



THE FUTURE OF REFRIGERANTS

CHANGE IS ALL AROUND US

 **DAIKIN**

Presenter Background

Philip Johnston, PEng

- GM, Environmental Business Development, Daikin Applied Americas Inc.
- 21 years of HVAC experience



Market Activity

Five Daikin R1234ze chillers serve German factory

31 JAN 2021



Opteon™ XL41 (R-454B) Refrigerant Selected by Johnson Controls for Air Cooled Scroll Chiller Platform in Europe

XL41 (R-454B) provides excellent performance and long term sustainability with a 78% reduction in GWP compared to R-410A

Carrier picks R454B for ducted ac

19 DEC 2018



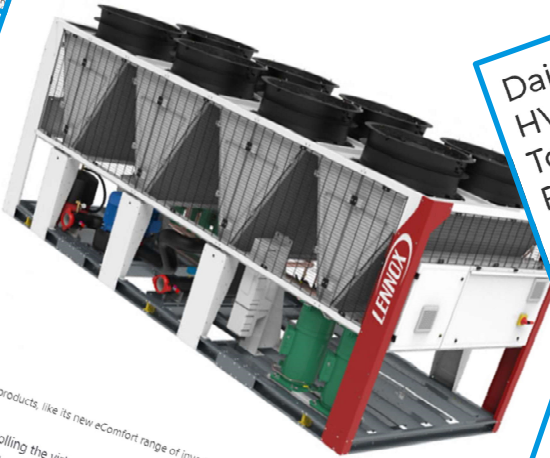
Trane to conduct field trials on R466A

29 JUN 2021



Lennox backs R32 as optimum replacement

25 APR 2021



Daikin Adopts R-32 For Key HVAC Products In North America To Reduce Greenhouse Gas Emissions And Climate Impacts

NEWS PROVIDED BY Daikin
Sep 26, 2019, 09:00 ET

WASHINGTON, Sept. 26, 2019 /PRNewswire - North America LLC: Daikin Applied Air Conditioning Inc. is developing ducted and ductless

Carrier Chooses R-32 Refrigerant for Commercial Scroll Chillers

CHARLOTTE, N.C. - Apr. 22, 2020

As part of its commitment to provide customers with solutions that use the right refrigerant for each application, Carrier has selected R-32 refrigerant to replace R-410A refrigerant, a high global warming potential (GWP) refrigerant, in commercial chillers using scroll technology. R-32 was chosen for its lower environmental impact, high energy efficiency, wide availability and ease of use. In Europe, the refrigerant will be offered in some scroll chillers beginning in the first half of 2020. Introductions will follow in other

Lennox products, like its new eComfort range of inverter scroll chillers, are...
is extolling the virtues of R32 over R-410A in scroll chiller...
top units.

Agenda

- Reason for change
- Legislation, regulation, product standards and codes
- Low GWP refrigerants proposed to replace R134a, R123 and R410A



Introduction: Daikin in the Refrigerants Landscape

To reduce environmental impact of a refrigerant throughout its life cycle, Daikin evaluates various aspects to select the appropriate refrigerant for each application, weighing safety, environmental impact, energy efficiency, & cost-effectiveness

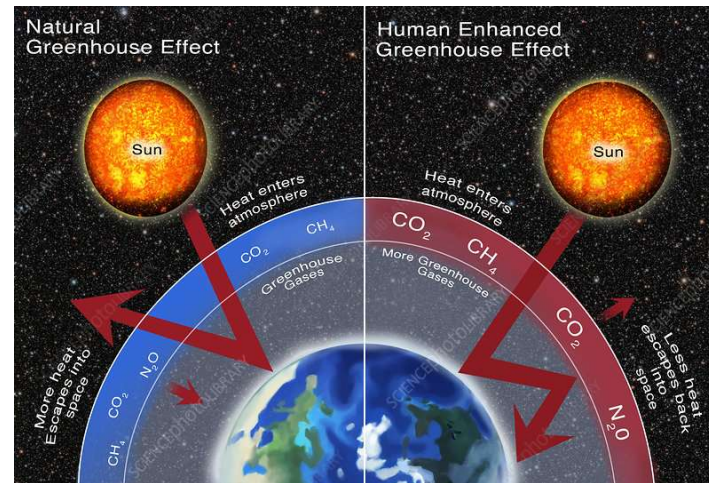
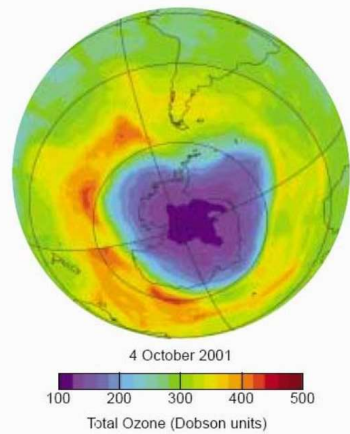
- #1 in the air conditioning business
 - Global refrigerant & environmental leader
- Widest, most comprehensive portfolio of HVAC equipment in the world
- Daikin manufactures refrigerants, offering free access to 100+ patents for R-32



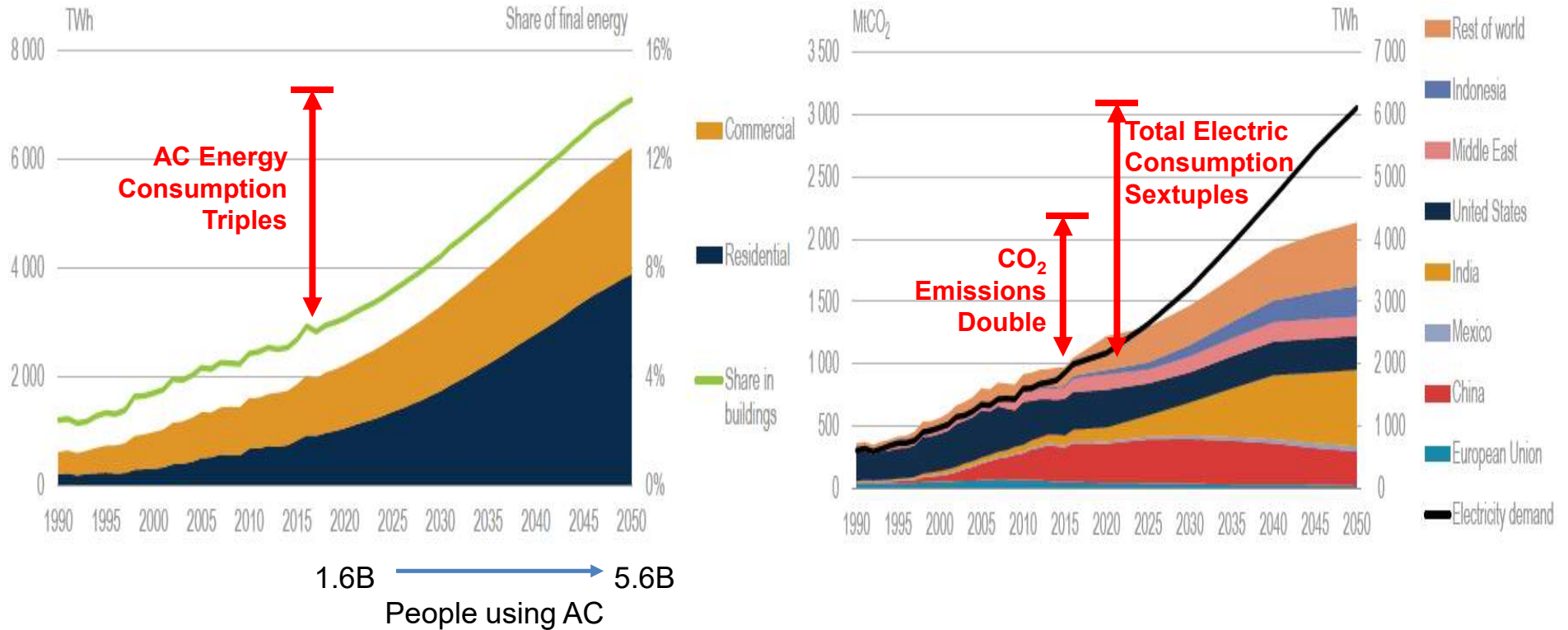
Questions You Want Answered

- **Why is HVAC&R industry changing refrigerants?**
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- What's the myth about GWP?
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

Evolution of Refrigerants

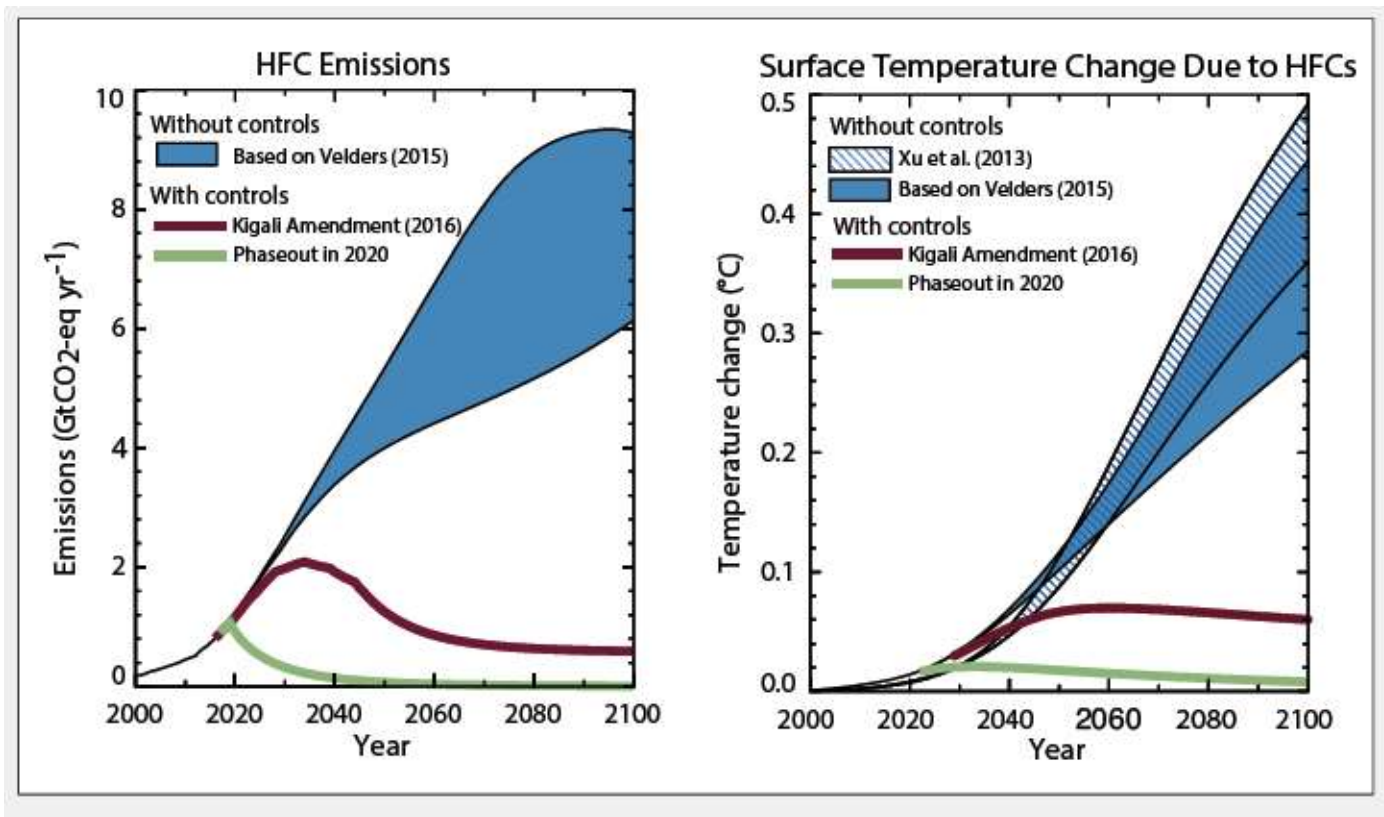


Growth of AC Through 2050: Impact to Energy Use and CO2 Emissions



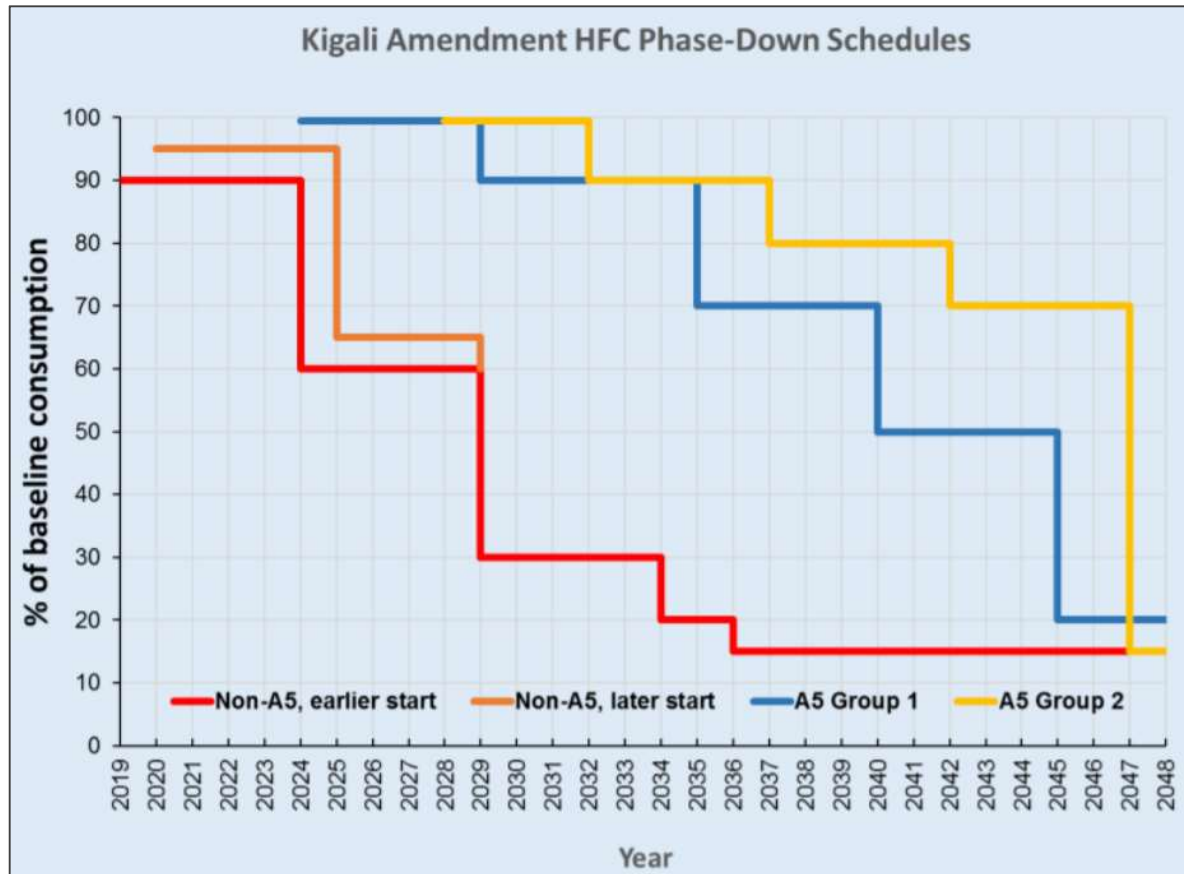
Source: IEA "The Future of Cooling"

Kigali Amendment to Montreal Protocol



Scientific Assessment of Ozone Depletion: 2018, Executive Summary

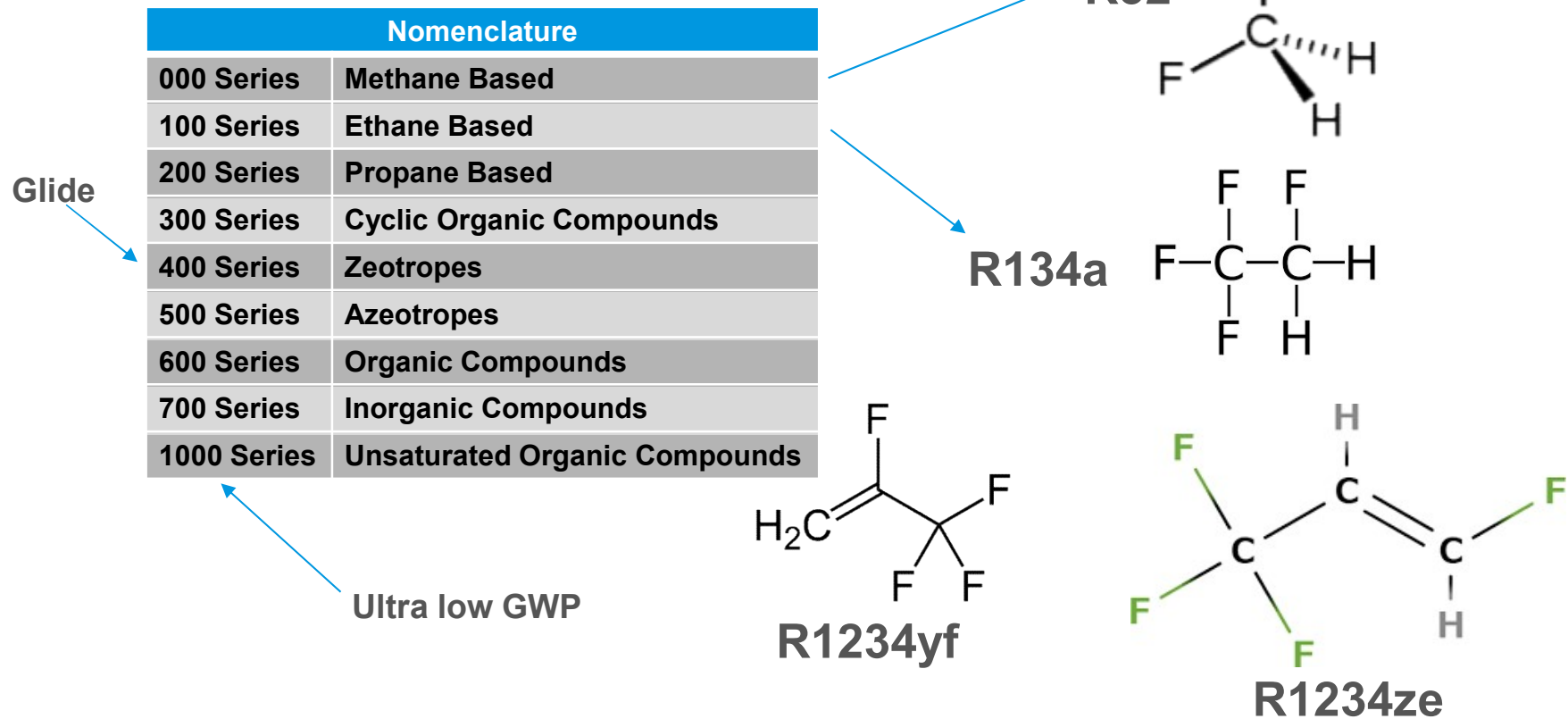
Kigali Amendment to Montreal Protocol



Questions You Want Answered

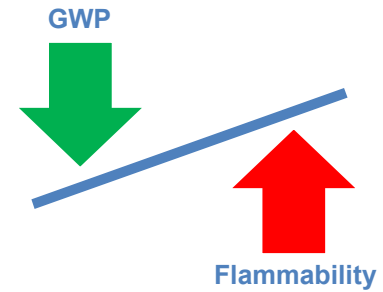
- Why is HVAC&R industry changing refrigerants?
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- What's the myth about GWP?
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

What are the Next-Gen Refrigerants?



ASHRAE 34 Basics: Flammability and Toxicity

Lowering GWP tends to increase flammability:



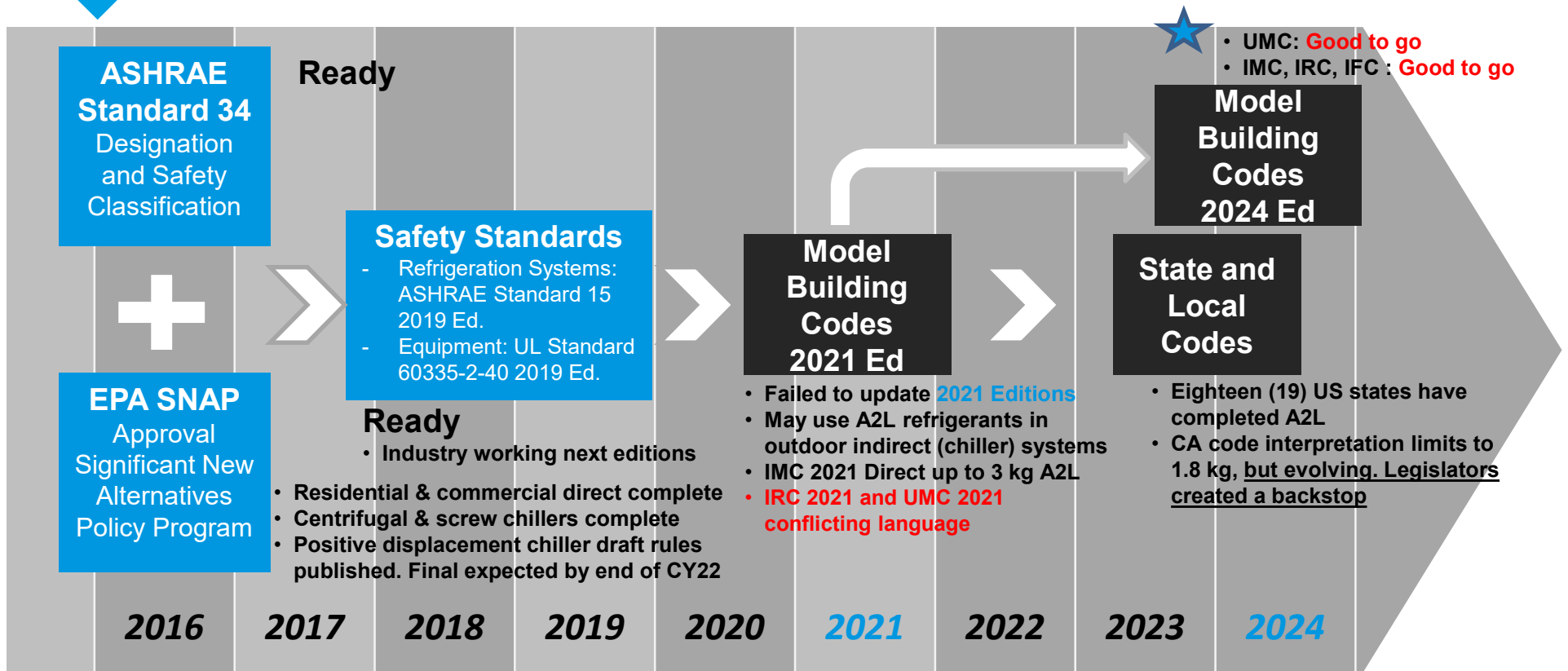
Higher Flammability (3)	A3	B3
Flammable (2)	A2	B2
Lower Flammability (2L)	A2L	B2L
No Flame Propagation (1)	A1	B1
	Lower Toxicity (A)	Higher Toxicity (B)

A2L R-1234ze(E)		B2L R-717 (Ammonia)
A1 R-134a R-513A R-515B R-1233zd(E)		B1 R-123 R-514A
R-32 R-454B	R-410A R-466A	
Medium Pressure	Low Pressure	High Pressure

Questions You Want Answered

- Why is HVAC&R industry changing refrigerants?
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- What's the myth about GWP?
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

Adoption Process: Group A2L Refrigerants - Briefly

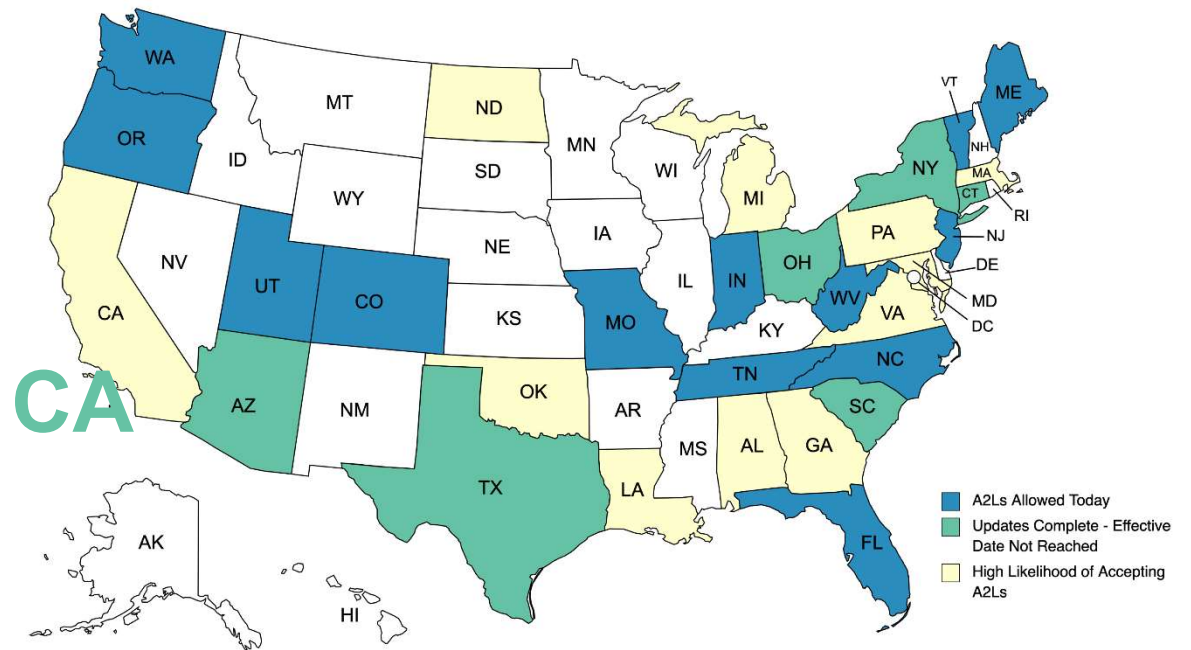


UMC, Uniform Mechanical Code
 IMC/IRC, International Mechanical Code/International Residential Code

**Group A2L Refrigerants CAN BE USED IN 13 STATES RIGHT NOW.
ALL STATES BY END OF 2024**

> CO, FL, IN, ME, MO, NC, NJ, OR, TN, UT, VT, WA, and WV already allow A2L refrigerants

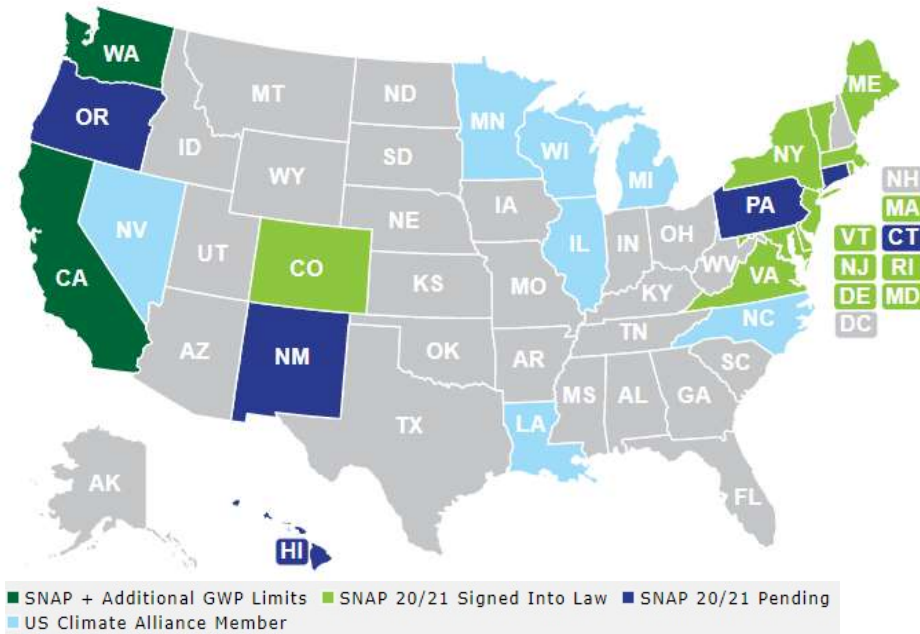
> AZ, CT, NY, OH, SC, and TX are complete, just waiting for the effective dates



Questions You Want Answered

- Why is HVAC&R industry changing refrigerants?
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- What's the myth about GWP?
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

States with HFC Legislation/Regulations



Source: <https://nasrc.org/hfc-policy>

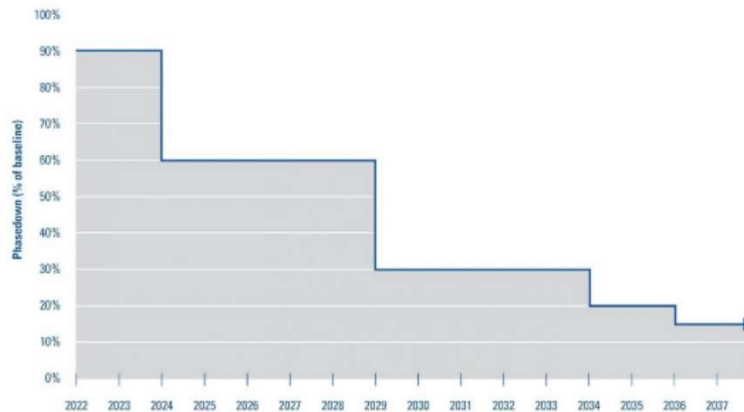
- California: 750 GWP limit
 - Jan '23 for PTAC and window AC
 - Jan '24 for Chillers
 - Jan '25 for Direct HVAC other than VRF
 - Jan '26 for VRF
- Washington state mirrors CA
- Other states with HFC regulations, have ruled on EPA SNAP Rules 20 and 21

AIM Act: Law Passed Dec. 2020 | EPA Rulemaking Sept. 2023



Phasedown Schedule

The following illustrates the HFC production and consumption phasedown schedule as outlined in the AIM Act.



©2022 Daikin Applied

- EPA must write rules to phase down production and consumption of bulk HFCs to 15% of baseline, maximize reclamation, minimize releases from equipment, and facilitate transition through sector-based restrictions
- Baseline (100%) is roughly 3 Million CO2 tonnes
 - Phase down began in 2022!!
 - 2024 - 60% of baseline
 - 2029 – 30% of baseline, etc.
- Imported Products Containing HFCs are not counted. Fair?
 - EPA has ruled in favor of 11 sector-based petitions
 - Align with CARB 750 limit and dates
 - Petitions can't delay the phasedown schedule, but may encourage an orderly and fair transition and will level the playing field for imported products

Questions You Want Answered

- Why is HVAC&R industry changing refrigerants?
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- **What's the myth about GWP?**
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

GWP is Not the Full Measure of Emissions

**Direct Effect
from
Refrigerant**



**Indirect Effect
from Energy
Use**

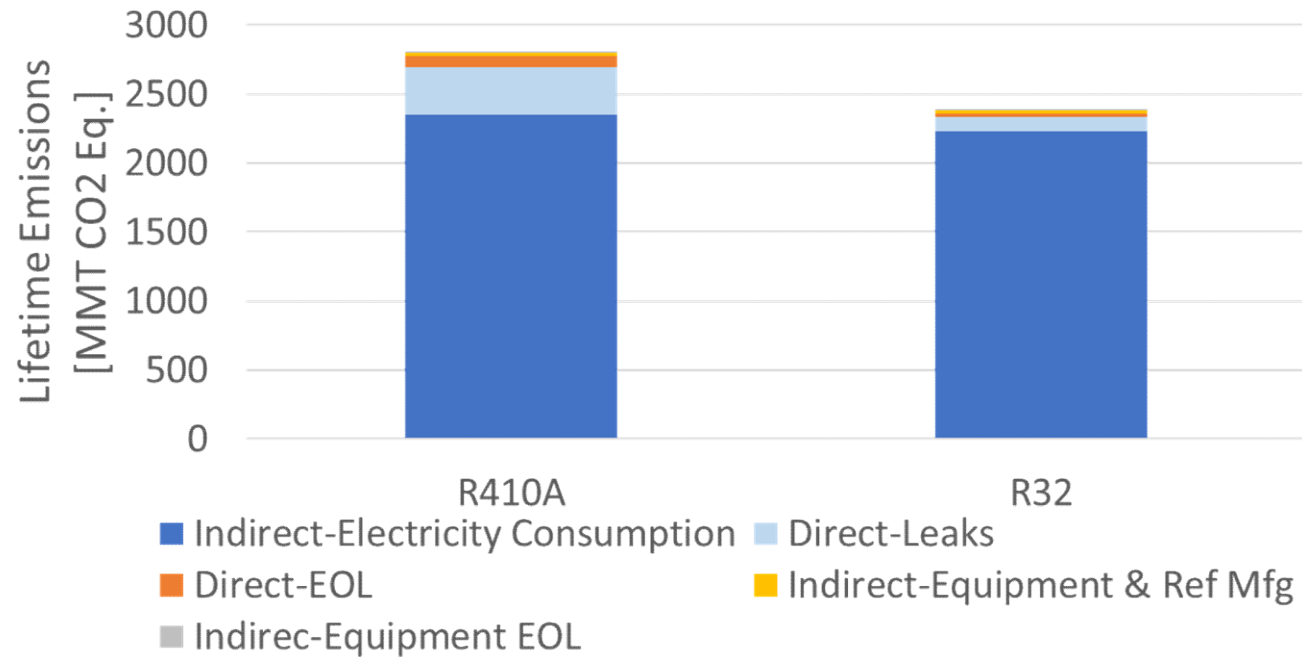


**Life Cycle
Climate
Performance
(LCCP)**

- Majority of climate impact from HVAC is electrical power generation over equipment lifetime
- A lower GWP refrigerant with lower efficiency could actually create more global warming!

Source: Zhang M., et al. 2011. "Life Cycle Climate Performance Model for Residential Heat Pump Systems." AHRTI Report 09003-01

CO₂ eq. Emissions Mostly from Electricity Consumption



Projected lifetime Residential AC & HP CO₂ Eq. Emissions in USA

Questions You Want Answered

- Why is HVAC&R industry changing refrigerants?
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- What's the myth about GWP?
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

R32

Why is R-32 the Right Choice to Replace R-410A?

PROVEN

in over 190 million
units installed around
the world

EASY

top off and recharge
R-32 in the field

EFFICIENT

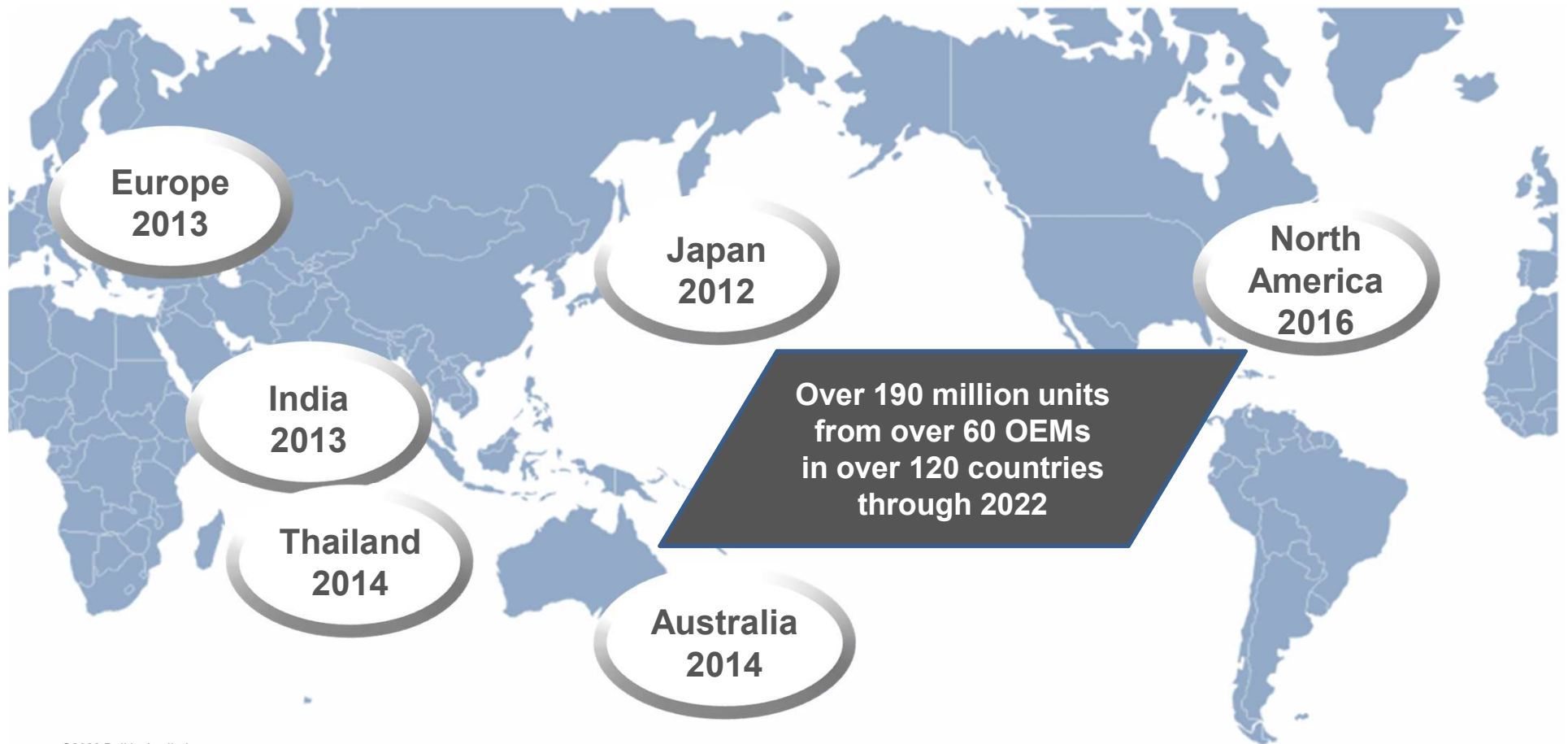
up to 12% more
efficient than
comparable R-410A
systems

AVAILABLE

a commodity with
no active patents on
the refrigerant

R-32 is a Trusted Commodity used Globally

PROVEN



R-32 Can Help Save Valuable Time, Money and Effort

AVAILABLE



COST

Less expensive than many blends to install and maintain during servicing, saving technicians valuable time and effort on site



ACCESSIBILITY

R-32 is used globally and is the base of many blends, for several decades

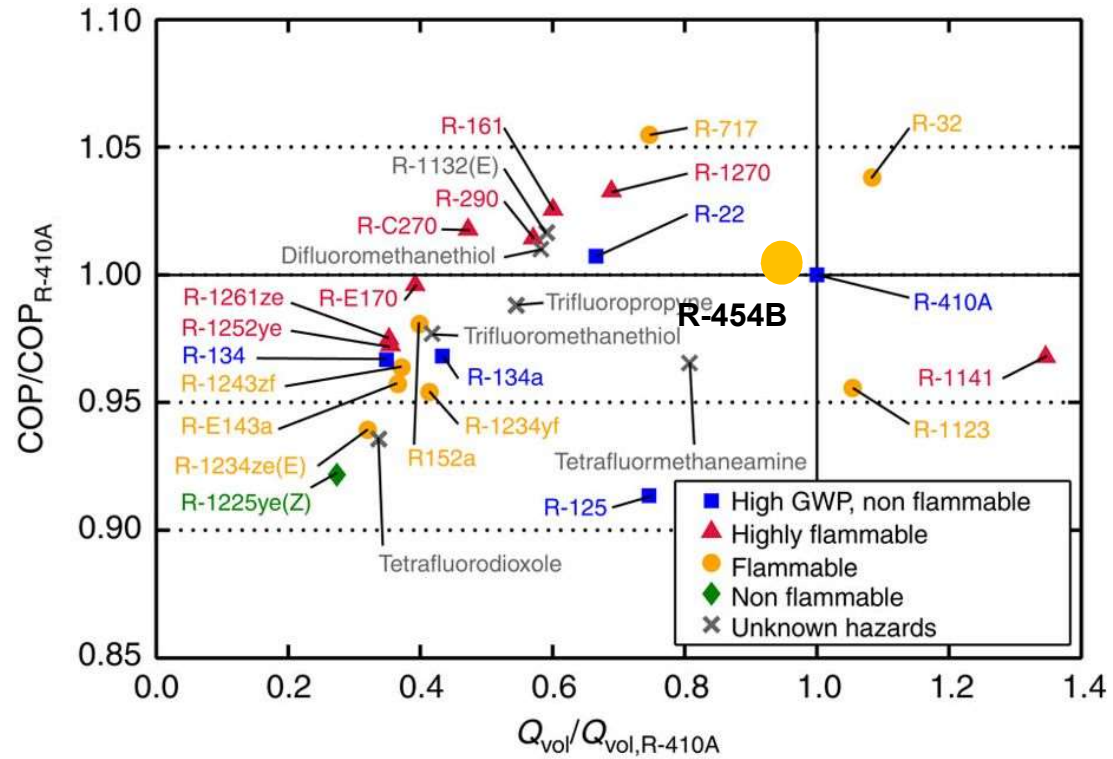
R-32 is a pure, single-component refrigerant, easy to reduce, reuse, recycle, service

- Reduce usage in the equipment
 - Reuse and easily clean on site, without changing the composition
 - Reclaim and recycle offsite in a simple cleaning process
 - Blends such as R-454B do not share these benefits
- R-32 can be changed in both liquid and gas phase
 - Blends like R-454B, should be charged in liquid phase as composition can change otherwise
 - R-32 can be topped up and recharged easily whereas blends can't
 - All of this means easier & faster service on site



R-32 Excellent Efficiency and Capacity: Better than R-410A and R454B

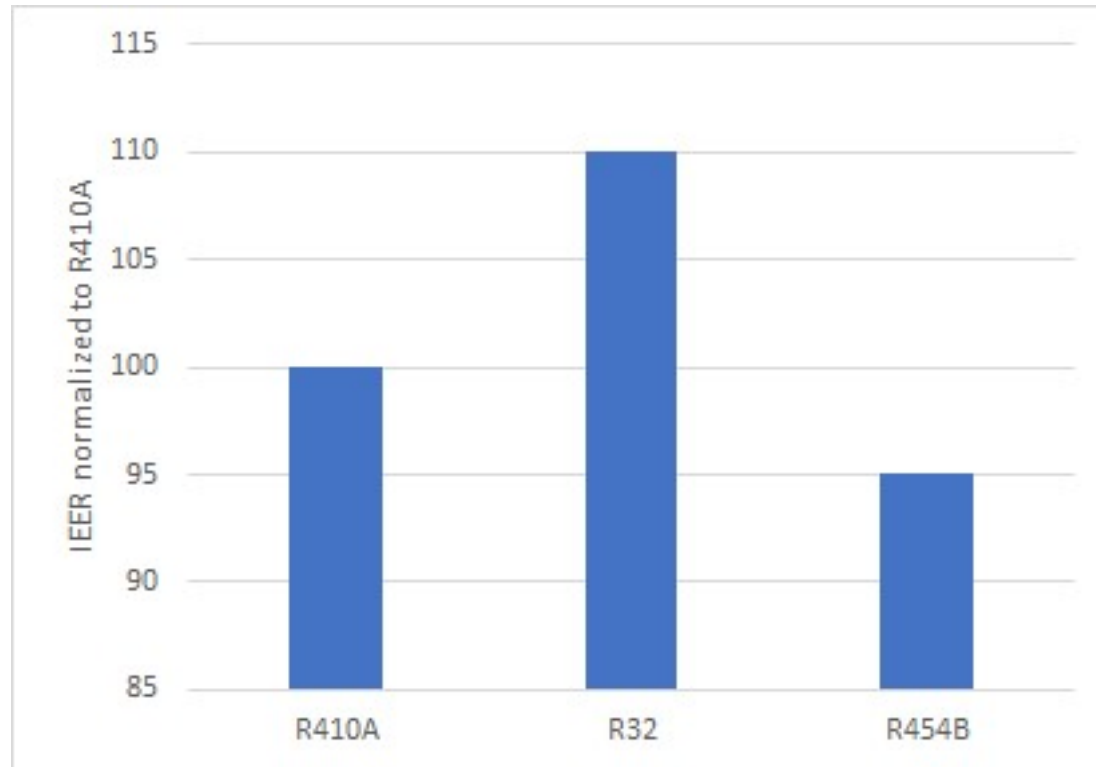
EFFICIENT



McLinden, M.O., Brown, J.S., Brignoli, R., Kazakov, A.F., Domanski, P.A., 2017. Limited options for low-global-warming-potential refrigerants. Nat. Comm. 8, 14476

R-32 Excellent Efficiency and Capacity: Better than R-410A and R454B

EFFICIENT

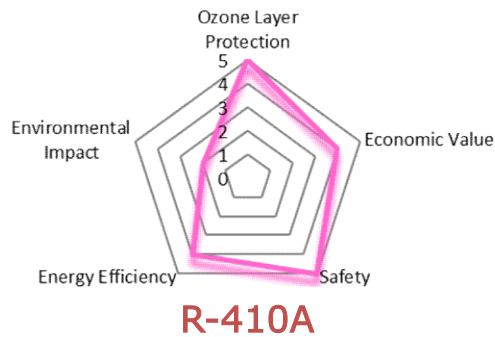


R410A, R32 and R454B test results in an inverter compressor packaged rooftop

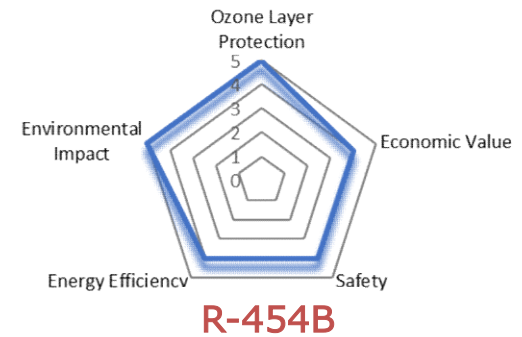
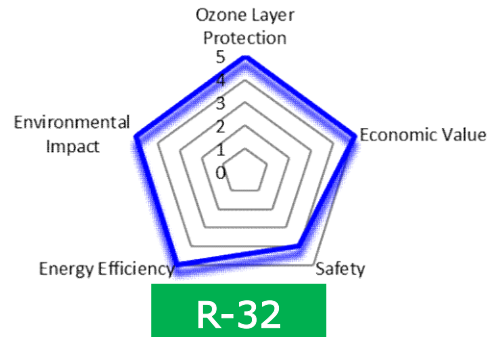
R32 Needs Less Refrigerant Charge than R410A and R454B

EFFICIENT

Less refrigerant to accomplish the same amount of capacity



LCCP : Life Cycle Climate Performance, LCA: Life Cycle Analysis



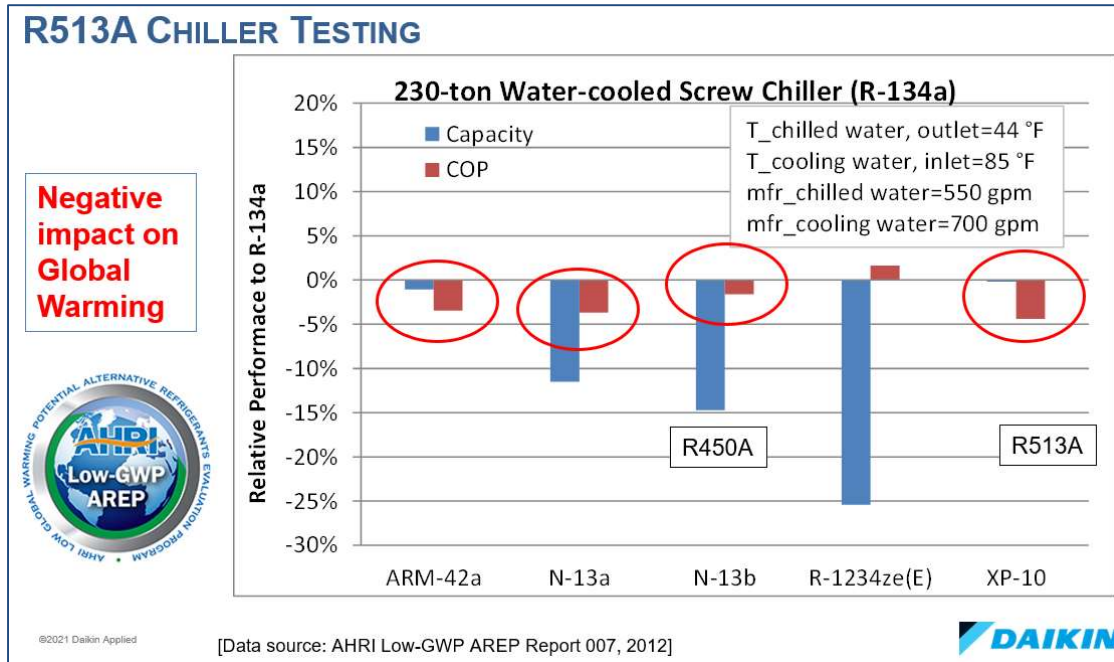
Refrigerant	Composition	ASHRAE 34 Classification	RCL (g/m ³)	GWP ₁₀₀ (AR4)	Glide (K)	Efficiency	Capacity
R410A	50% R32 / 50% R125	A1	420	2088	< 0.5		
R32	Pure 100% R32	A2L	77	675 <i>-ATS</i>	0		
R454B	68.9% R32 / 31.1% R1234yf	A2L	76	466	1.5		

“Effective” direct GWP takes into account refrigerant charge levels

Questions You Want Answered

- Why is HVAC&R industry changing refrigerants?
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- What's the myth about GWP?
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

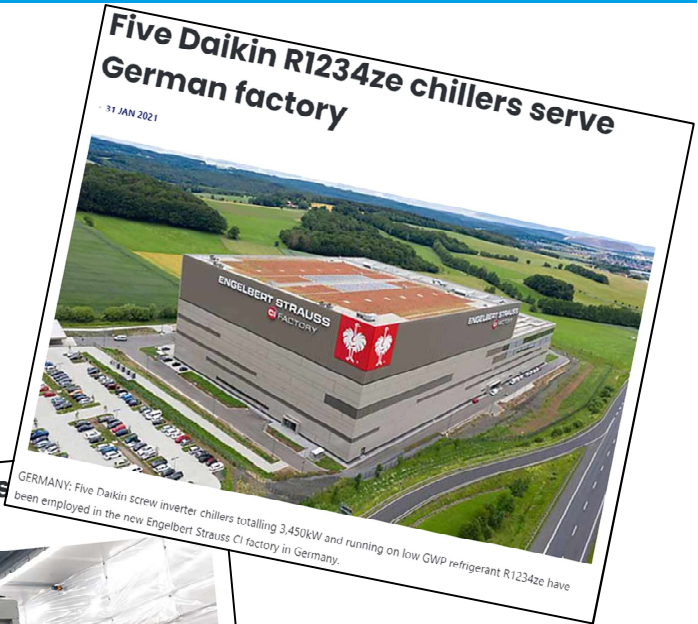
What about non-flammable No Flame Propagation R513A?



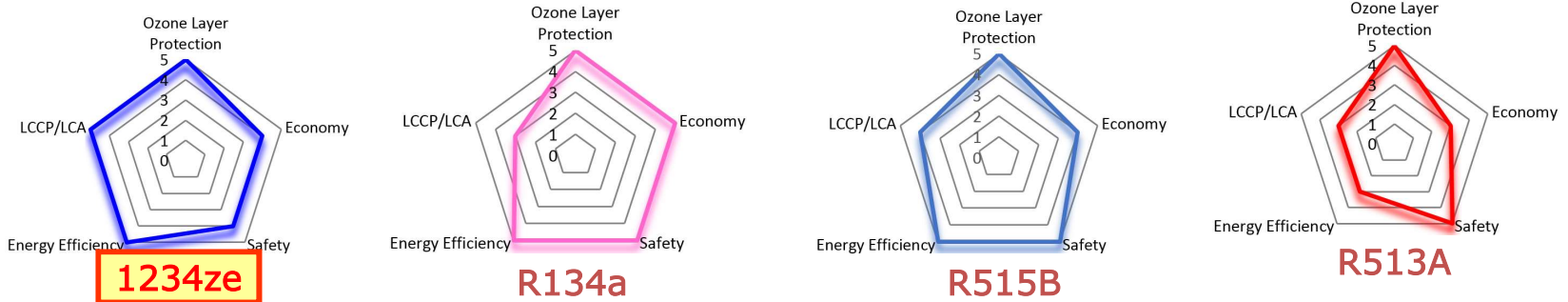
- Blend: R-134a (44%) & R-1234yf (56%)
- GWP of 631
- Offered by many major chiller manufacturers
- Group A1 – no flame propagation & lower toxicity
- 3-5% worse efficiency
- Customers demanding lower GWP refrigerant by policy or where most electrical power is renewable

What About R-1234ze(E) & R-515B?

- **R-1234ze(E)** already used by some Europeans
 - Pure, single-component refrigerant
 - 25% less capacity than R-134a
- **R-515B** is a blend comprised mostly of R-1234ze (91.1%) with 8.9% R-227ea
 - Very similar to R-1234ze from a performance standpoint
 - GWP goes from 1 to 292 but is now ~~non-flammable~~ no flame propagation refrigerant



R134a Replacements



LCCP : Life Cycle Climate Performance, LCA: Life Cycle Analysis

<i>R134a excellent value today for A1</i>	Refrigerant	ASHRAE 34 Classification	GWP ₁₀₀ (AR4)	Composition	Efficiency	Capacity	<i>R1234ze(E) excellent long-term choice</i>
	R134a	A1	1430				
	R513A	A1	631	44% R134a / 56% R1234yf			
	R515B	A1	293	91.1% R1234ze / 8.90% R227ea			
	R1234ze	A2L	1				

Questions You Want Answered

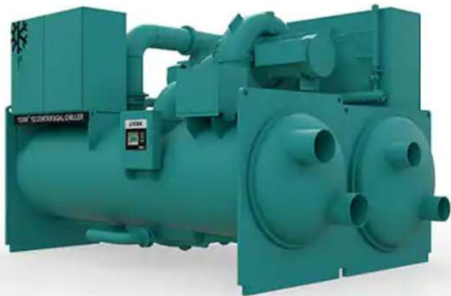
- Why is HVAC&R industry changing refrigerants?
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- What's the myth about GWP?
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

Is R514A is a Good Low Pressure Refrigerant?

R514A

- Blend: 74.7% R1336mzz + 25.3% R1130
- GWP of 2 – ultra low GWP
- Non-ASME and competitor can use much of the R123 designs
- Only one OEM
- Higher toxicity B, just like R123

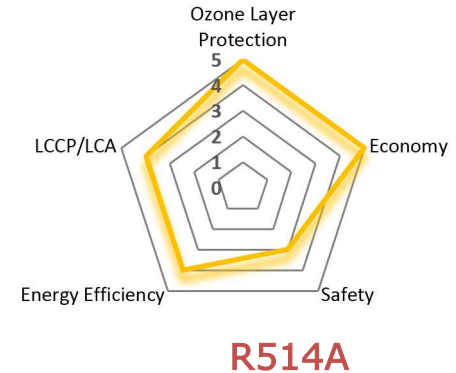
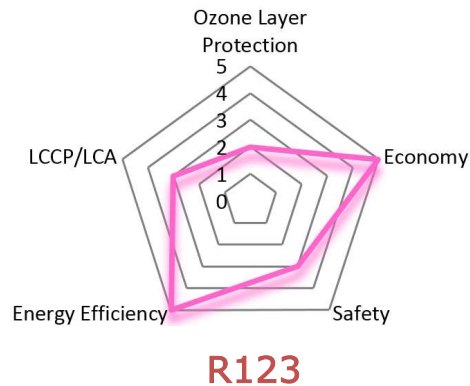
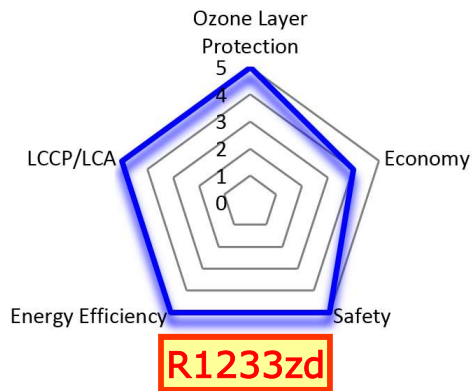
R1233zd Offered by Major Centrifugal Chiller Manufacturers



- Single component
- GWP of 1 – ultra low GWP
- Lower Pressure
- Group A1 – no flame propagation & lower toxicity
- Offered by many major chiller manufacturers



R123 Replacements



LCCP : Life Cycle Climate Performance, LCA: Life Cycle Analysis

Refrigerant	ASHRAE 34 Classification	GWP ₁₀₀ (AR4)	Composition	Efficiency	Capacity	Toxicity
R123	B1	77				Red
R1233zd	A1	~1		Yellow	Green	Green
R514A	B1	~2	74.7% R1336mzz/ 25.3% R1130	Yellow	Red	Red

R1233zd available now. Will be the most commonly used low pressure refrigerant

Questions You Want Answered

- Why is HVAC&R industry changing refrigerants?
- How are refrigerants classified in ASHRAE Standard 34?
- Are safety standards, model building codes and local building codes ready?
- When are governments transitioning to lower GWP refrigerants in HVAC sector?
- What's the myth about GWP?
- Why have some OEMs selected R454B to replace R410A?
- Will R513A be the ultimate replacement for R134a?
- Why is an OEM pushing R514A pretty hard to replace R123?
- Where can I get additional information on this transition?

Where can I go for information?



<https://www.daikinapplied.com/training>

<https://www.ahrinet.org/saferefrigerant>

<https://www.escogroup.org/training/lowgwprefrigerant.html>

<https://www.acca.org/education/a2l-refrigerants>

<https://www.rses.org/training/lowgwpa2l.aspx>

<https://www.r32reasons.com/>

R32

There's more than one good reason to choose R-32.

In fact, there are 32 of them.

Summary

Transition is Underway

Our Industry can safely commercialize low GWP refrigerants to reduce the impact of global warming

EPA has published some regulations as result of AIM Act – more regs coming

Low Pressure Centrifugal

“A1” R1233zd is available today from all chiller OEMs and the long-term solution

R134a Replacements

R515B and R1234ze(E) chiller products emerging

R513A available from all chiller OEMs

R410a Replacements

Will see R454B and R32

Single component R32 is the global standard with improved performance as compared to R410A - Proven, Easy, Efficient, Available



THANK YOU FOR YOUR TIME AND ATTENTION

For more information, contact:

- Philip Johnston
- Philip.Johnston@daikinapplied.com

