

# FUTURE OF REFRIGERANTS

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# WHAT IS A REFRIGERANT?

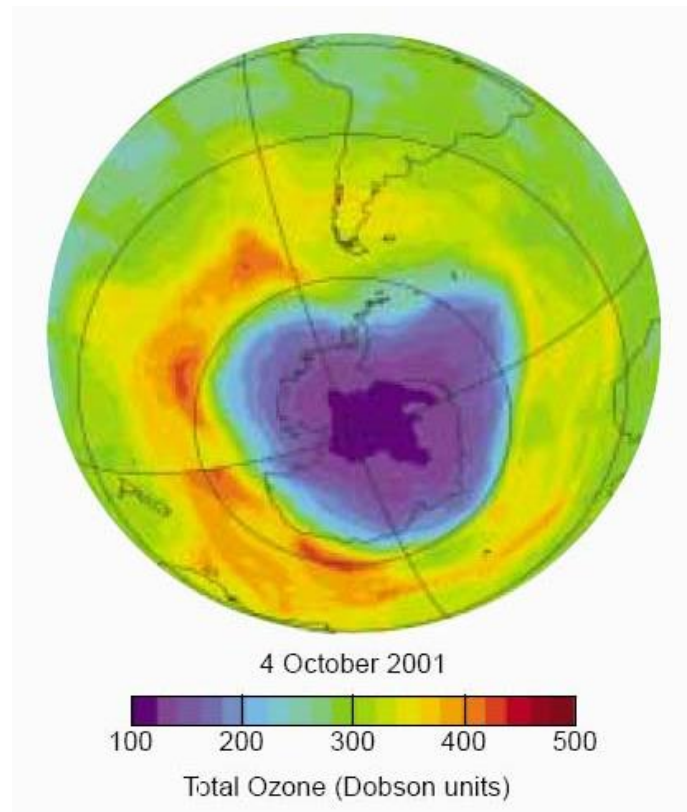
In a refrigerating system - the medium of heat transfer, which picks up heat by **evaporating at a low temperature and pressure**, and gives up heat on **condensing at a higher temperature and pressure**.

*Ref: ASHRAE Terminology of HVAC&R*



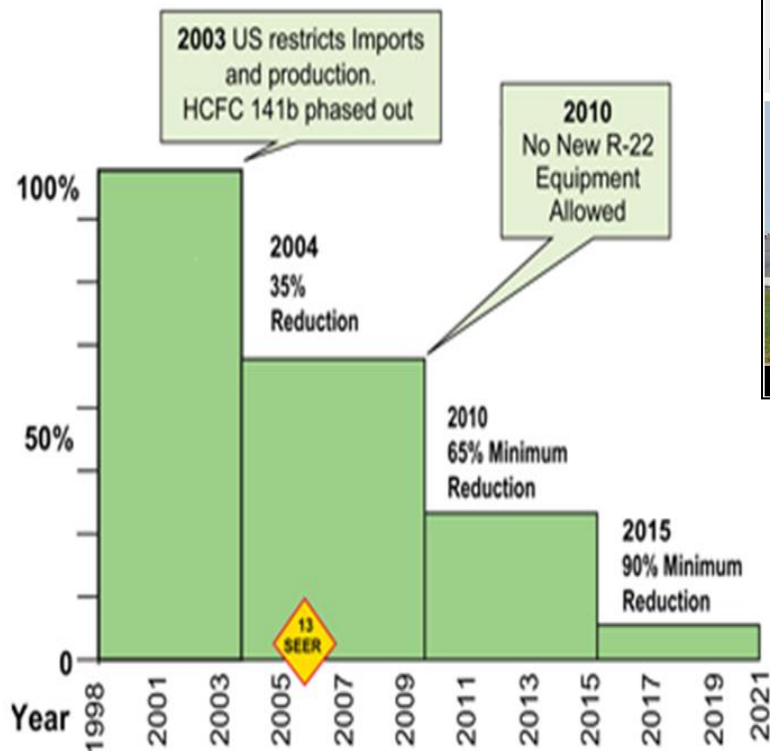
# BASICS

- › ODP = Ozone Depletion Potential
- › Ozone is depleted by compounds that contain chlorine that make it into the upper atmosphere
- › To protect the ozone, the Montreal Protocol has phased out CFCs and HCFCs



# BASICS

- › ODP Reductions from US Clean Air Act
- › ~~CFC~~ – ~~HCFC~~ – HFC – HFO



**2010 - Stop all R22 Production**

**1/1/2020 – Stop all R123 Production**

## BASICS

- What about GWP?





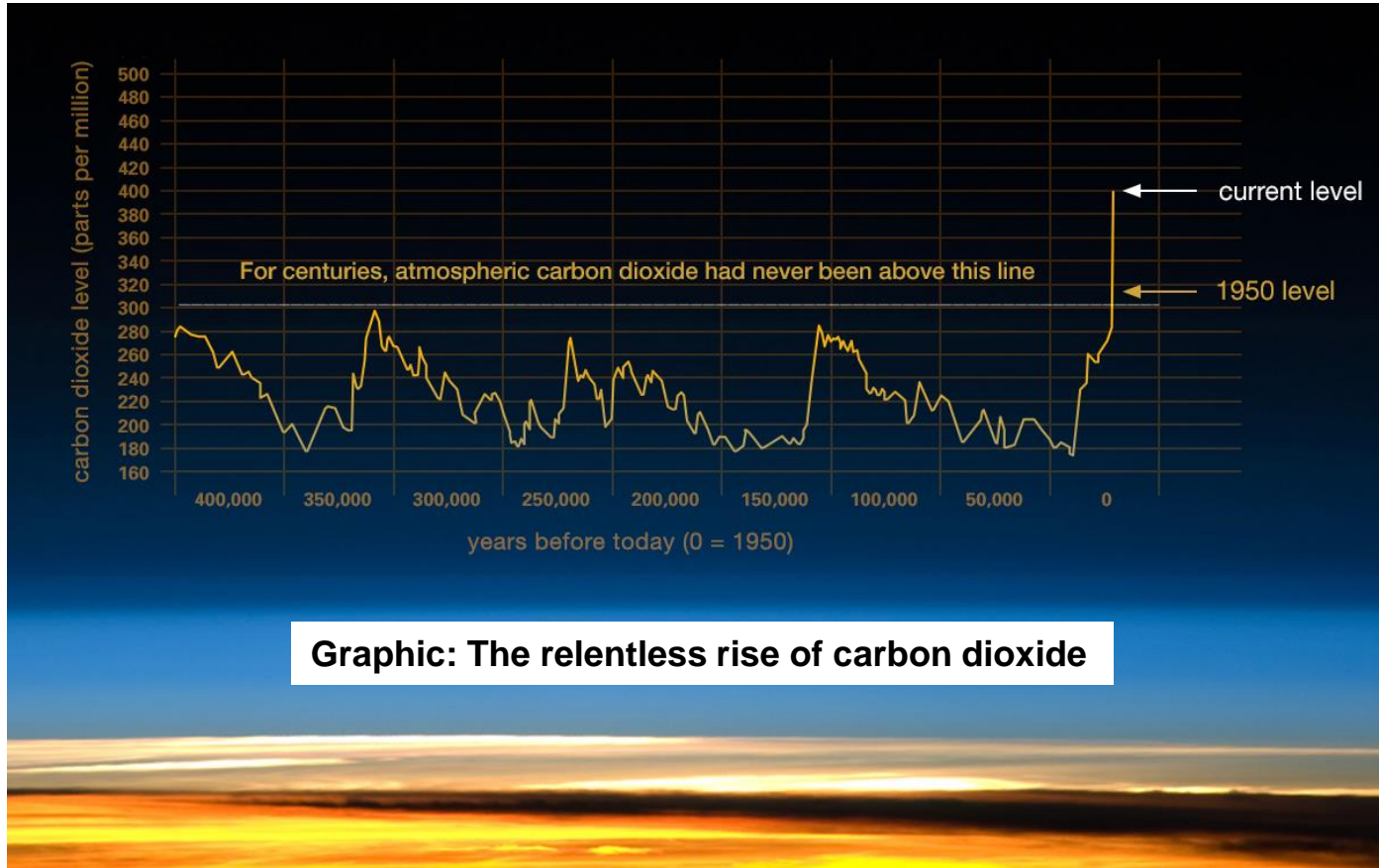
# BASICS

- › GWP = Global Warming Potential
- › GWP is a measure of the relative impact a refrigerant has on global warming by trapping heat in the atmosphere
- › *GWP does not provide visibility to efficiency*
- › CO<sub>2</sub>                      GWP = 1
- › HFC134a                GWP = 1300
- › R410A                  GWP = 1924

***Global Climate Change concern is driving the decisions today***

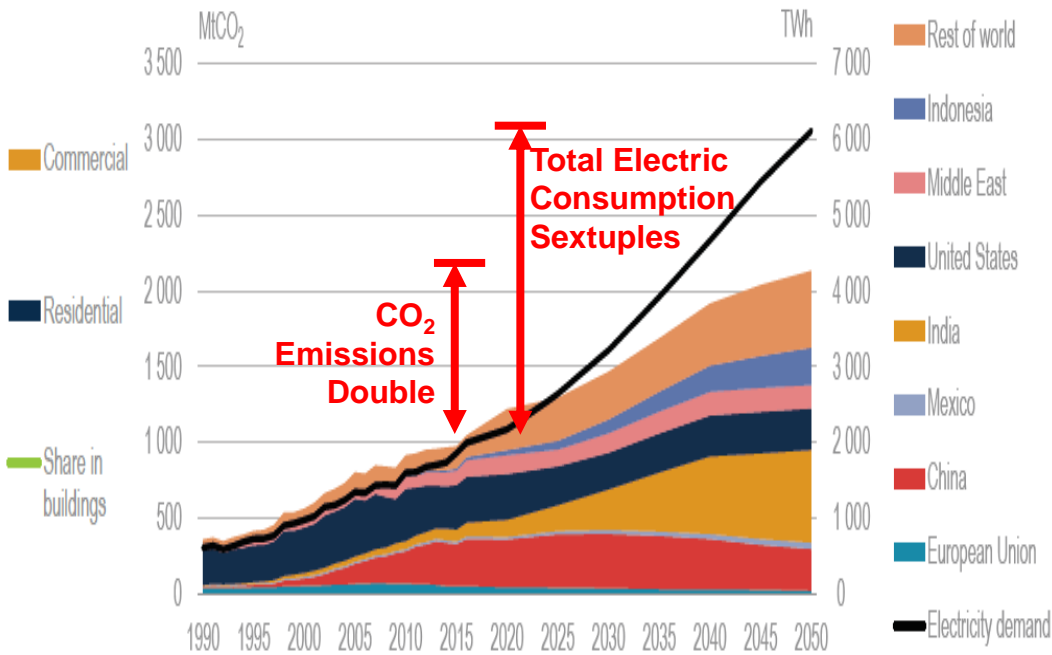
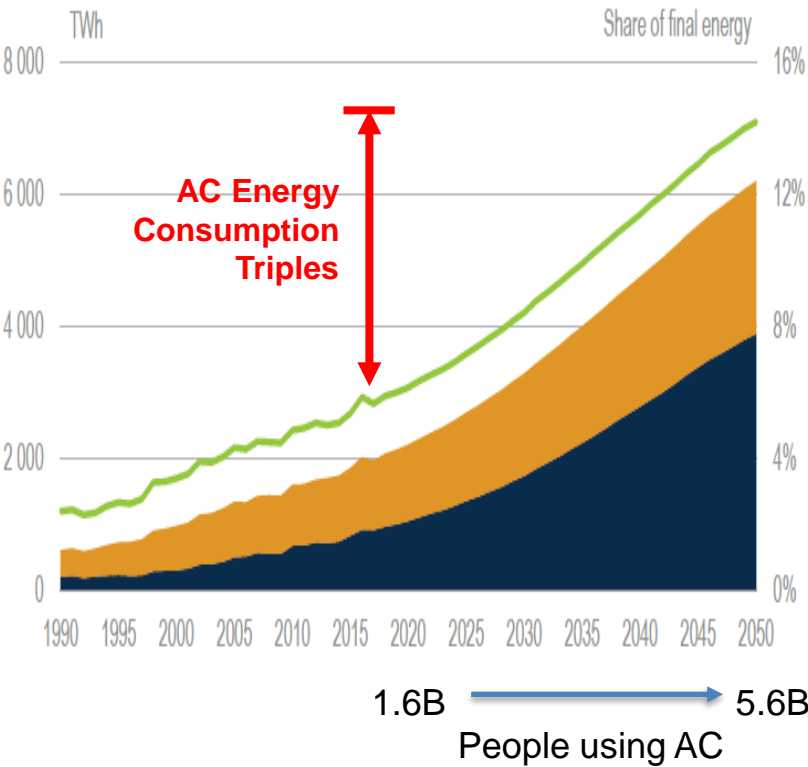


# IS THERE A PROBLEM?



[http://climate.nasa.gov/climate\\_resources/24/](http://climate.nasa.gov/climate_resources/24/)

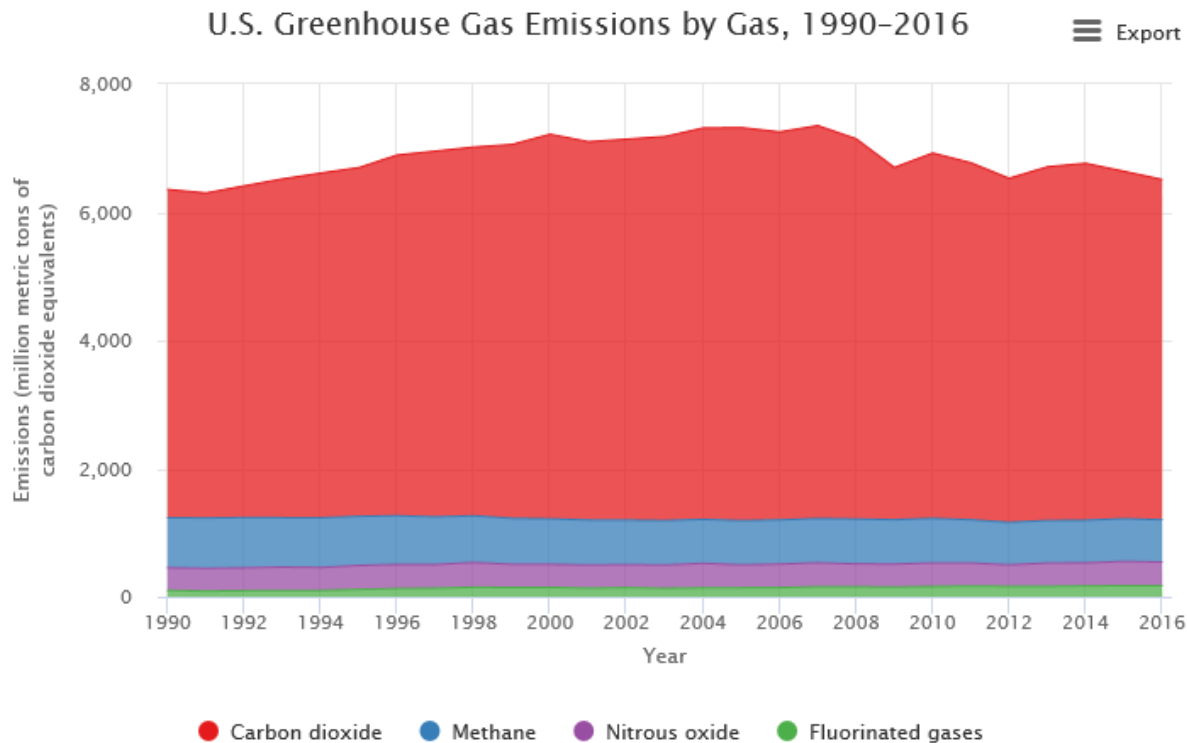
# GROWTH OF AC THROUGH 2050 - IMPACT TO ENERGY USE AND CO2 EMISSIONS



Source: IEA "The Future of Cooling"



# US EPA ANNUAL GHG REPORT

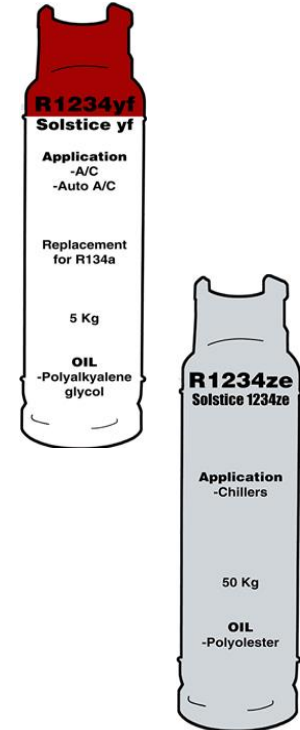


Source: U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2016.  
<https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>

# WHAT WILL BE DONE WITH REFRIGERANTS TO HELP REDUCE GWP?

- › HFO - Hydrofluoro olefins are those chemicals that are composed of fluorine and carbon and have at least one double bond connecting the atoms. Hydrofluoro olefins are non-ozone-depleting substances with relatively low GWP values.

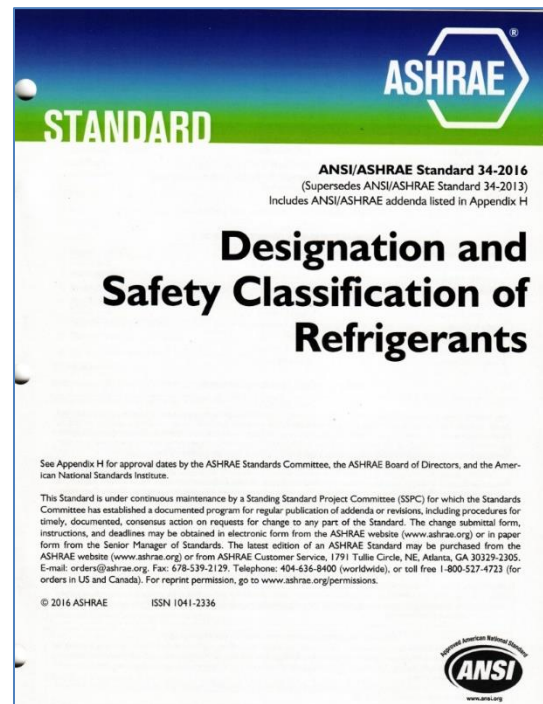
*HFO – Short atmospheric lifetime – Less climate impact*



# BASICS

- › Refrigerant number designations
- › Toxicity – A or B
- › Flammability – 1 thru 3

## ASHRAE Standard 34



# ASHRAE 34-2016

- › Toxicity – ASHRAE 34
  - A (lower toxicity) or
  - B (higher toxicity)
- › Flammability - ASHRAE 34
  - 1 (no flame propagation)
  - 2L (lower flammability) - effect of ignition is not so large, and typically difficult to ignite
  - 2 (lower flammability)
  - 3 (higher flammability)

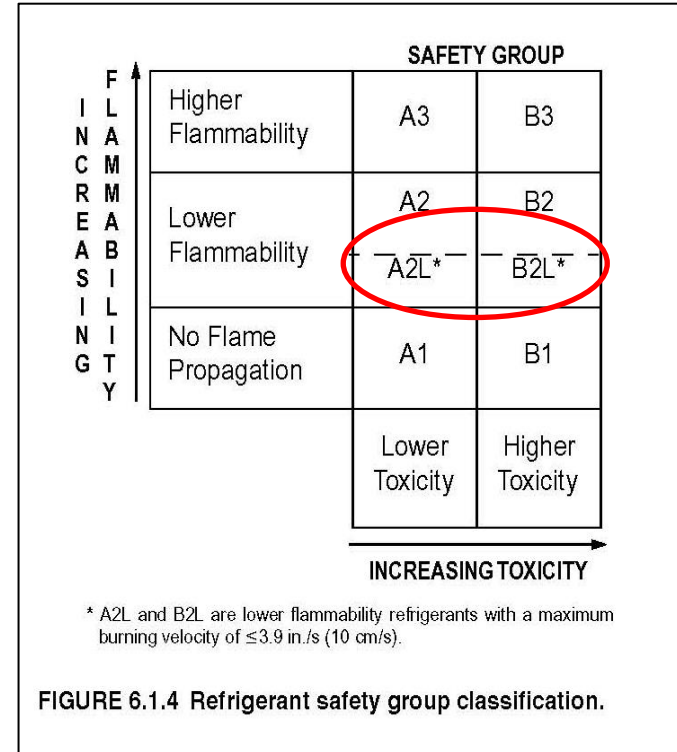




FIGURE 6.1.4 Refrigerant safety group classification.

*2L not yet recognized in North America building codes!*

# BASICS – FLAMMABILITY AND TOXICITY

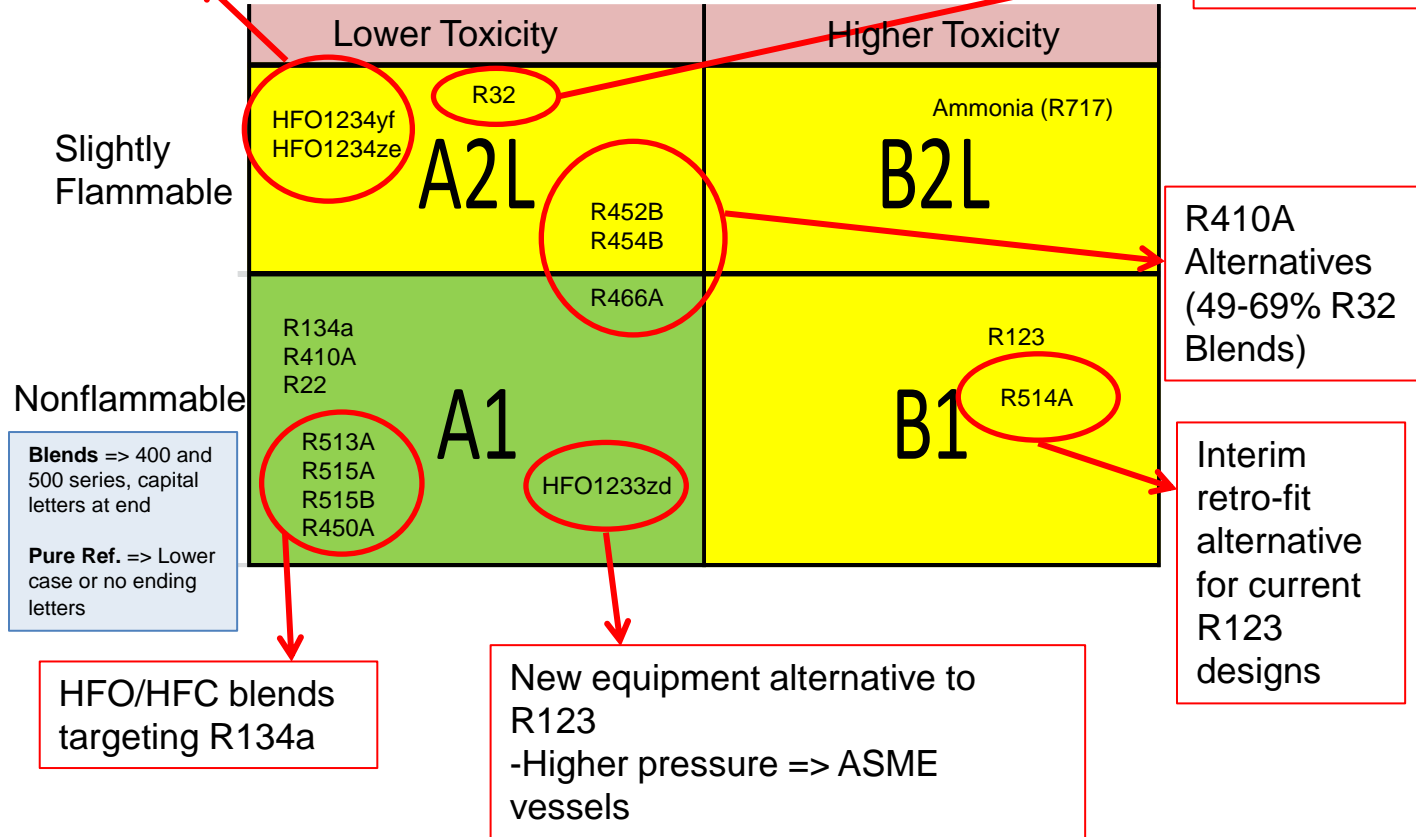
		Safety Group	
 Increasing Flammability	Higher Flammability	<small>Propane (R290)</small> <b>A3</b>	<b>B3</b>
	Lower Flammability	<b>A2</b>	<b>B2</b>
		<b>A2L</b>	<small>Ammonia (R717)</small> <b>B2L</b>
	No Flame Propagation	<small>R134a R410A R22</small> <b>A1</b>	<small>R123</small> <b>B1</b>
		 Increasing Toxicity	



# BASICS – FLAMMABILITY AND TOXICITY

R134a Alternatives  
1234yf in 26/50 top 2019 auto models

Good R410A Alternative  
Being used globally  
Basis of 410A (with  
R125)



# GWP IS NOT A MEASURE OF EFFICIENCY

## Direct Effect from Chemical

- › Refrigerant GWP
- › End-of-Life Impact



## Indirect Effect from Energy Use

- › Construction materials
- › Equipment efficiency



## Total Equivalent Warming Impact

*The majority of climate impact from HVAC is power generation for electricity use over equipment lifetime*

*In effect, a lower GWP refrigerant with lower efficiency could actually create more global warming*

# REGULATORY UPDATE

- › US
- › Canada
- › State Activity



# CHANGES ARE COMING

- › HFCs will be phased down (134a & 410A)
- › Drivers:
  - October 15, 2016 Kigali Amendment to the Montreal Protocol, phase down framework is defined
  - F-gas regulations in Europe
  - EPA SNAP Program / Climate Action Plan
  - Canada HFC activities
  - California actions
- › Code adoption process

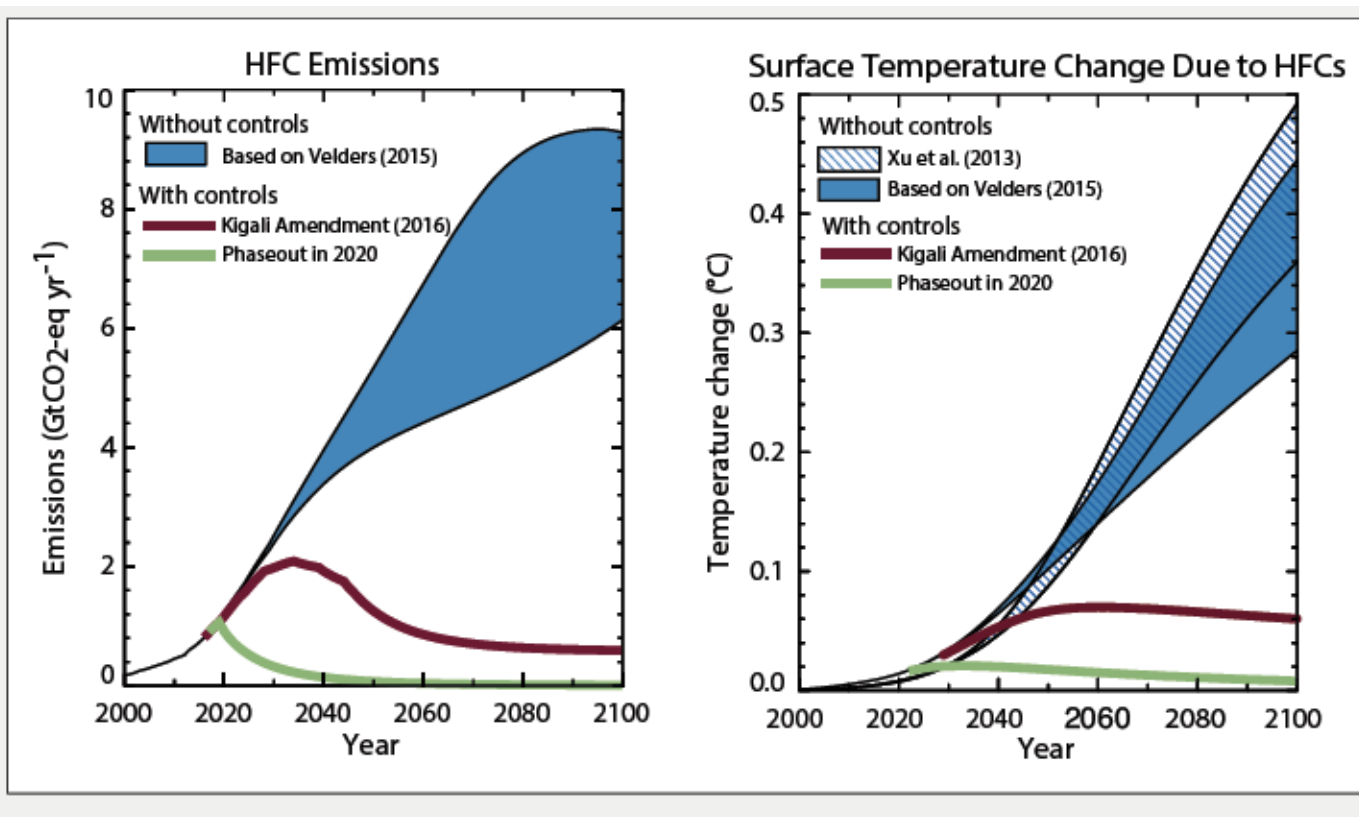


# KIGALI AMENDMENT TO THE MONTREAL PROTOCOL

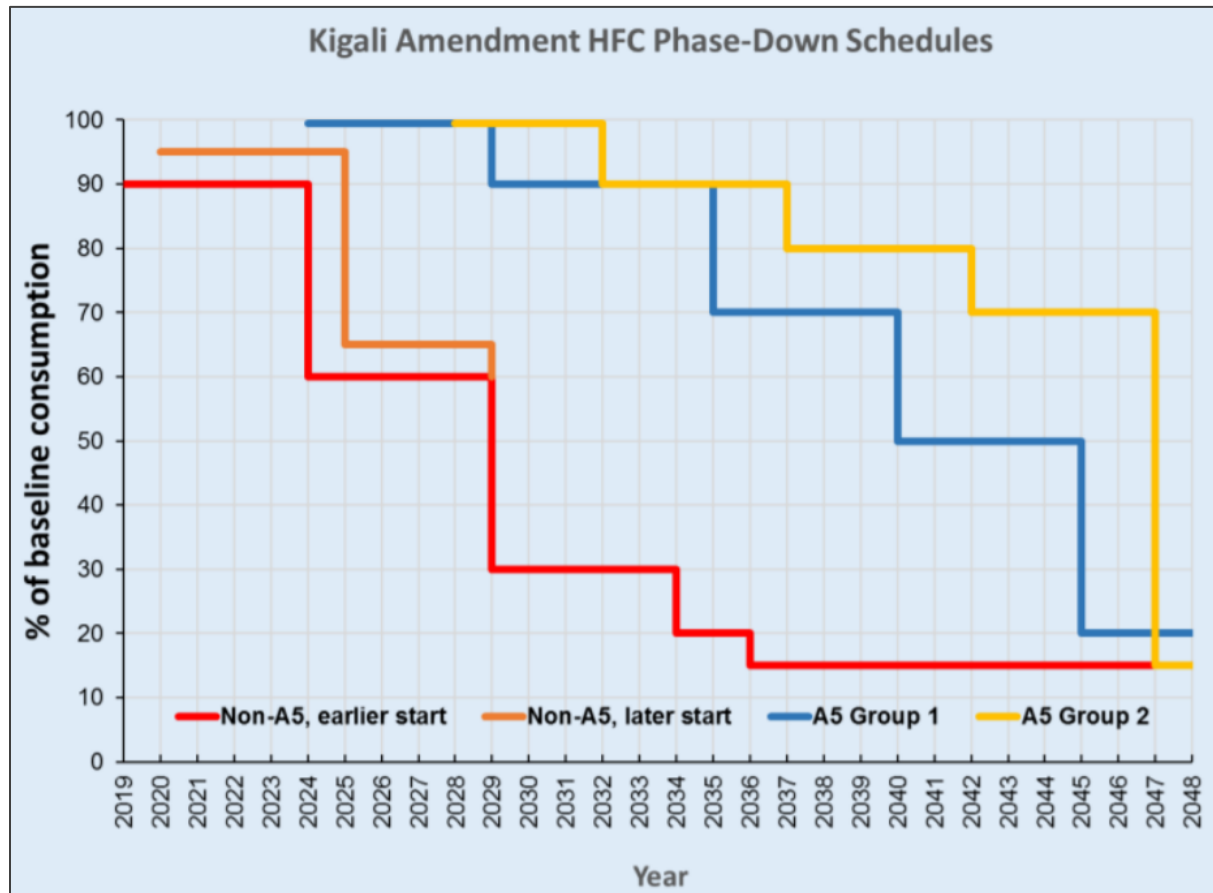
- › In October 2016 a multi-national agreement was reached in Kigali, Rwanda to phase down HFCs by 85% between now and 2047
- › This will be done as an amendment to the Montreal Protocol, so all countries (Including the US) who approve it will follow the guidelines
- › Phase down will be done on a GWP weighted basis
  - Eliminating higher GWP HFCs such as R404A (GWP=3940) will have more of an impact than reductions in R134a (GWP=1300)



# KIGALI AMENDMENT TO MONTREAL PROTOCOL

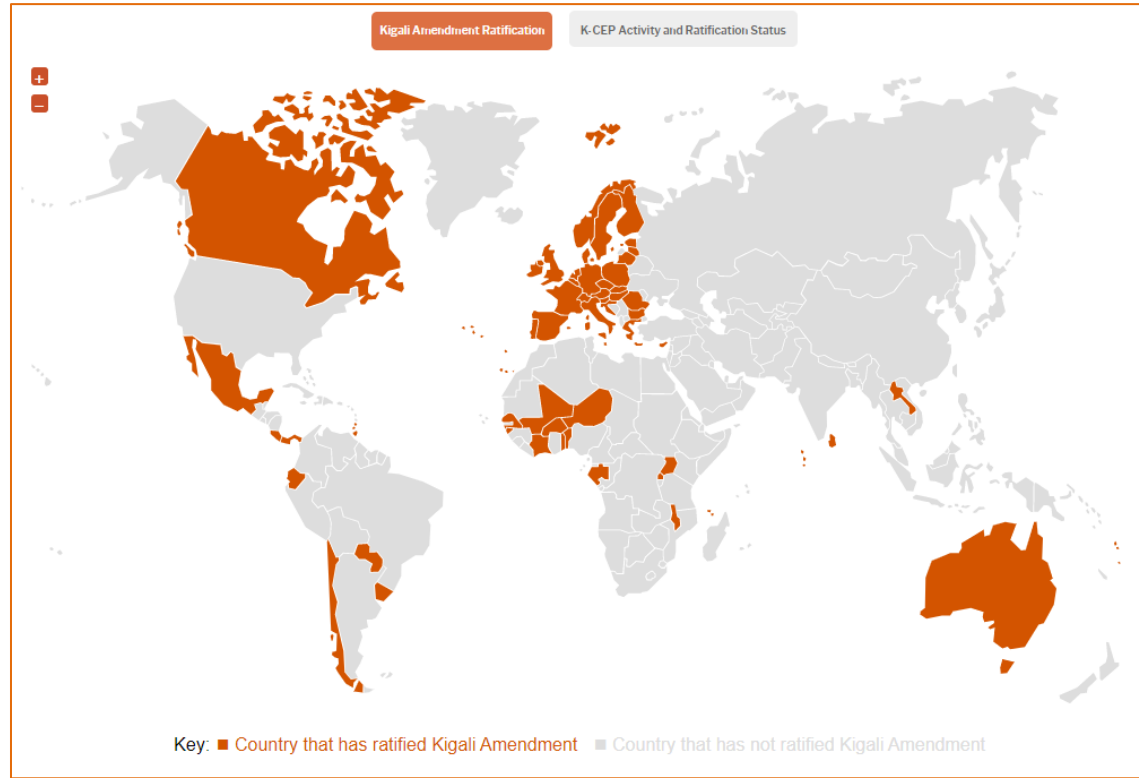


# KIGALI AMENDMENT TO THE MONTREAL PROTOCOL



- › In October 2016 a multi-national agreement was reached in Kigali, Rwanda to phase down HFCs by 85% between now and 2047
- › Based on AR4 GWP values\*
- › Phase down will be done on a GWP weighted basis
  - Eliminating higher GWP HFCs such as R404A (GWP=3940) will have more of an impact than reductions in R134a (GWP=1300)

# CANADA & MEXICO HAVE RATIFIED THE KIGALI AGREEMENT



**Sept. 2022: 138 Countries Ratified**

# UNTIL RECENTLY WHAT WAS BEING DONE IN THE UNITED STATES TO PHASE DOWN REFRIGERANTS?



- › The Significant New Alternatives Policy (SNAP) Program is the US Environmental Protection Agency's (EPA) program originally intended to evaluate and regulate substitutes for the ozone-depleting chemicals
- 2016 -17 SNAP started to set up regulations to de-list refrigerants
- The authority of SNAP was challenged in court and ruled they did not have the authority. This was appealed and declined. Supreme Court Declined to hear the case.
- The United States had no national policy

# Low GWP REFRIGERANTS – CALIFORNIA

- › California Air Resource Board (December 10, 2020 meeting) voted to approve the staff proposal on its HFC regulation. Key provisions:
  - GWP 750 ban
    - Room AC and dehumidifiers: January 1, 2023
    - VRF: January 1, 2026
    - Other AC equipment: January 1, 2025
    - Chillers: January 1, 2024
  - Refrigerant Recovery, Recycle, and Reuse (R4) Program
    - 10% use of reclaimed refrigerant by AC manufacturers for 2023 and 2024 shipments into CA
    - Early action credit for low GWP refrigerant use
      - Reclaim rulemaking in 2021. Likely excludes chillers and could source reclaim nationwide, but all TBD



# WHO IS THE US CLIMATE ALLIANCE?

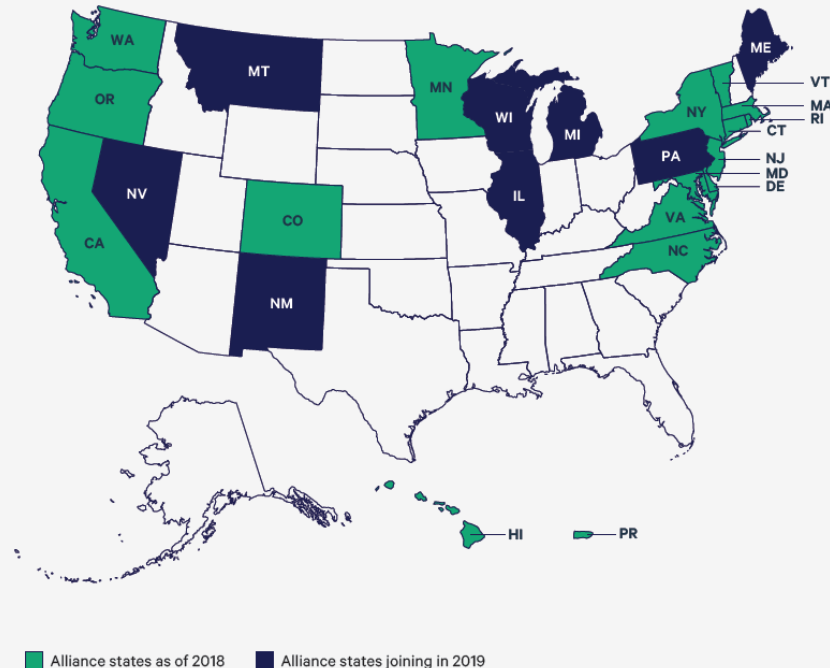
ES-MAP 1 U.S. Climate Alliance States

UNITED STATES  
CLIMATE ALLIANCE

- › 24 States and Puerto Rico will honor the Paris & Kigali Agreements
- › Reduce use of HFCs; speeding up de-listings
  - Refrigerants GWP > 750 (134a, 410A, 407C, 404A)
  - All Commercial AC and Residential AC included
- › Reduce GHG emissions to 26-28% less than 2005 levels by 2025
- › Forcing manufacturers to move fast
  - Testing for AHRI Certification, reliability, and optimization a prime issue

California  
Colorado  
Connecticut  
Delaware  
Hawai'i  
Illinois\*  
Maine\*  
Maryland  
Massachusetts  
Michigan\*  
Minnesota  
Montana\*  
Nevada\*  
New Jersey  
New Mexico\*  
New York  
North Carolina  
Oregon  
Pennsylvania\*  
Puerto Rico  
Rhode Island  
Vermont  
Virginia  
Washington  
Wisconsin\*

\*Alliance state joining in 2019



## DECEMBER 2020 – UNITED STATES TAKES ACTION

- Congress Passes Government Funding Bill with COVID-19 Relief Provisions In December, Congress passed a \$2.3 trillion legislative package to fund the government through September 30, 2021.
- The package also provided \$900 billion in Coronavirus relief and included energy and tax provisions.
- The bill also included the **American Innovation and Manufacturing Act (AIM) Act**
- **Sept. 21, 2022 - US Senate ratifies Kigali Amendment** –Rules are already in place.

# Low GWP REFRIGERANTS – FEDERAL ACTION

- › The AIM Act (American Innovation and Manufacturing Act) is now law, included within the December Omnibus spending bill
  - Gives EPA authority to phasedown HFCs roughly aligned with Kigali Amendment to Montreal Protocol
  - Establish the phase-down program and allocate allowances for production and consumption by Oct 1, 2021 (Specific rules from production in 2022 & 2023 are out, more to follow)
  - EPA will take petitions from any party for sector transitions
  - Environment groups likely to petition to reinstate SNAP Rules 20 & 21
    - Rule 21 would ban use of R134a and R410A in new chillers January 1, 2024
    - Rule 20 addresses aerosols, foams and MAC (mobile AC, i.e. automobiles)





FOR IMMEDIATE RELEASE: December 1, 2016

[www.epa.gov/snap](http://www.epa.gov/snap)

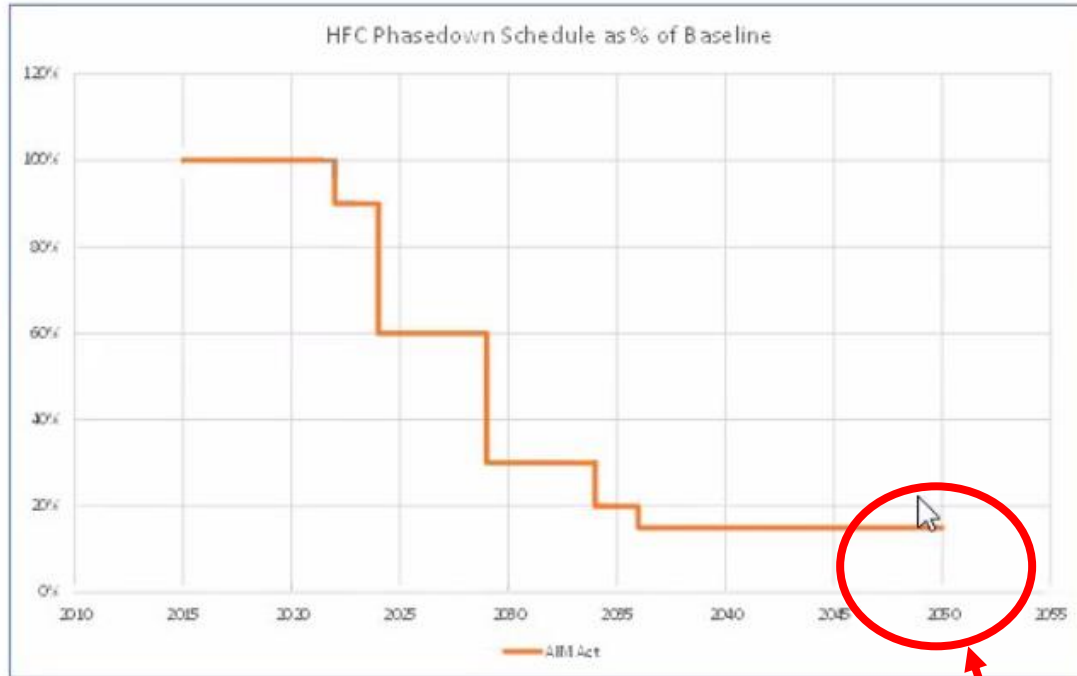
## FACT SHEET

### Final Rule 21 - Protection of Stratospheric Ozone: Significant New Alternatives Policy Program New and Changed Listings

#### CHANGE OF LISTING STATUS

End-Uses	Substitutes	Date of Change of Status
Air Conditioning		
Centrifugal chillers (new)	FOR12A, FOR12B, HFC-134a, HFC-227ea, HFC-236fa, HFC-245fa, R-125/134a/600a (28.1/70/1.9), R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-410A, R-410B, R-417A, R-421A, R-422B, R-422C, R-422D, R-423A, R-424A, R-434A, R-438A, R-507A, R5-44 (2003 composition), and THR-03	Unacceptable, except as otherwise allowed under a narrowed use limit, as of January 1, 2024
Centrifugal chillers (new)	HFC-134a for military marine vessels	Acceptable, subject to narrowed use limits, as of January 1, 2024
Centrifugal chillers (new)	HFC-134a and R-404A for human-rated spacecraft and related support equipment	Acceptable, subject to narrowed use limits, as of January 1, 2024
Positive displacement chillers (new)	FOR12A, FOR12B, HFC-134a, HFC-227ea, KDD6, R-125/134a/600a (28.1/70/1.9), R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-410A, R-410B, R-417A, R-421A, R-422B, R-422C, R-422D, R-424A, R-434A, R-437A, R-438A, R-507A, R5-44 (2003 composition), SP34E, and THR-03	Unacceptable, except as otherwise allowed under a narrowed use limit, as of January 1, 2024

# THE AIM ACT



The AIM Act phases down the consumption and production of HFCs on the following schedule compared to a baseline set in 20:

- 2022: 10% reduction
- 2024: 40% reduction
- 2029: 70% reduction
- 2034: 80% reduction
- 2036: 85% reduction

Does not go to zero!



## CHILLERS SPECIFICALLY

- **Phasedown** does not mean **Phaseout**.
- **Phasedown** does not restrict the use of HFCs in existing chillers nor require that the refrigerant be changed.
- As production of HFCs drops in accordance with the Kigali schedule, recycled and reclaimed refrigerant will play a bigger role in the aftermarket.
- Key difference between the CFC/HCFC phase-out and the HFC phase-down is the end state. Kigali allows 15% of the baseline production/consumption in 2036 for HFCs, where CFCs/HCFCs went to essentially zero.
- This means that there will be some new refrigerant available in addition to the recycle/reclaim for servicing existing installations

## DESIRE FOR REFRIGERANT CHANGE VS. CODE CHANGE

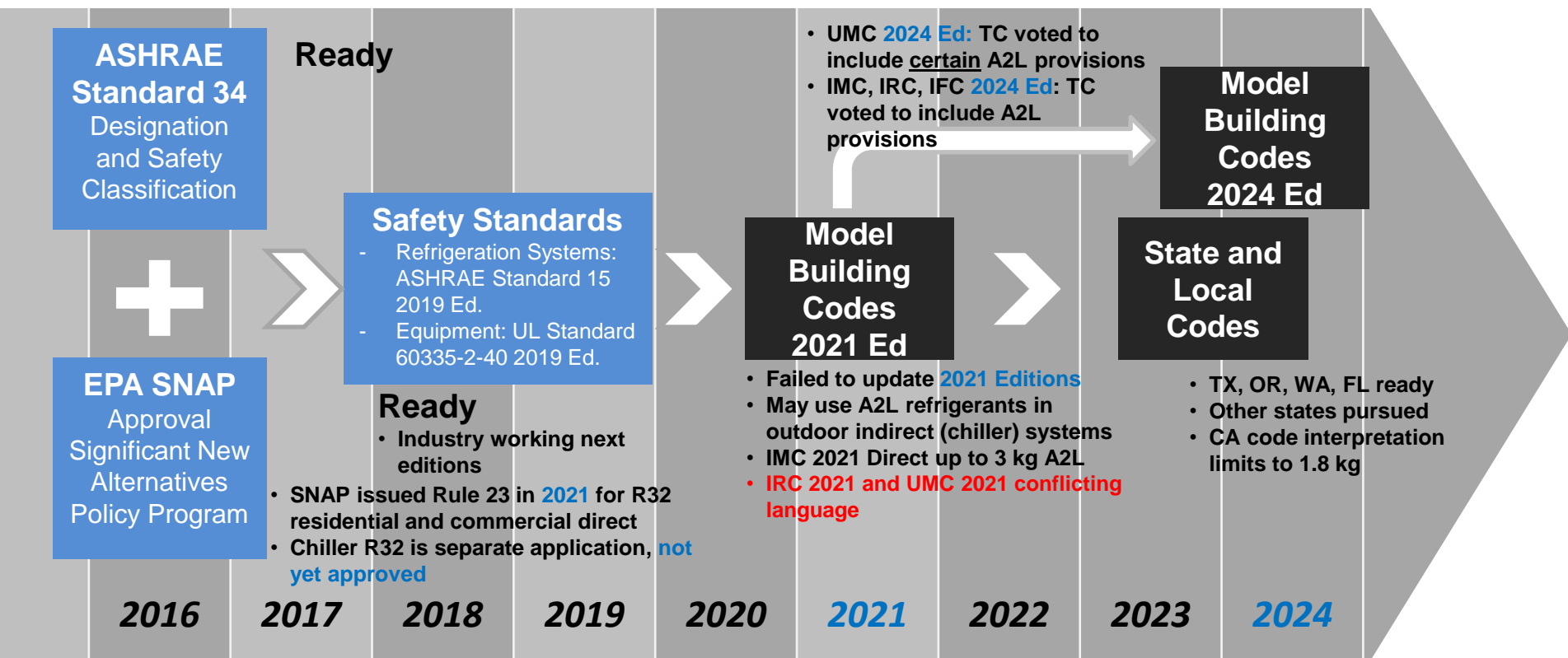


# R-134A PHASE OUT - EXEMPTION FOR PROCESS COOLING

- Industrial process air conditioning was exempt from the Jan 1, 2024 date
- The EPA considers Data Centers and Industrial Process cooling to be in this category



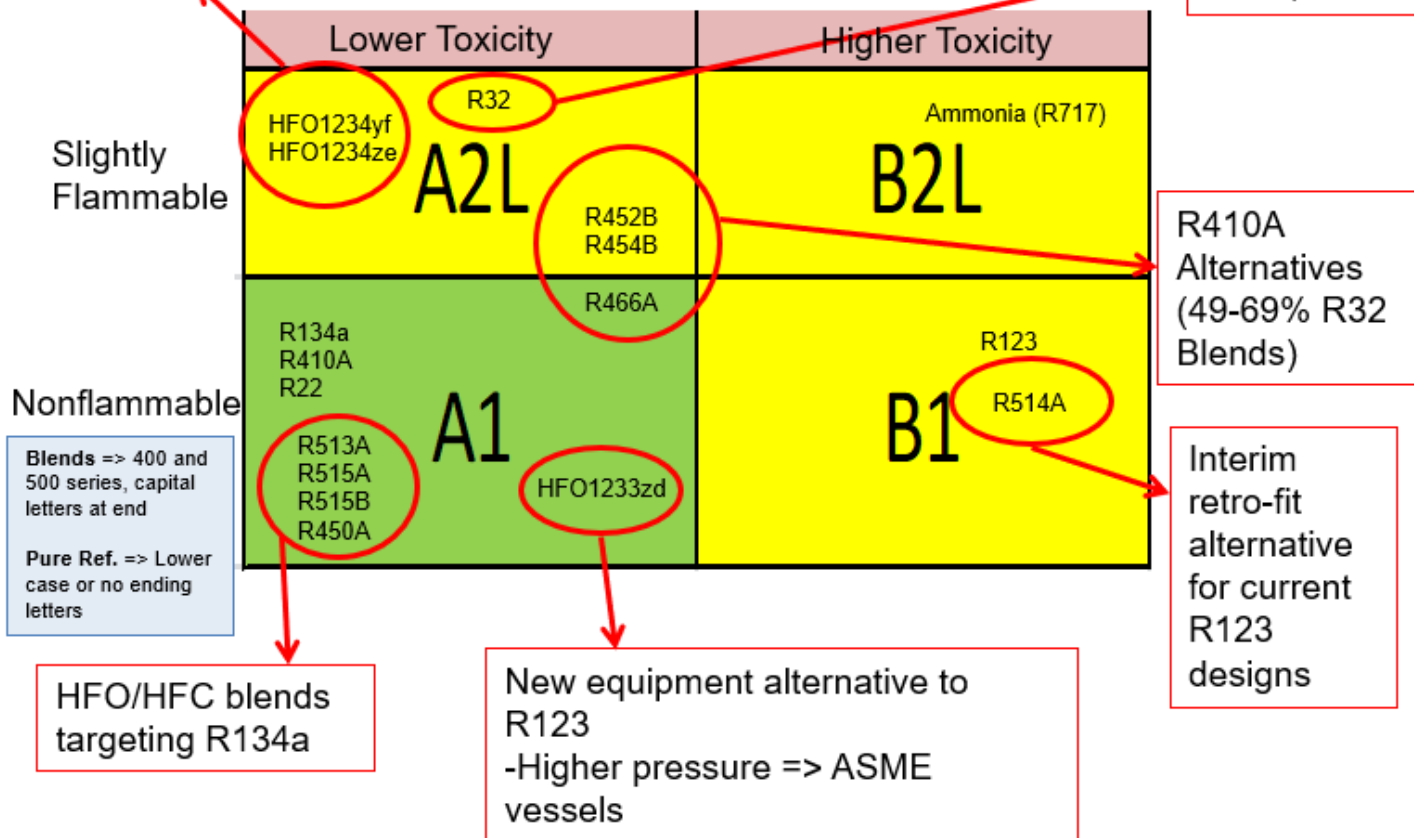
# ADOPTION PROCESS – GROUP A2L REFRIGERANTS - BRIEFLY



# BASICS – FLAMMABILITY AND TOXICITY

R134a Alternatives  
1234yf in 26/50 top 2019 auto models

Good R410A Alternative  
Being used globally  
Basis of 410A (with  
R125)



# ALTERNATIVES TO HFC134A IN POSITIVE PRESSURE CENTRIFUGAL & SCREW CHILLERS

## Now

- R-134a, a positive pressure, A1 (nonflammable, lower toxicity)
- Pure Refrigerant, GWP of 1300

## Interim Alternative

- R513A, A1 (nonflammable, lower toxicity)
- Blend (44% R134-a & 56% R1234yf), GWP of 573
- Similar capacity to R-134a, but a 2-3% negative impact on efficiency
- Recommendation – Okay if you must get below 600 GWP, if not stick with HFC134a

# ALTERNATIVES TO HFC134A IN POSITIVE PRESSURE CENTRIFUGAL & SCREW CHILLERS

## Long Term

- **R1234ze**, A2L (slightly flammable, lower toxicity)
- Pure HFO Refrigerant, GWP of 1
- Efficiency similar to R-134a
- Requires new compressor designs to match R-134a capacity, and A2L changes in building codes
  
- **R515B**, A1 (nonflammable, lower toxicity)
- Blend, (91% R1234ze, 9% R227), GWP of 292
- Good efficiency but has some capacity loss associated with R1234ze and a GWP of 292 versus 1 for R1234ze

# ALTERNATIVES IN LOW PRESSURE CENTRIFUGAL CHILLERS

**Now** – for existing HCFC123 designs

- **R-514A**, B1 (non-flammable, **higher** toxicity - limited acceptance)
- Blend (75% R1336mzz, 25% R1130), GWP of 2
- Similar performance and working pressures to HCFC123

**Now & Long Term**

- **R1233zd**, A1 (nonflammable, lower toxicity)
- Pure HFO Refrigerant, GWP of 1
- Good Efficiency
- Requires ASME certified construction (HCFC123 did not)



# ALTERNATIVES TO R-410A COMMERCIAL AIR CONDITIONERS

## SCROLL CHILLERS, ROOFTOP, WATER SOURCE HEAT PUMPS, ETC.

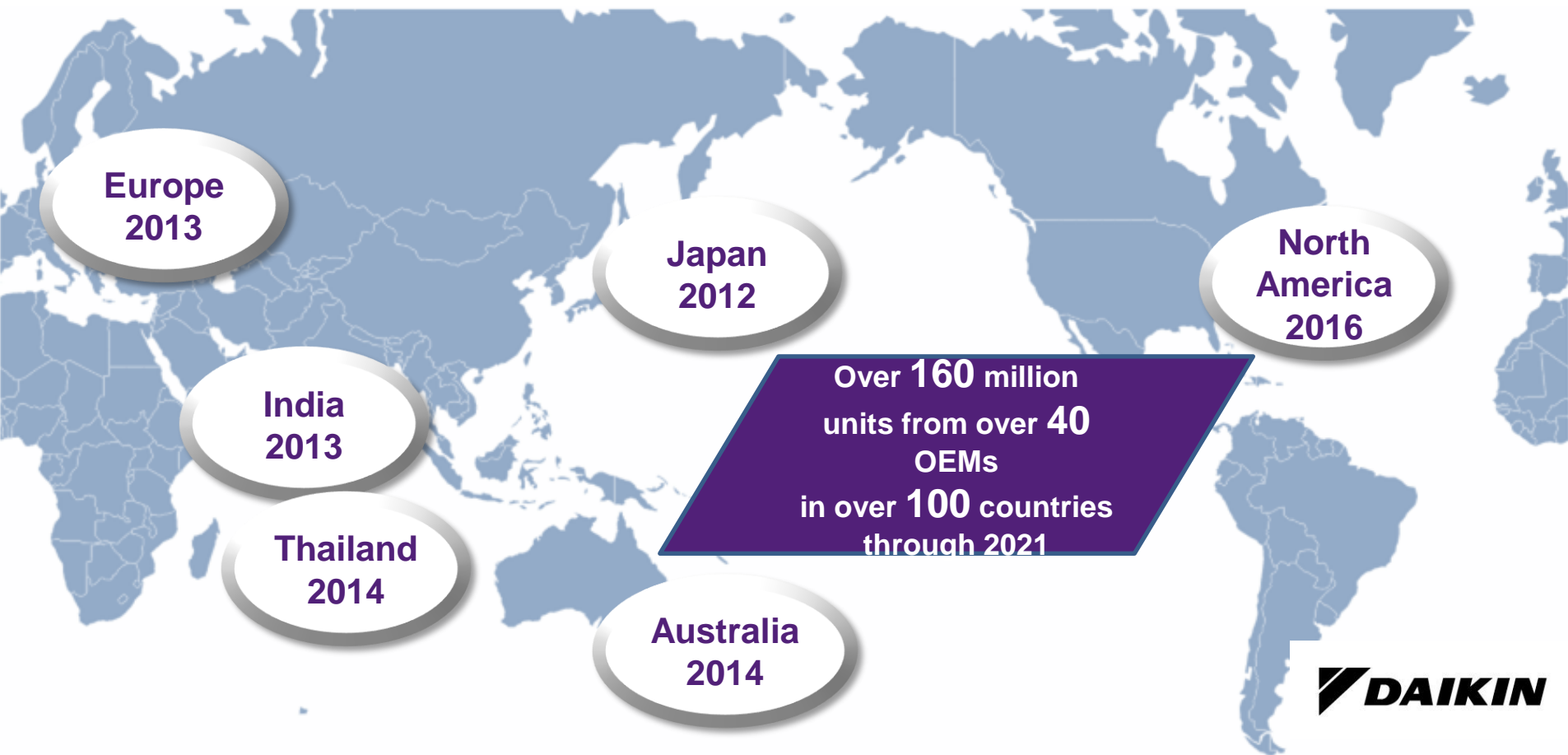
### Now

- R-410A, A1 (nonflammable, lower toxicity)
- Blend (50% R32 / 50% R125), GWP of 1924

### Long Term

- R32, A2L (slightly flammable, lower toxicity)
- Pure Refrigerant, GWP of 677
  - R32 needs less refrigerant charge than R410A and R454B to accomplish the same amount of capacity – GWP closer to 475
- 10% more capacity as compared to R-410A
- Up to 10% more energy efficient than R-410A
- Enables reduced charge, compact design and higher efficiency
- Over 160 million R32 units are in operation globally built by more than 40 OEM's

# R-32 IS A TRUSTED COMMODITY USED GLOBALLY



# WHAT TO SPECIFY AND USE TODAY?

- R-134a remains the best choice today for a positive pressure, non-flammable application (screw and centrifugal chillers). There are no restrictions on the use of R-134a at this time and it offers the most efficient and economical alternative. R513A would be a choice if customers insist on change.
- For low pressure applications, R1233zd will be the universally used A1 low-GWP long-term refrigerant for low pressure centrifugal chillers.
- R410A remains the best choice today for positive pressure equipment today.
  - We anticipate this to be the case until building codes recognize and include the use of A2L refrigerants.
  - At that time, R32 and R1234ze(E) will be the best alternatives to R410A and R134a, respectively.

# SUMMARY

- Refrigerant changes will happen in a controlled manner
- The United States is on board and playing catch with the rest of the world
- Building Codes will be a hold up
- By the time Building Codes catch up new equipment will be available with new generation of Refrigerants
- Little immediate action required now by designers

# QUESTIONS?



***GARDINER***

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