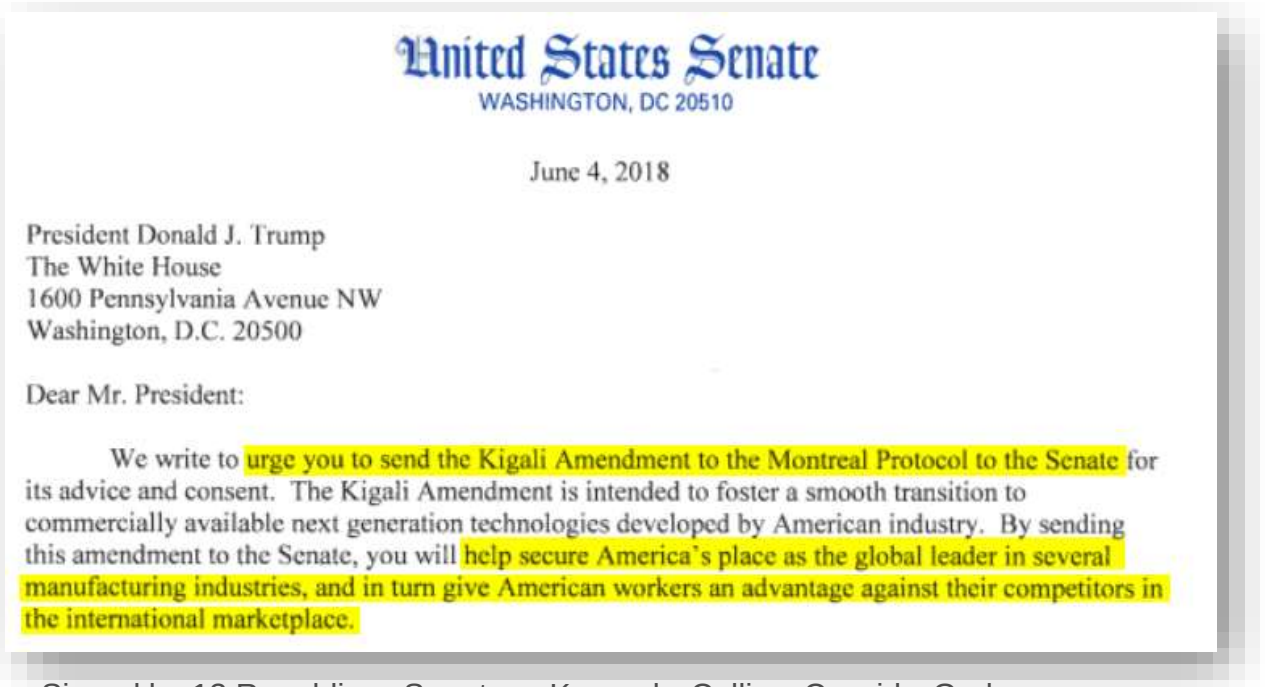
The Kigali Amendment



The US has not ratified the Kigali Amendment

- **May 2018:** Letter to President Trump from 32 HVAC&R companies urging he submit the Amendment for ratification
- **June 2018:** Similar demand from 13 Republican Senators



United States Senate
WASHINGTON, DC 20510

June 4, 2018

President Donald J. Trump
The White House
1600 Pennsylvania Avenue NW
Washington, D.C. 20500

Dear Mr. President:

We write to urge you to send the Kigali Amendment to the Montreal Protocol to the Senate for its advice and consent. The Kigali Amendment is intended to foster a smooth transition to commercially available next generation technologies developed by American industry. By sending this amendment to the Senate, you will help secure America's place as the global leader in several manufacturing industries, and in turn give American workers an advantage against their competitors in the international marketplace.

Signed by 13 Republican Senators: Kennedy, Collins, Cassidy, Graham, Mukowski, Isakson, Alexander, Rubio, Moran, Scott, Blunt, Boozman, Young

https://www.documentcloud.org/documents/4501544-Senate-Letter-on-Kigali-6-4-18.html

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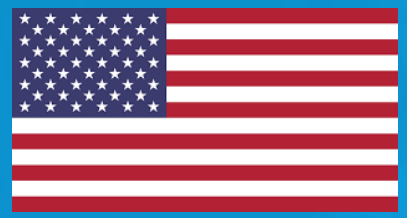
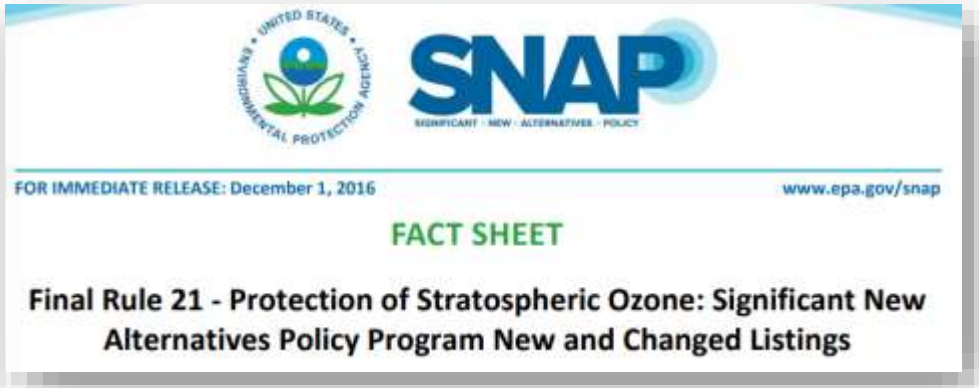
SNAP



Significant New Alternative Policy, by the EPA

- Under Clean Air Act (CAA); identify and evaluate substitutes for ozone-depleting substances
- Reviews ODP, GWP, Toxicity, Flammability, H&S, IAQ, Ecosystems
- Rule 20 (2016) and 21 (2017) introduced HFC phase downs



21: Deemed a long list of HFCs unacceptable for chillers (only) starting January 1st 2024 (including R-410a)

(No reference to ASHPs or VRV)

https://www.epa.gov/sites/production/files/2016-12/documents/snap_action_scr2_factsheet.pdf

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SNAP Court Rulings

August 2017: Mexichem Fluor Inc. v. EPA regarding SNAP 20

Case won. Not admitted to U.S. Supreme court.

April 2018: EPA vacated SNAP 20 in its entirety

June 2018: New York Attorney General (and 11 others) suit against the EPA challenging its method for fully vacating SNAP 20

April 2020: Case won. EPA needs to follow proper procedures for vacating SNAP 20.

April 2019: Mexichem Fluor Inc. v. EPA regarding SNAP rule 21

Case won based on precedence.

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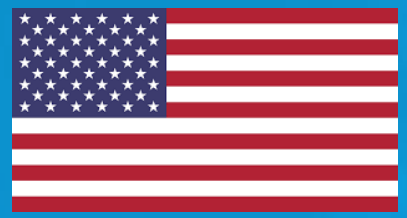
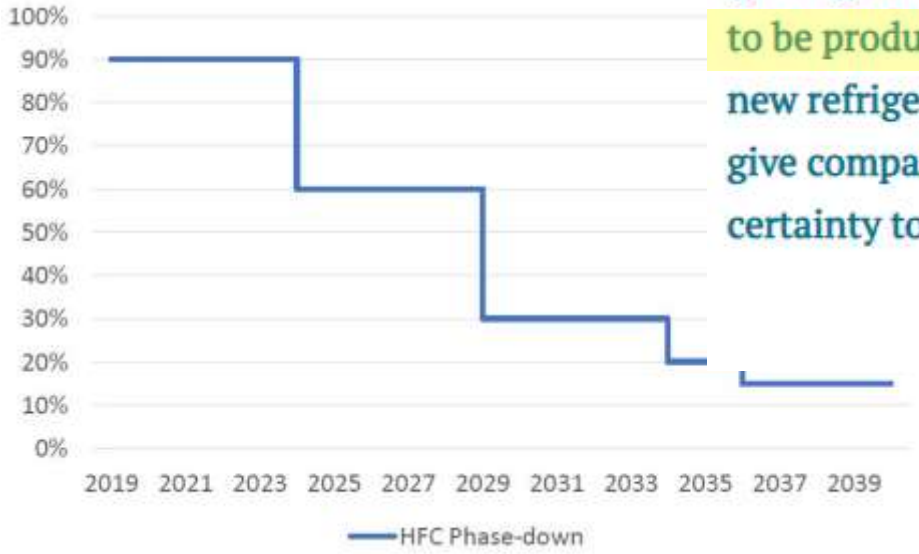
Federal Policies



Update on Federal Policies

- No SNAP 20 or SNAP 21 implementation
- S.2754 – American Innovation and Manufacturing Act of 2019
  - Introduced to Senate October 30th 2019
- H.R.5544 – American Innovation and Manufacturing Leadership Act of 2020
  - Introduced in House January 7th 2020
- Both align with Kigali to phase down HFCs over 15 years



"The world is moving away from HFCs, and the U.S. is in danger of getting stuck at the starting gate. We want these new refrigerants to be produced in the U.S., not in China. We want to export these new refrigerants, not import them. That won't happen unless we give companies in Louisiana and across the U.S. much-needed certainty to create thousands of new jobs."

— Sen. John Kennedy (R-Louisiana)
Co-sponsor of S. 2754

**** Not much movement on these… opposition looking for preemption language ****

https://www.achrnews.com/articles/142249-senate-hfc-phasedown-plan-debuts-with-broad-support

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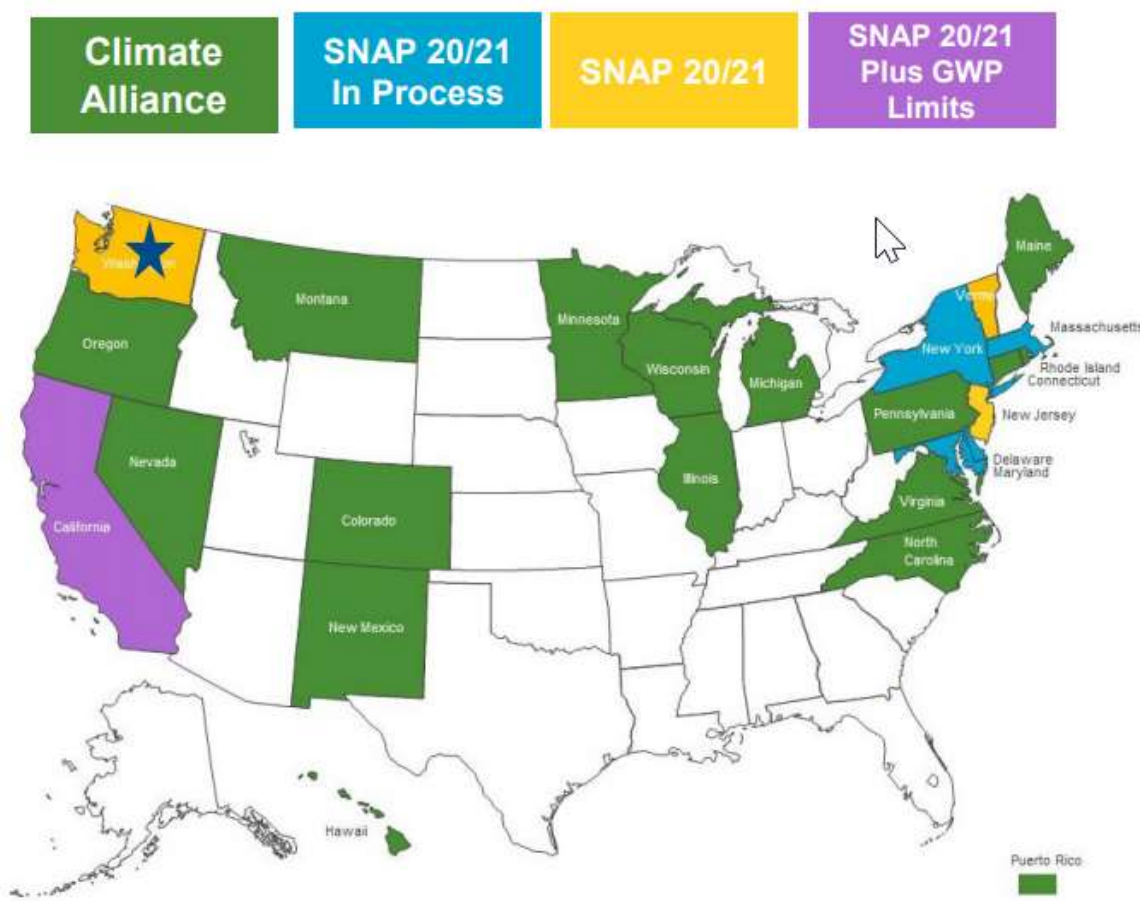
State Policies

- U.S. Climate Alliance states are taking the lead
- Some states are working on proposals for HFC phase downs
- Many follow the SNAP 20/21 guidelines



- In place or have announced timeline for proposal:
  - *CA, WA, VT, NJ*
- Intention, no timeline yet:
  - *NY, MD, DE, MA, OR, CO, CT, ME, RI, HI*

https://cdn.baseplatform.io/files/base/ebm/contractingbusiness/document/2020/01/Opteon_HFC_Regulations_Factsheet.5e2b04c8a47b8.pdf
https://www.contractingbusiness.com/refrigeration/article/21121301/new-jersey-governor-signs-bill-for-faster-phaseout-of-hfc-refrigerants

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California CARB

- California is going beyond SNAP 21
- Added a GWP limit of 750 for AC & ASHP
- How will they do this with an A1 refrigerant?

California Air Resources Board (CARB) Activity

In September 2018, the California Cooling Act (SB 1013) adopted SNAP Rules 20 and 21. Additional regulations related to the Short-Lived Climate Pollutant (SLCP) plan are proposed, as shown below. CARB is currently seeking stakeholder input.

Proposed Stationary Refrigerant Limits	Year	GWP Limit[1]
New Commercial Refrigeration Systems >50 lb	2022	150
New Air Conditioning and Heat Pump Equipment	2023	750
Refrigerants Sales and Service (Existing Systems)[2]	2022	1500

[1]GWP – IPCC 4th Assessment Report, AR4

[2]Exemptions for R-410A and reclaimed refrigerant under consideration

First reference to ASHPs

https://cdn.baseplatform.io/files/base/ebm/contractingbusiness/document/2020/01/Opteon_HFC_Regulations_Factsheet.5e2b04c8a47b8.pdf

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Overview

- No current Federal plan for HFC phase downs
  - Kigali not ratified
  - SNAP 20/21 ruled out
- A couple new bills with HFC phase down plans similar to Kigali are currently stuck in Congress / House
- Climate alliance states are taking the lead and implementing some phase downs
  - Generally following SNAP 20/21 rules
- Phase downs in HVAC apply to chillers only

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Agenda

- Why do we care
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- R-32: the original and the future A2L low GWP refrigerant

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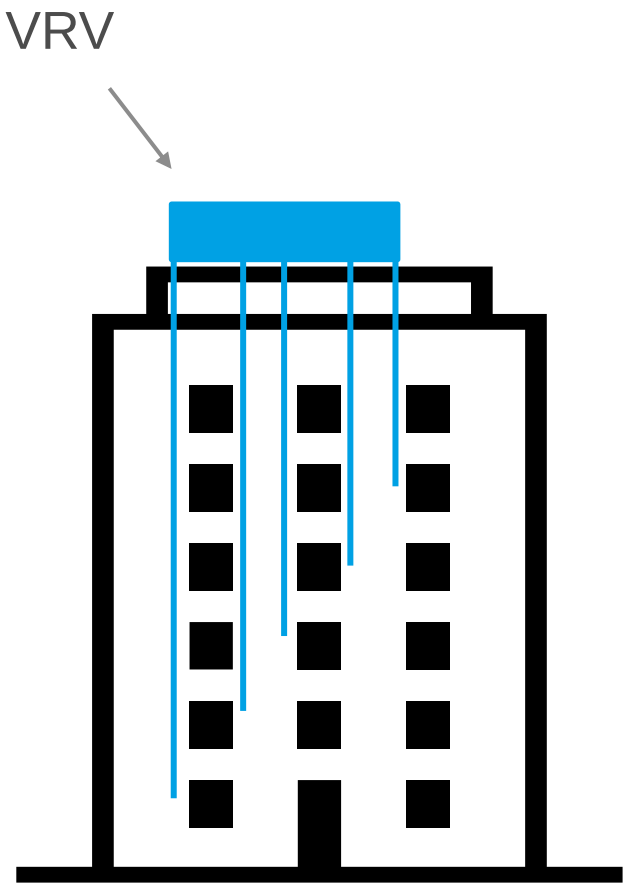
VRV & ASHPs

How do we electrify our building HVAC using VRV & ASHP



- While abiding to current building codes pertaining to running only A1 refrigerants through buildings
- While looking to lower GWP

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Low GWP Class A1

The search for a low GWP R-410a alternative in class A1

Everyone started mixing things…

- High efficiency
- Low GWP

R-32

R-1234yf
R-1234ze
R-125
CF_3I
R-134a

- Fluorine based
- High GWP
- Flame retardant

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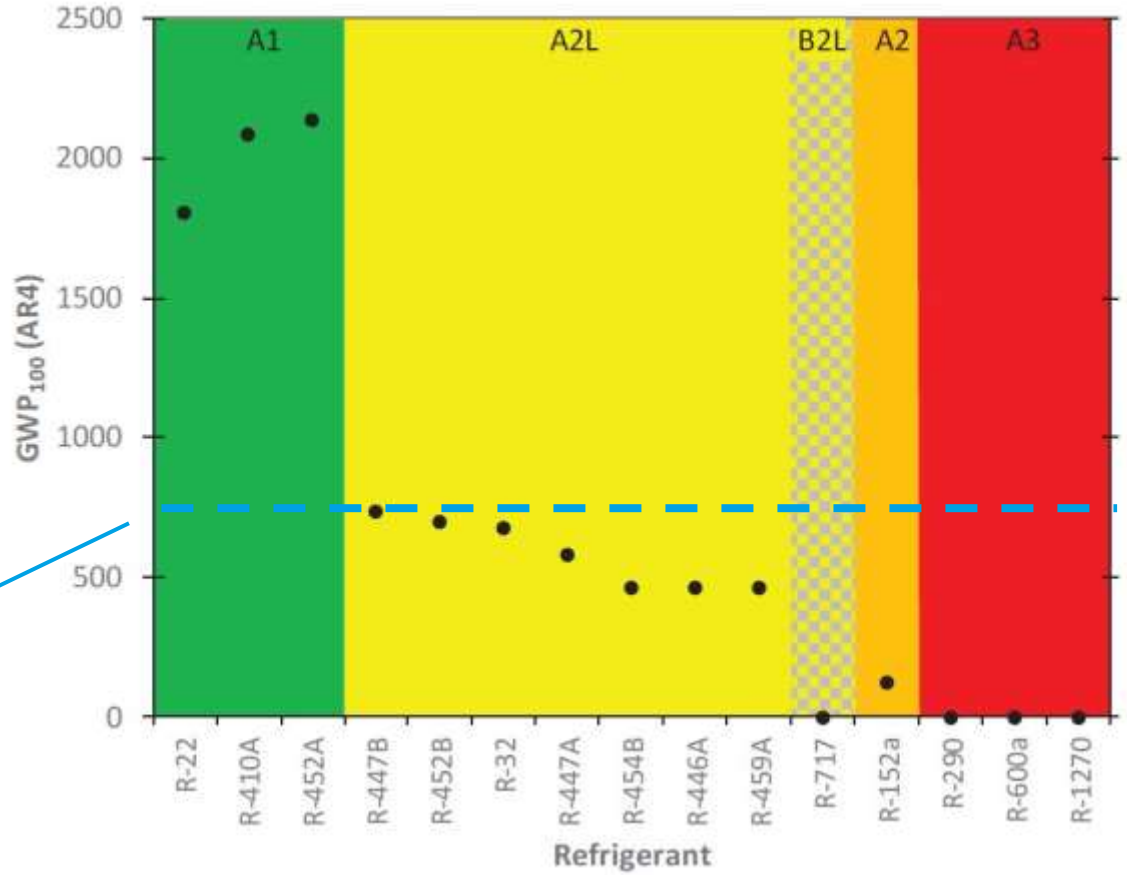
Low GWP Class A1

The search for a low GWP R-410a alternative in class A1

What's so difficult?

- Flammability and GWP are essentially inversely proportional
- As you add Fluorine based chemicals, you decrease flammability, but increase GWP



California CARB 750 GWP maximum

https://www.achrnews.com/articles/141733-understanding-a2l-refrigerants-for-air-conditioners

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Low GWP Class A1

The search for a low GWP R-410a alternative in class A1

Long story short… nobody can really get there

Some look like they might have…

- Example: R-466A [49% R-32 / 39.5% CF_3I / 11.5% R-125]
- GWP 697
- A1

There are other key characteristics for refrigerants that could makes these types of complex blends unviable

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Life Cycle Climate Performance

The total CO_2 equivalency from cradle to grave of an HVAC unit

Low GWP Class A1

	R-466a
How much refrigerant do you need?	Increase Net GWP > 800
How much electricity does the equipment consume?	Reduced efficiency More emissions Higher operational costs
Is it stable, is it corrosive?	C-I bond is weak Acidic once broken down Temperature limits
Does it use readily available chemicals?	CF_3I not easy to make Iodine is the issue
Is it owned / patented by a single manufacturer?	Yes

The search for a zero ODP low GWP R-410a alternative in class A1
Long story short… nobody can really get there

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Understanding A2L flammability

"The trend is clear: to shift the balance towards being more environmentally friendly, we must accept some degree of flammability"[1]

- "R-410a behaves very similarly to R-32 [A2L] especially when exposed to higher temperatures (ie. a fire)"[1]
- A2L refrigerants will NOT ignite from static sparks or toasters.
- A2L refrigerants cannot sustain a flame with concentrations below the LFL
- A2L and A1 refrigerants have similar Hot Surface Ignition Temperatures (HSIT)
- A2L and A1 refrigerants will produce similar byproducts when combusted
  - Hydrofluoric Acid (HF) is product with both, not Hydrochloric Acid (as with R-22)

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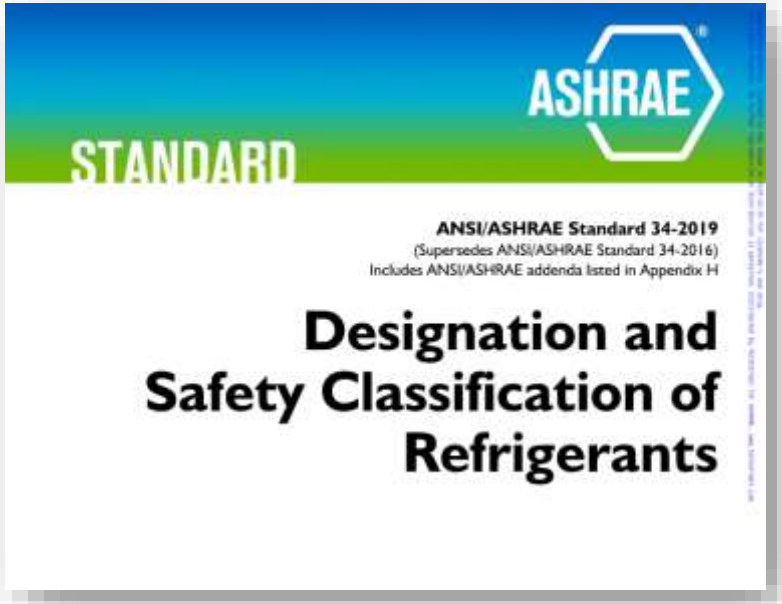
1. http://www.ahrinet.org/App_Content/ahri/files/Resources/AHRI_SRTTF_Low_GWP_Refrigerants_FAQs.pdf
2. https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2554&context=iracc

Codes & Standards on A2L

ASHRAE 15 2019

- 7.5.2 now includes refers to a new section (7.6) for A2L refrigerants
- Addition of warning labels
- Introduces refrigerant detection (automatic shut down of equipment except fans and dampers)
- Limits on ‘ignition sources’ such as open flames or surfaces > 700C



ASHRAE 34 2016

- Includes A2L classification

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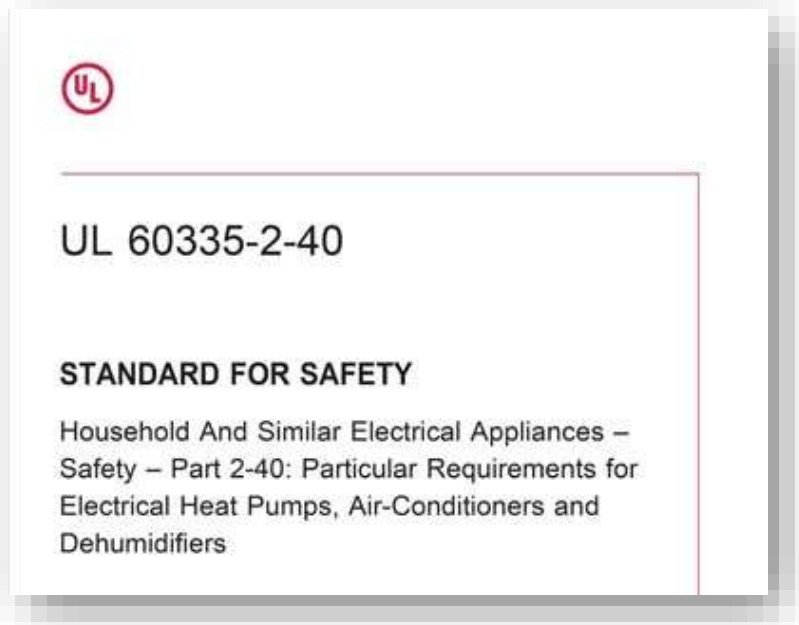
Codes & Standards on A2L

UL 1995

- Current standard for safety of VRV and ASHP equipment
- Currently under the 4th edition, valid until 2024



UL 60335-2-40[1]

- New standard for safety for VRV and ASHP equipment, becoming effecting in 2024
- Binational standard (US & Canada)
- Based on IEC 60335-2-40 currently being used in Europe
- UL 60335-2-40 is more conservative
- Introduces factory installed refrigerant leak detection as part of the equipment, and its testing

https://www.ul.com/news/understanding-ul-60335-2-40-refrigerant-detector-requirements

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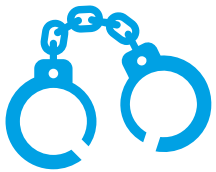
Codes & Standards on A2L

- ASHRAE standards seem to have A2L covered
- Equipment standards seem to have A2L covered
- Are we good to go???

NO



- Model building codes first need to adopt these new standards
  - Universal Mechanical Code (UMC)
  - International Mechanical Code (IMC)
- So far, the 2021 round of these model codes have essentially rejected A2L
- Next round is 2024 (work starts in 2021)

- State / County / Local codes need updates (1-8 years)
  - Based on one of the model codes
- Some states (CA, WA) considering no longer using the model codes in order to incorporate A2L

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A2L in Washington State?

WA Code Council Paves the Way for Use of A2L Refrigerants

BY ALEX AYERS

11/13/2019 - HVAC Government Affairs

The Washington State Building Code Council has voted to fully adopt ASHRAE 15-2019 and the 3rd edition of UL 60335-2-40. Adoption of these codes will allow the use of mildly flammable A2L refrigerants in refrigeration and air-conditioning including the use in occupied dwellings. Washington is the first state to bypass the model code organizations to directly adopt the updated ASHRAE and UL standards to allow the use of A2L refrigerants.

With this code adoption, the use of A2L refrigerants can begin on July 1, 2020, however market availability of equipment designed to use A2L refrigerants is not expected for several years. This code adoption will allow manufacturers to begin testing equipment in various conditions for use in a few years.

https://blog.hardinet.org/wa-code-council-refrigerants

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AHRI Task Force

AHRI Safe Refrigerant Transition Task Force

AHRI SAFE REFRIGERANT TRANSITION TASK FORCE

AHRI's Safe Refrigerant Transition Task Force has been formed to address every step of the supply chain in the safe refrigerant transition to low global warming potential refrigerants. The task force comprises AHRI members and stakeholders employed with contractors, government agencies, the fire service, unions, training organizations and other businesses.

http://www.ahrinet.org/SafeRefrigerant

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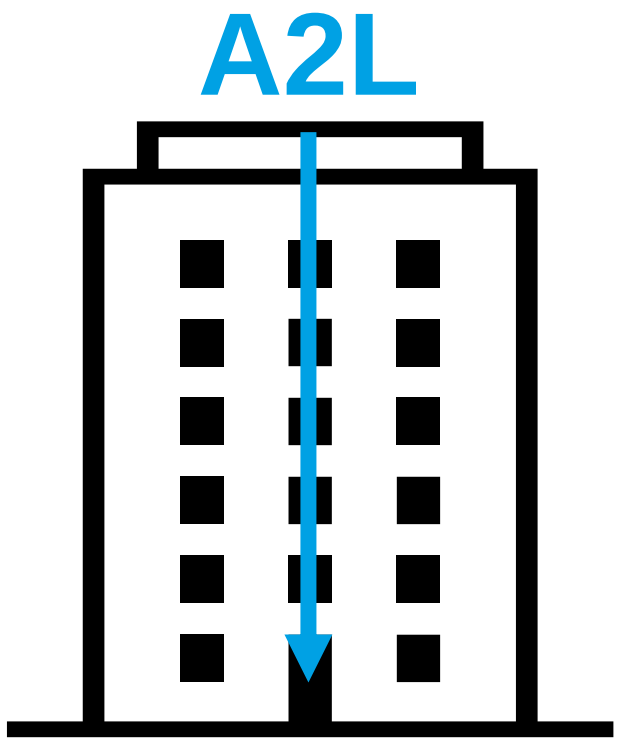
Low GWP Class A2L

As we (im)patiently wait for A2L to be allowed in buildings… it's time for manufacturers to start 'picking their A2L horse' and start developing high efficiency equipment with it



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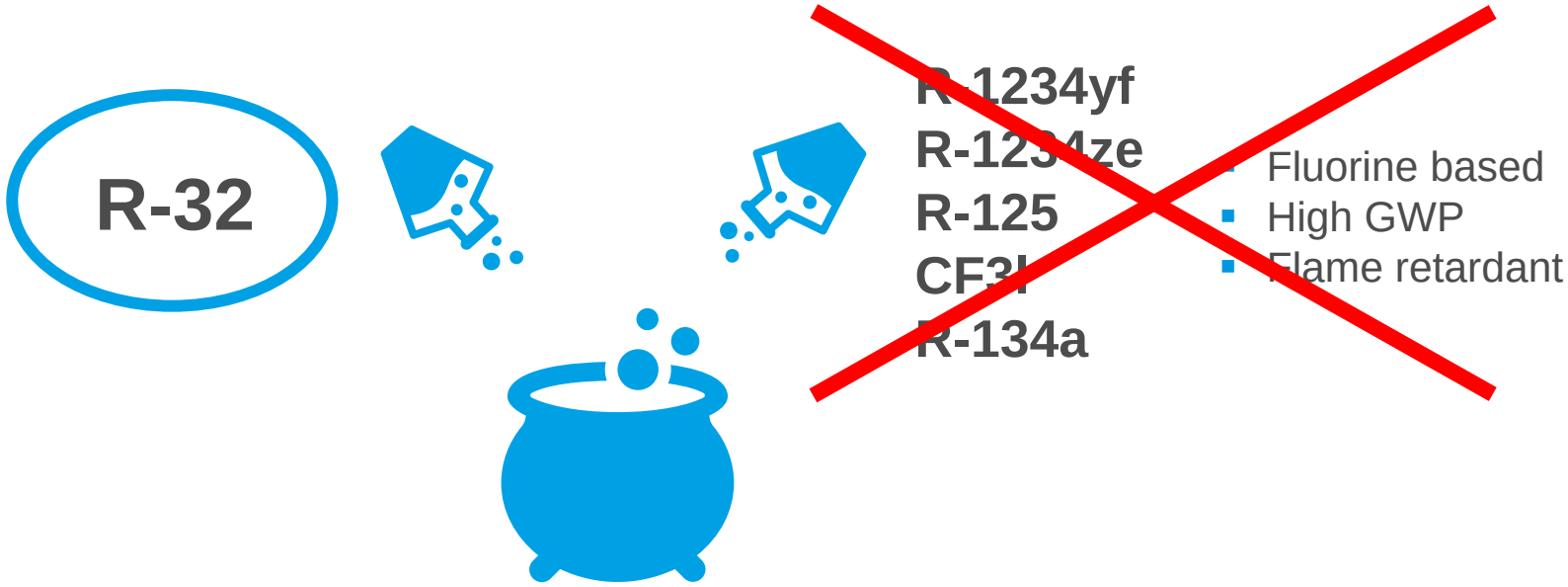
Low GWP Class A2L

The search for a low GWP R-410a alternative in class A2L

Optimizing for best LCCP impacts



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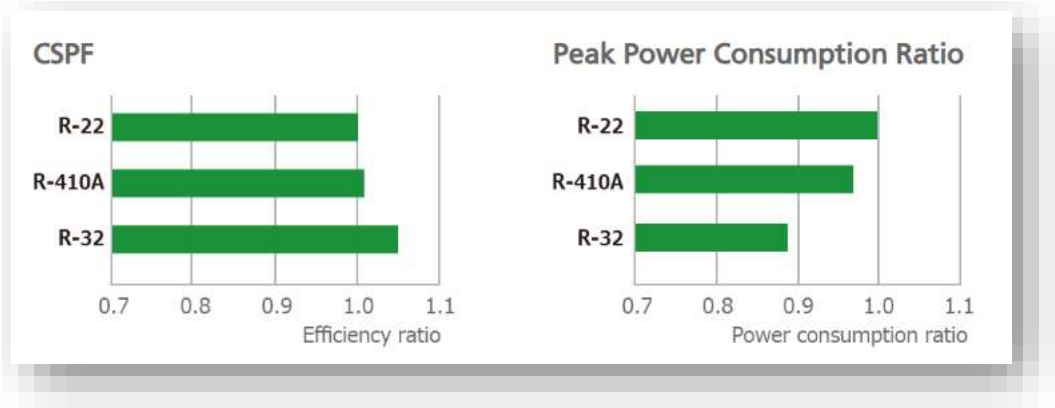
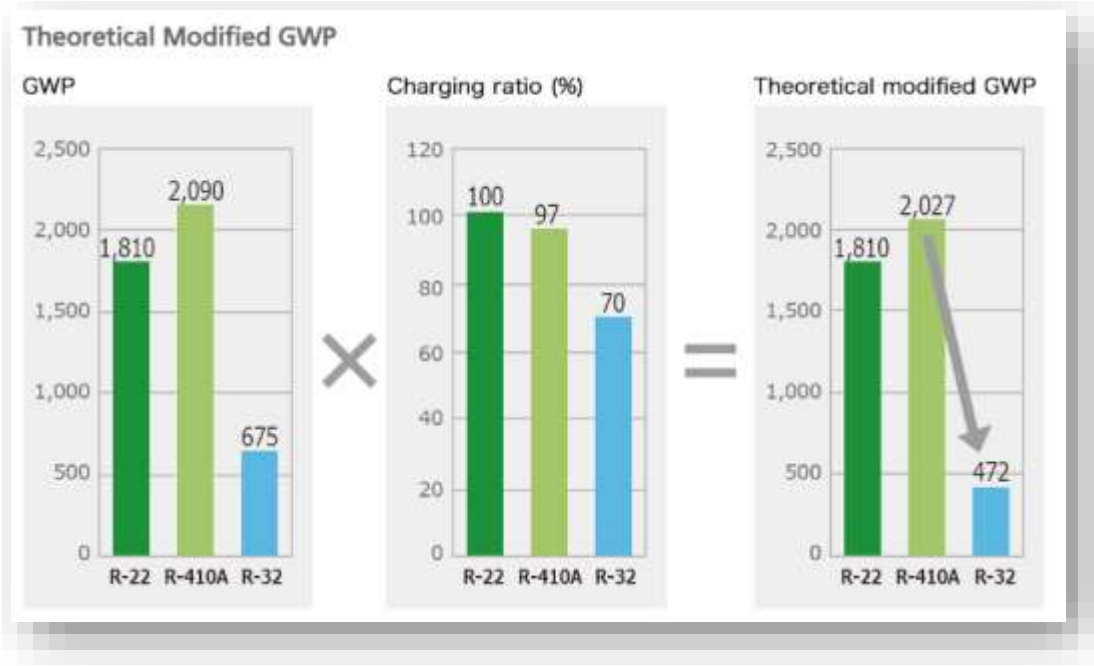
R-32

- More efficient (10% > R-410a)
  - Major LCCP impacts
  - Operational Cost impact
- Higher capacity (28% less charge)
- GWP of 677
  - Theoretical GWP 472
- Readily available (every lb of R-410a has ½ lb of R-32)
  - 100M+ R-32 AC units around the world
- Simple pure refrigerant
  - Not a Zeotropic mixture





https://www.daikin.com/csr/information/influence/hfc32.html

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R-32

Daikin is highly involved with R-32

- 2011: Offered free access to 93 patents to emerging countries
- 2012: Launched first global R-32 residential equipment in Japan
- 2015: Expanded free patent access globally

But – this is not just Daikin

https://www.daikin.com/patent/r32/

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R-32 VRV

https://www.daikin.eu/en_us/product-group/vrv/vrv5.html

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Remember this slide?

Refrigerant Classification

ASHRAE 15

RCL

ASHRAE Standard 15 – Safety Standard for Refrigeration Systems

- Introduces Refrigerant Concentration Limit (RCL) to ensure safety in case of a complete refrigerant discharge in the smallest occupied space
  - Analyzes toxicity, oxygen deprivation and flammability
  - Worse case maximum concentration determines the RCL

- R-410a
  1. Low toxicity
  2. No flame propagation at 60C
  3. Oxygen deprivation determines the RCL
     - RCL of R-410a = 26 lbs / mcf

Oxygen Percentage Available	Symptoms	Altitude equivalent [ft] Of effective oxygen %
21	Normal conditions, no effect.	0
19.5	OSHA oxygen-deficient atmosphere.	2,000
17	Muscular impairment, rapid breaths.	5,500
12	Dizziness, headache, rapid fatigue.	14,500
9	Unconsciousness.	22,000
7 to 6	Death within a few minutes.	29,000

23

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ASHRAE Standard 15 – Safety Standard for Refrigeration Systems

R-32
VRV

- Refrigerant Concentration Limit (RCL) is the worse case between:
  1. Toxicity concentration limit
  2. Oxygen deprivation concentration limit
  3. Flammability concentration limit

- **R-32**
  1. Low toxicity
  2. Oxygen deprivation limit is not the limiting factor
  3. **Flammability concentration limit = 25% of LFL**
     - RCL of R-32 = **4.8 lbs / mcf**

- ASHRAE 15 2019
  - A2L systems > 4 lbs require refrigerant detection (new 7.6 section on A2L)
  - No wording yet on whether refrigerant detection mitigates the 4.8 RCL limit

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ASHRAE VRF Committee

Variable Refrigerant Flow (VRF)

ASHRAE Technical Committee 8.7

Home | Membership | Meetings | Documents | Functions | More

Agenda

TC0807 Orlando Agenda 20200203

Upcoming TC Meetings

Location:	Orlando, FL

Committee Chair

Arturo Thur de Koos

TC0807@ashrae.net

Committee Scope

TC 8.7 is concerned with the design, performance, and application of variable refrigerant flow systems into commercial HVAC systems.

http://tc0807.ashraetcs.org/index.php

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Conclusion

- CFCs & HCFCs are fully phased out, we are now using HFCs
- HFCs have high GWP due to flame retardant additives to maintain A1 class
- Building codes (model or local) do not currently allow anything but A1 refrigerants through buildings (VRV & ASHPs). Still years away.
- There are no Federal phase down plans for HFCs (some bills in the works)
- Climate Alliance states starting to implement SNAP-like phase downs
  - Applies to chillers only in HVAC
- VRV & ASHPs cannot transition to lower GWP HFCs until A2L is allowed in buildings
  - Standards are already addressing A2L and incorporating leak detection
- R-32 is the go-to A2L refrigerant with lowest LCCP impact

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Extra Resources

- **Understanding A2L Refrigerants for Air Conditioners (ACHR News)**
  - https://www.achrnews.com/articles/141733-understanding-a2l-refrigerants-for-air-conditioners
- **About Montreal Protocol (UN Environment)**
  - https://www.unenvironment.org/ozonaction/who-we-are/about-montreal-protocol
- **U.S. STATES TAKE THE LEAD IN HFC PHASEDOWN (NRDC)**
  - https://www.nrdc.org/sites/default/files/media-uploads/fact_sheet_on_state_hfc_action_0.pdf
- **Refrigerants and their environmental impact Substitution of HCFC and HFC. Search for an adequate refrigerant (Benhadid-Dib / Benzaoui)**
  - https://www.sciencedirect.com/science/article/pii/S1876610212008661
- **US Refrigerant Regulations Update and Emerging Trends (Emerson)**
  - https://climate.emerson.com/documents/ahr-e360-breakfast-2020-us-refrigerant-regulations-update-emerging-trends-en-us-6320408.pdf
- **Your Guide to Federal and State HFC Regulations in North America for HVACR Refrigerants (Opteon)**
  - https://cdn.baseplatform.io/files/base/ebm/contractingbusiness/document/2020/01/Opteon_HFC_Regulations_Factsheet.5e2b04c8a47b8.pdf
- **R-32: The Most Balanced Refrigerant for Stationary Air Conditioners and Heat Pumps (Daikin)**
  - https://www.daikin.com/csr/information/influence/hfc32.html
- **Lower Global Warming Potential Refrigerants: Frequently Asked Questions (AHRI SRTTF)**
  - http://www.ahrinet.org/App_Content/ahri/files/Resources/AHRI_SRTTF_Low_GWP_Refrigerants_FAQs.pdf
- **New Refrigerants, Higher-Flammability Refrigerants Addressed in Updated ASHRAE Standards 15, 34 (ASHRAE)**
  - https://www.ashrae.org/news/esociety/new-refrigerants-higher-flammability-refrigerants-addressed-in-updated-ashrae-standards-15-34

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