

Refrigerant Update

THE NEXT TRANSITION HAS BEGUN

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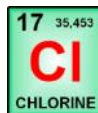


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Understanding the Timeline

Past (CFCs)
R-12, R-11, R-113 more...

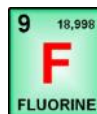


⇒ ODP

Low-ODP
or no ODP

Present (HCFCs & HFCs)

R-22, R-134a, R-410A, R-407C
R-123, R-404A R-245fa more...

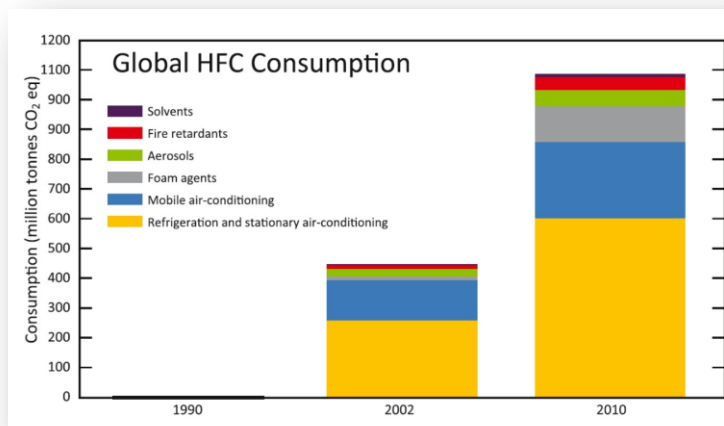


⇒ GWP

Reduced
GWP

Future (HFO & Blends)

R-1234yf, R-1234ze, R-1233zd,
R-513A, R-1336mzz, more...



**Short Atmospheric Life
Reduces Impacts**

There's more to refrigerant selection than just ODP & GWP

US Government Partnership with Industry

Executive action, reduce greenhouse gas emissions...






October 2015



White House statement: "These industry associations and companies are making significant commitments to phase out or phase down their use of HFCs and transition to climate-friendly alternatives, good for the environment and good for business,"

AHRI president and CEO Stephen Yurek stated: "Close to **\$2bn has been spent** by the industry since 2009 researching energy-efficient equipment and the utilization of low-GWP refrigerants," Yurek stated, "and over the next 10 years, the HVACR industry will invest an additional **\$5bn** for r&d and capital expenditures to develop and commercialize low-GWP technologies."

22 companies have committed to cutting HFC emissions by 2020

	Carrier , announced that its commitment to pursue the commercialization of HFC-free refrigerants in road transportation refrigeration by 2020.
	Danfoss , announced that it's championing a stakeholder task force to accelerate adoption of standards and building codes for next generation, low-GWP refrigerants.
	Johnson Controls , announced that it commits to using the lowest GWP option for each application that best fits the needs of its customers. It also committed to spend an additional \$50 million over the next three years to develop new products and improve and expand its existing portfolio.
	Goodman Manufacturing Company , commitment to help slash greenhouse gas emissions by developing low-global warming potential (GWP) air conditioners and/or heat pumps. Daikin aims to reduce its greenhouse gas emissions in 2020 to one-quarter of its 2005 emissions.
	Ingersoll Rand , commitment to slashing greenhouse gas emissions at their operations by 35%, reduce GHG associated with our products by 50% (increased unit efficiency and the transition to lower GWP refrigerants) and will invest \$500M in research and development... all by 2020

???



Final Rule - Protection of Stratospheric Ozone:

Change of Listing Status for Certain Substitutes
under the Significant New Alternatives Policy Program

Under this final rule, various HFCs and HFC-containing blends that were previously listed as acceptable alternatives will be listed as unacceptable in various end-uses in the aerosols, foam blowing, and refrigeration and air conditioning sectors where other alternatives are available or potentially available that pose lower overall risk to human health and the environment.



EPA-HFC 7-2015

Final Rule

What?

- Changes the status of certain HFCs now that safer alternatives are available

Which industrial sectors are included?

- Aerosols
- Refrigeration & Air Conditioning
- Foam Blowing

Who is affected?

- Chemical producers and some manufacturers of equipment and products using aerosol propellants, refrigerants, and foam blowing agents

When?

- Starting in January 2016; see table for dates for all affected end-uses

Signature Final Rule put into place on July 2, 2015



SNAP
SIGNIFICANT - NEW - ALTERNATIVES - POLICY

U.S. Environmental Protection Agency (EPA) that sets forth the timeframes for the phaseout of certain hydrofluorocarbons (HFCs) in specific applications...

...the EPA is using the SNAP program to help transition the industry away from high-GWP products used in refrigeration and air conditioning, aerosols, and foam-blowing sectors where lower- GWP products are available.

Refrigerants: R-404A, R-507A & R-134a

...as of Jan. 1, 2017, in supermarket systems, and Jan. 1, 2018, in remote condensing units, R-404A, R-507A, and several other high-GWP refrigerants cannot be used in new installations.

low-emissions technology by identifying and approving climate-friendly chemicals while prohibiting certain uses of the most harmful chemical alternatives." In our first effort to take a broader look at the SNAP lists, we have focused on those listed substitutes that have a high GWP relative to other alternatives in specific end-uses. In determining whether to change the status of these substitutes for particular end-uses, we performed a full comparative risk analysis, based on our criteria for review, with other available alternatives also listed as acceptable for these end-uses.

Today's Action

Under this final rule, various HFCs and HFC-containing blends that were previously listed as acceptable alternatives will be listed as unacceptable in various end-uses in the aerosols, foam blowing, and refrigeration and air conditioning sectors where other alternatives are available or potentially available that pose lower overall risk to human health and the environment. Consistent with CAA section 612 as we have historically interpreted it under the SNAP program, EPA is making these modifications based on evaluation of the substitutes addressed in this action using the SNAP criteria for review and considering the current suite of other available and potentially available substitutes.

This action modifies the listings by sector and end-use, as summarized in the table below. For a more detailed table of the status changes by sector and end-use, consult the tables in the addendum to this document.

SUMMARY OF SECTORS MODIFIED BY THE FINAL RULE

End-Uses	Final Rule Change of Status Date*
Aerosol Propellants**	
HFC-125	January 2016
HFC-134a	One year from date of publication / January 2018
HFC-227ea and Blends	One year from date of publication
Foams***	
Rigid Polyurethane and Polyisocyanurate Laminated Boardstock	January 2017
Flexible Polyurethane	January 2017
Integral Skin Polyurethane	January 2017
Polystyrene Extruded Sheet	January 2017
Phenolic Insulation Board and Bunstock	January 2017
Rigid Polyurethane Slabstock and Other	January 2017
Rigid Polyurethane Appliance Foam	January 2017
Rigid Polyurethane Commercial Refrigeration and Sandwich Panel	January 2019
Polyolefin	January 2020
Polyurethane Marine Flotation Foam	January 2020
Polystyrene Extruded Boardstock and Billet (XPS)	January 2020
Rigid Polyurethane Spray Foam	January 2020
Closed Cell Foams	January 2021
Refrigeration and Air Conditioning -- Motor Vehicle Air Conditioning	No status change finalized
HFC & HFC Blends in New Light-Duty Systems	Applicability not finalized
HFC-134a in New Light-Duty Systems	
Refrigeration and Air Conditioning -- Retail Food Refrigeration	MY 2017
Supermarket Systems (Retrofitted)	MY 2021 ****
	One year from date of publication

Phase-Out is already underway ... using existing laws

EPA Looking at Further Ban on HFCs

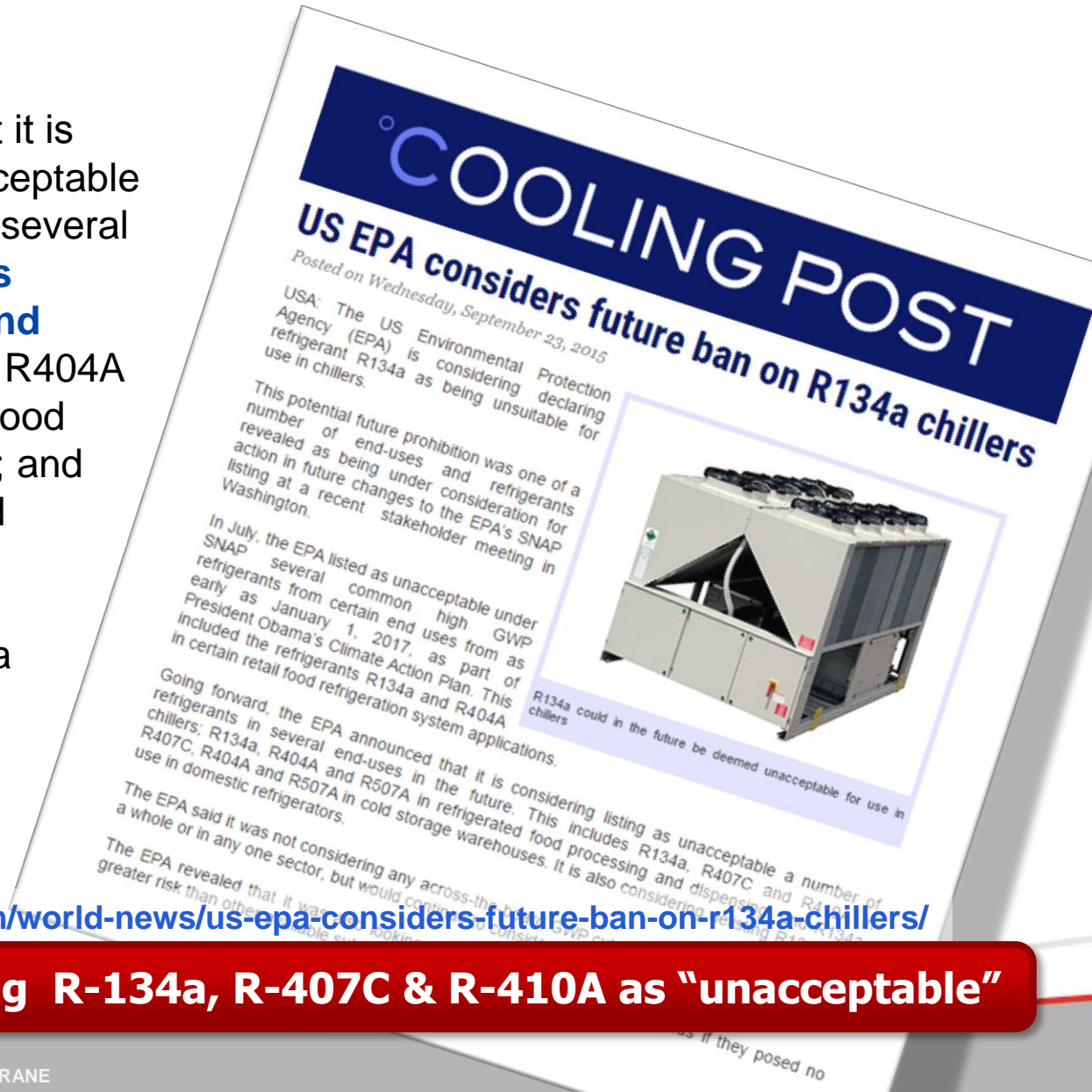
Next round of HFC listings as “unacceptable”

September 23, 2015

“...the EPA announced that it is considering listing as unacceptable a number of refrigerants in several end-uses in the future. **This includes R134a, R407C and R410A in chillers**; R134a, R404A and R507A in refrigerated food processing and dispensing; and R134a, R407C, R404A and R507A in cold storage warehouses. It is also considering delisting R134a from use in domestic refrigerators.”

<http://www.coolingpost.com/world-news/us-epa-considers-future-ban-on-r134a-chillers/>

EPA is considering listing R-134a, R-407C & R-410A as “unacceptable”



What is happening in the **Industry...**



Just looking at Air Cooled Chillers that are using something other than R-134a & R-410A



... These are just a few of the screw or scroll chillers available now with new HFO refrigerants.



New equipment offered in the market, using Low-GWP fluids

What is happening in the **Industry...**

Also available for the Water Cooled markets as well...

...both Screw and Centrifugal units.



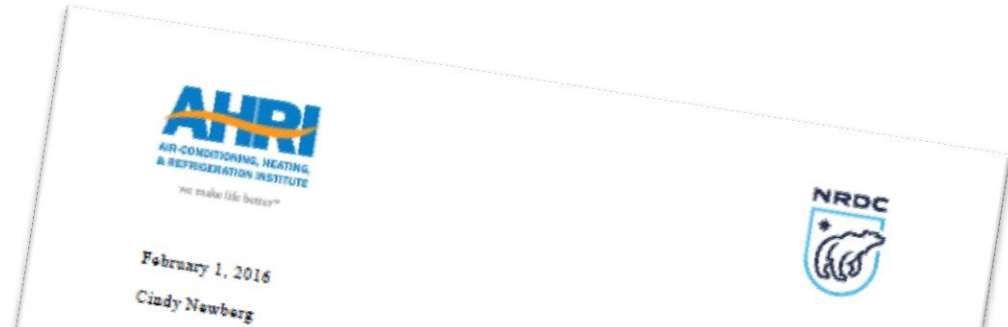
New equipment offered in the market, using Low-GWP fluids

Industry Consensus and Agreement with NRDC

AHRI Support of Phase-out of HFCs

February 1, 2016

ARCTIC COOL CHILLERS LIMITED
ARCTIC HILL
BLUE STAR LIMITED
CARRIER CORPORATION
CENTURY CORPORATION
CHONGQING GENERAL INDUSTRY (GROUP) CO., LTD.
CHONGQING MIDEA GENERAL REFRIGERATION EQUIPMENT
CLIMA-FLEX SA DE CV
CLIMACOOOL CORP.



AHRI and NRDC have engaged in discussions on the importance of responsibly moving beyond high-GWP refrigerants used in chillers. Considerations have included the safety of alternatives, the continued improvement of system energy efficiency, reasonable product development timelines, and the avoidance of market migration. With these factors in mind, AHRI and NRDC support EPA finalizing the following changes of status:

- Remove R-134a, R-410A, and R-407C from the list of acceptable substitutes in all new air-cooled and water-cooled chillers using centrifugal, screw, scroll, and all other compressor types effective January 1, 2025

This proposal allows eight years from the publication of the final rule for industry to finish designing and

ZHEJIANG DUNAN ARTIFICIAL ENVIRONMENT CO., LTD.
ZHEJIANG KING AIR CONDITIONER CO., LTD.

Remove R-134a, R-410A, and R-407C from the list of acceptable substitutes in all new air-cooled and water-cooled chillers using centrifugal, screw, scroll, and all other compressor types effective January 1, 2025

This proposal allows eight years from the publication of the final rule for industry to finish designing and bringing to market chillers using alternative refrigerants. Manufacturers will be permitted to continue to use R-134a, R-410A, and R-407C for a limited period of time. In addition, this conversion is long process members of industry face red... may permit some manufact...

Industry Support of Phase-out by January 1st 2025

Proposed Rule

What is EPA proposing?

- List as acceptable subject to use conditions, list as unacceptable, and change the status of several substances
- Exempt propane from the CAA's section 608 venting prohibition
- Clarify status of acceptable fire suppression alternative

Which industrial sectors are included?

- Refrigeration & Air Conditioning
- Fire Suppression & Explosion Protection
- Foam Blowing

Who is affected?

- Chemical producers, some manufacturers, and some end-users of equipment and products using refrigerants, fire suppressants, and foam blowing agents

When?

- Starting 30 days after publication of a final rule; see table for dates



FOR IMMEDIATE RELEASE:
March 29, 2016

www.epa.gov/snap

FACT SHEET

PROPOSED CHANGE OF LISTING STATUS

End-Uses	Substitutes	Proposed Effective Date
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, RS-44 (2003 composition), and THR-03	Unacceptable, except as otherwise allowed under a narrowed use limit, 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, RS-44 (2003 composition), SP34E, and THR-03	Unacceptable, except as otherwise allowed under a narrowed use limit, as of January 1, 2024

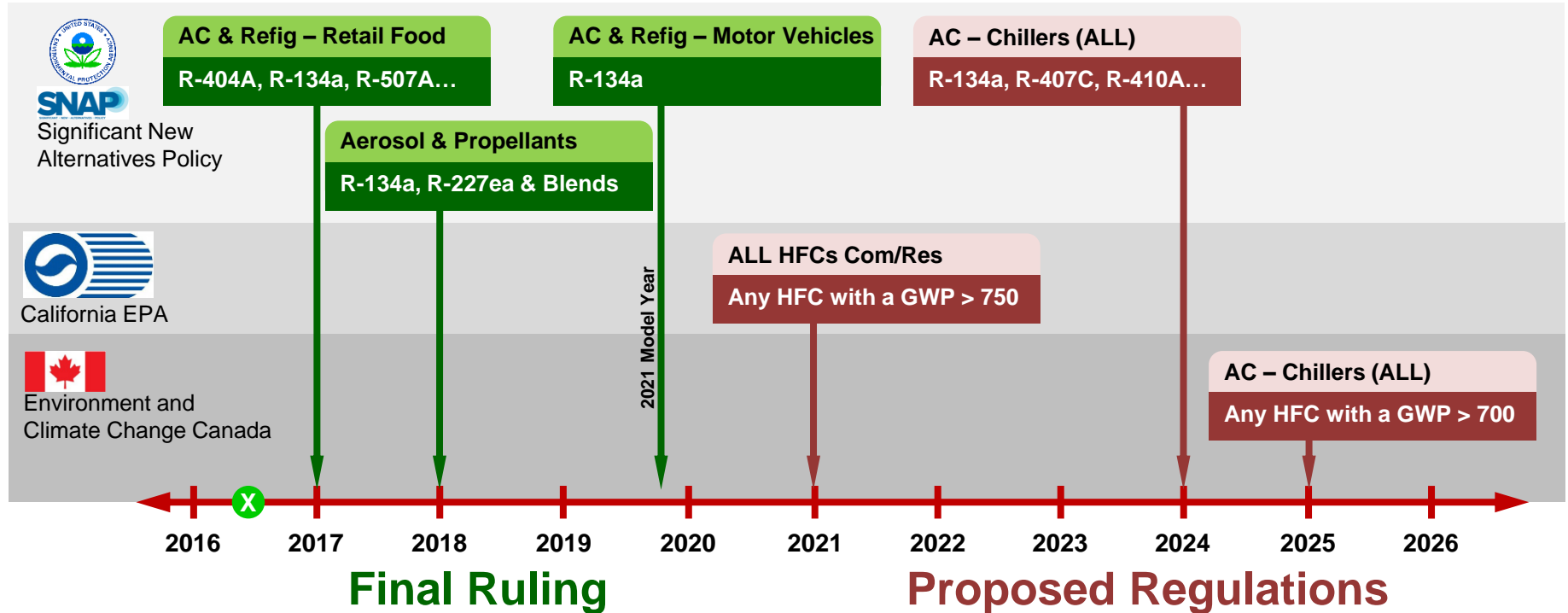


EPA Proposed
Rule

Proposed Rule sent out for public review March 29, 2016

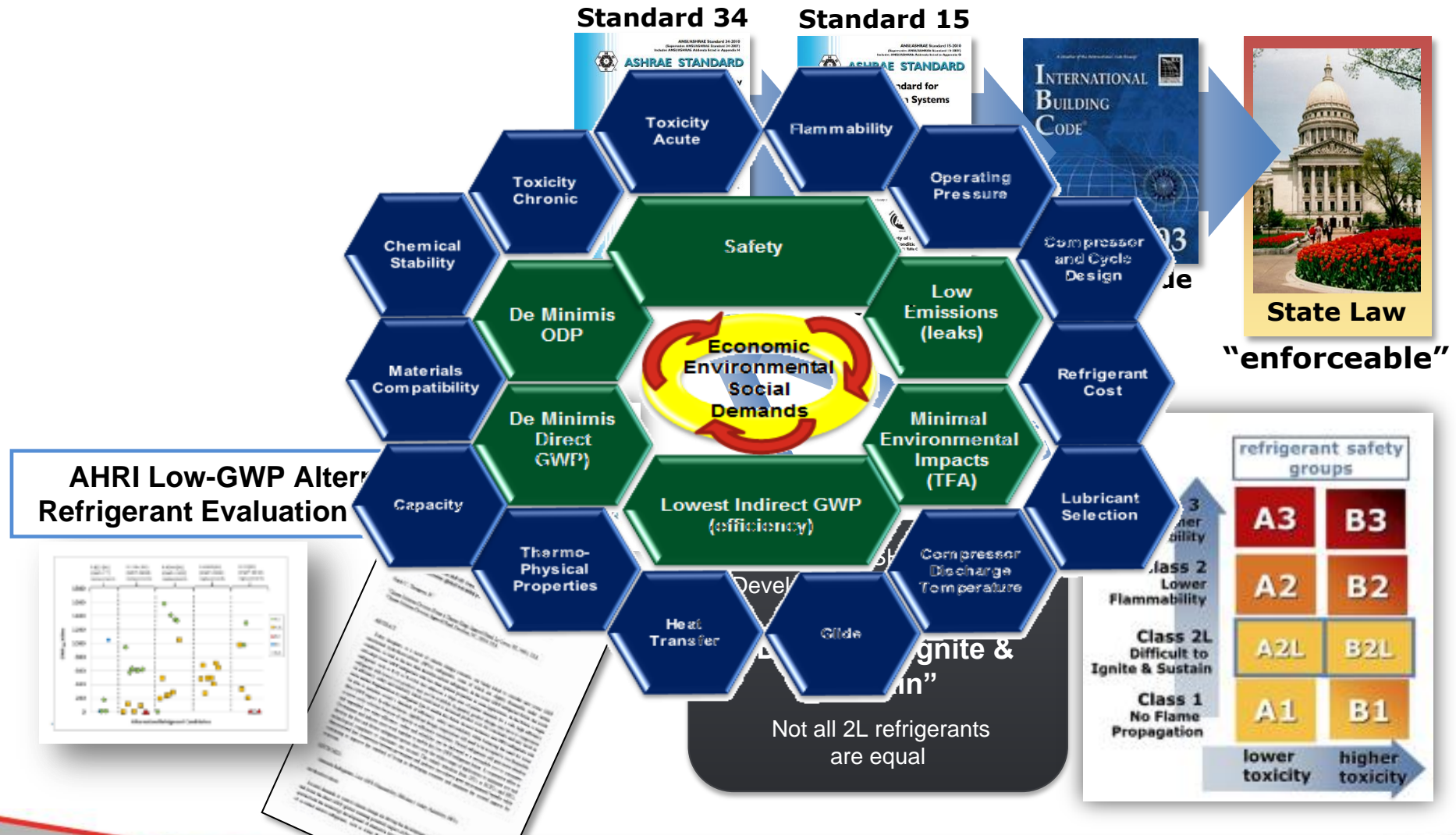
HFC Regulations in US and Canada

Ban on Shipment of New Equipment with HFCs



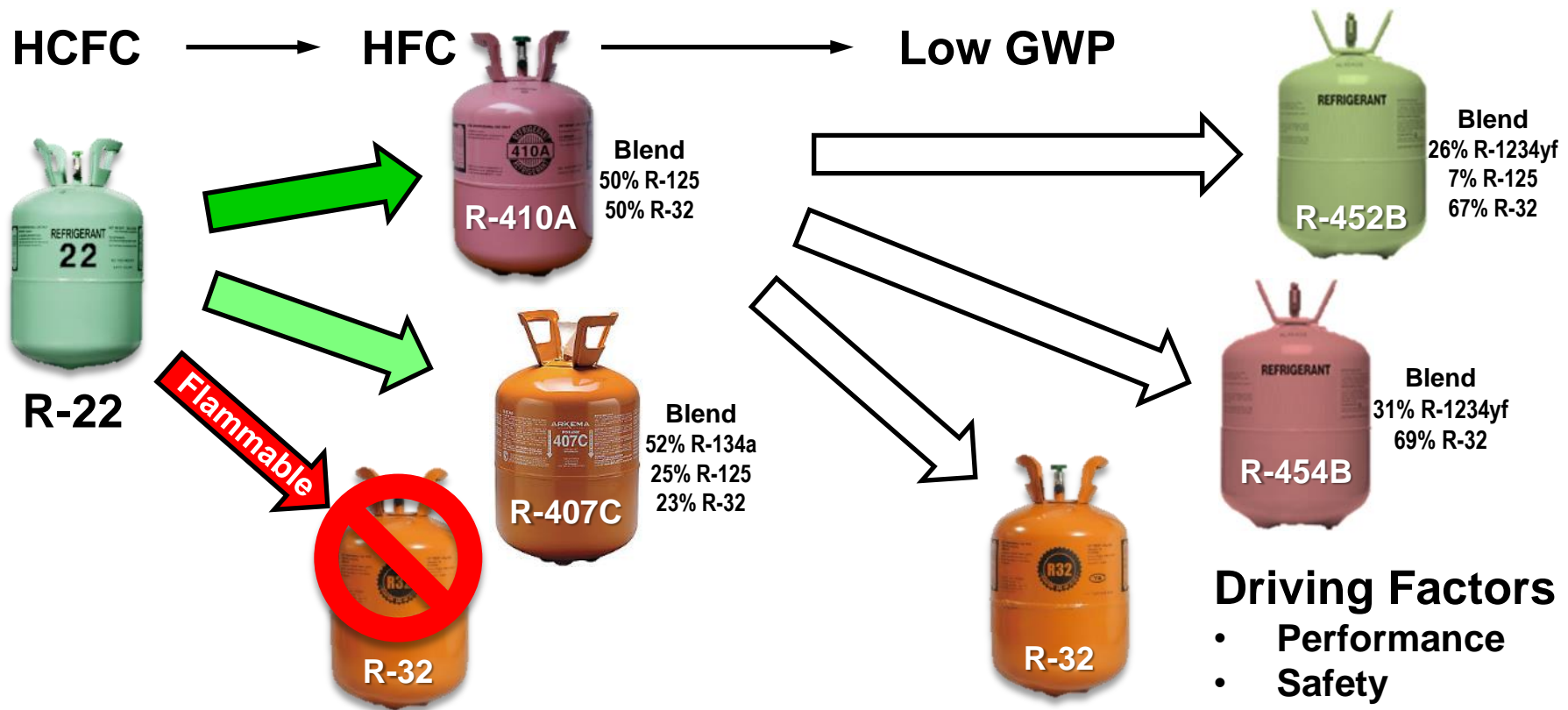
North America HFC Phase-Out dates on High GWP Refrigerants

Next-Generation Refrigerants



New refrigerants raise new questions...

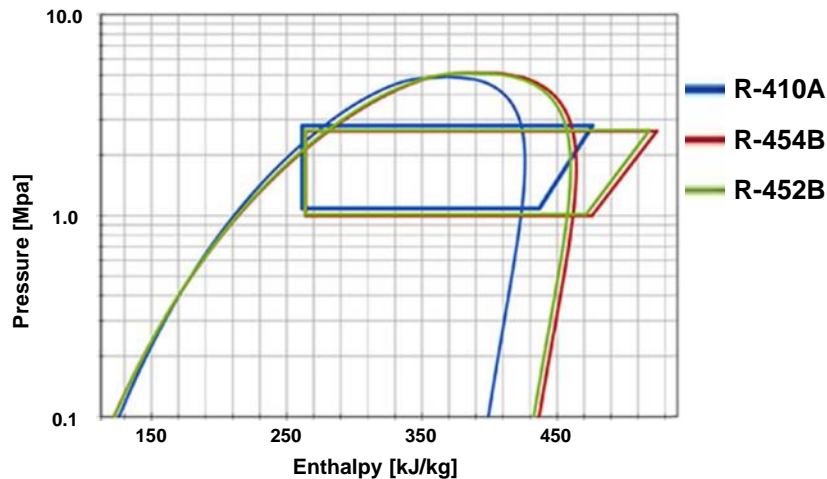
High Pressure Refrigerant Replacements



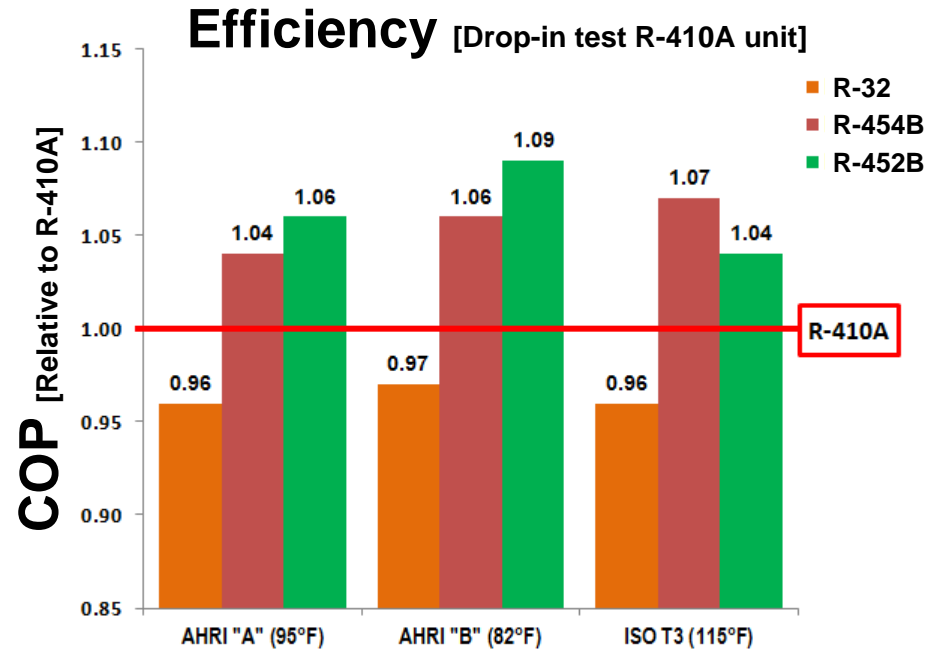
Next transition with High Pressure Refrigerants

High Pressure Refrigerant Replacements

Drop-in Tests – Performance Results



5% Improvement on efficiency
10% Reduction on unit charge



<http://www.coolingpost.com/world-news/is-dr-55-best-option-to-replace-r410a/>

R-452B provides better performance than current generation R-410A

High Pressure Refrigerant Replacements

Review of Safety

Tests are said to have shown that R-452B also exhibits a slower burning velocity and higher minimum ignition energy requirement when compared to R32.

Although R-452B has the same A2L “mildly flammable” classification as R32, Chemours maintains that some global OEMs have indicated that the lower flammability properties of XL55 are compelling and are likely to be an important consideration in product selection, especially for larger charge size equipment.

Almost **70% reduction in GWP** over R-410A



R-452B



R-454B

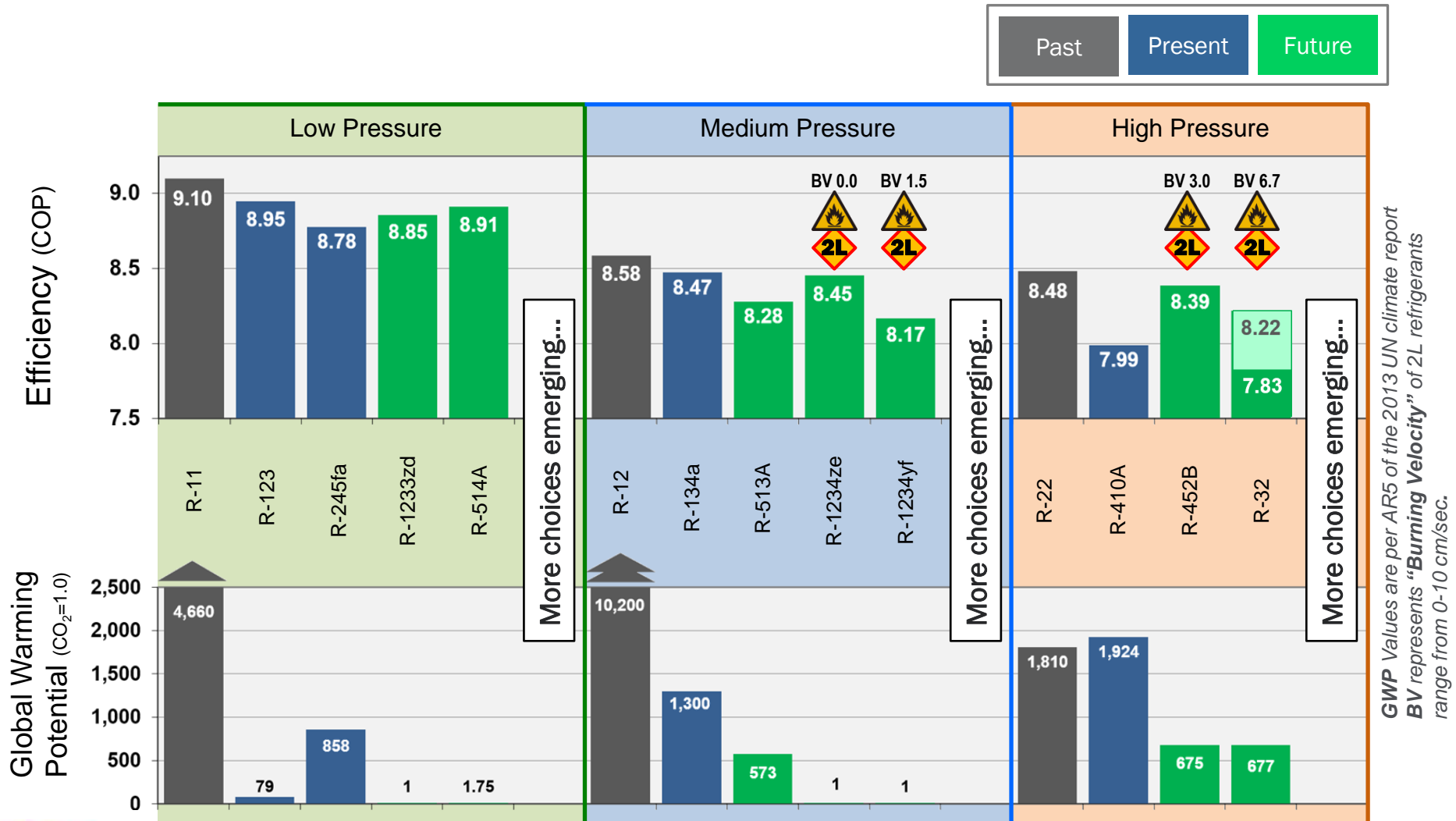


R-32

Not all 2L refrigerants are the same...

With choices now available...

Next Transition Begins...



Industry commitments and available options are increasing

Centrifugal Refrigerant Choices & Comparison



Next round of HFC listings as “unacceptable”

	Low Pressure			Medium Pressure			
	R-123	R-1233zd	R-514A	R-134a	R-513A	R-1234yf	R-1234ze
Flammability	Non (1)	Non (1)	Non (1)	Non (1)	Non (1)	Slight (2L)	Slight (2L)
Toxicity	Higher (B)	Lower (A)	TBD	Lower (A)	Lower (A)	Lower (A)	Lower (A)
Fluid Efficiency	9.4 COP	9.3 COP	9.4 COP	8.5 COP	8.3 COP	8.2 COP	8.5 COP
Capacity Change	1	35% Gain	Same	1	Same	5% Loss	25% Loss
GWP	79	1	< 2	1300	573	1	1
	In Current Trane Product Offering			In Current Trane Screw Product Offering		Under Evaluation for Trane Products	

Low Pressure

R-123	1,000 ton	
R-1233zd	1,350 ton	35% gain over R-123
R-514A	1,000 ton	

Medium Pressure

R-134a	1,000 ton	
R-513A	1,051 ton	Slight gain over R-134a
 R-1234yf	950 ton	5% loss over R-134a
 R-1234ze	775 ton	25% loss over R-134a

Replacement refrigerant impact on Efficiency, Capacity & Flammability

How Can I Protect My Investment?

- There are **no** perfect refrigerants
- Take a balanced approach
Safety, Environmental Impact, Efficiency
- R-123, R-134a, R-410A, R-404A, R-407C are all responsible HVAC refrigerant choices...**Today**
- Leak tightness is key!
Means lower emissions, higher efficiencies, lower cost

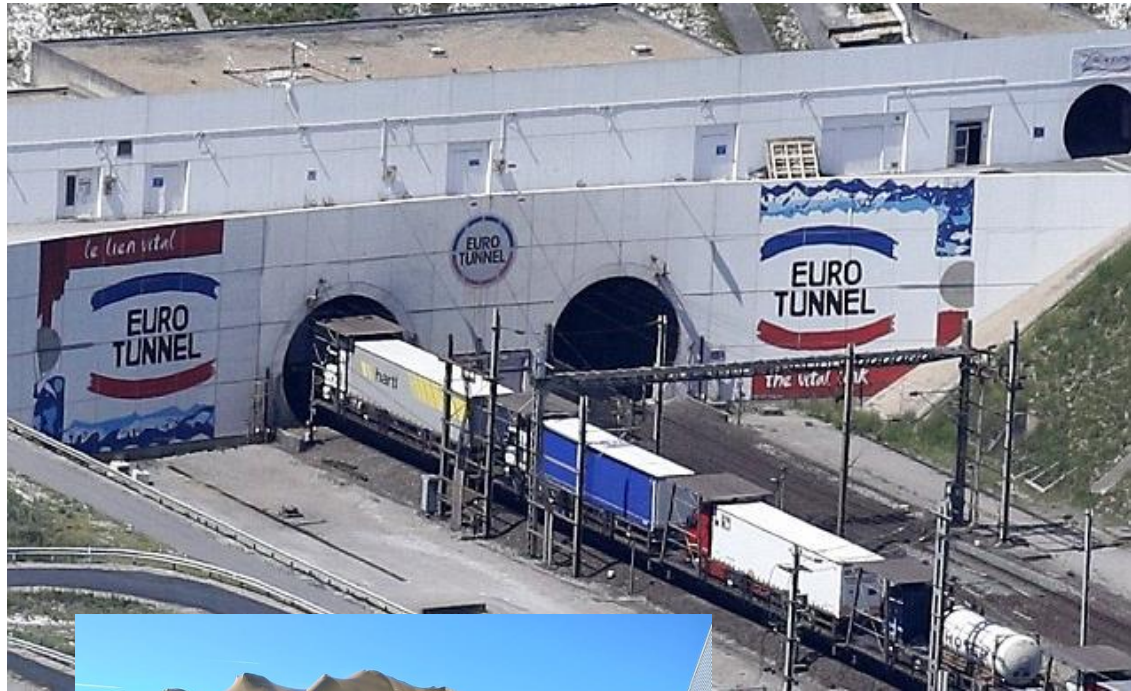


Understand the Facts

Field Example

Original Calais chiller plant went on line in 1994 supporting the temperatures needed for the tunnel. It was determined due service history and the need reduce energy consumption, to replace the chillers on the French side. These chillers perform a mission critical job because the ambient tunnel temperature would reach 55°C (130°F). This would make the trains unbearably warm for passengers, but it would probably cause equipment to malfunction and the tracks to buckle eventually.

- **Three Centrifugal Chillers**
 - Using R-1233zd “HFO”
 - 2 x 9 MW (2,560 ton)
 - 1 x 11 MW (3,130 ton)
- **Total Capacity 30 MW (8,523 tons)**



Low-GWP Solution that Exceeds Performance and Efficiency of the PAST

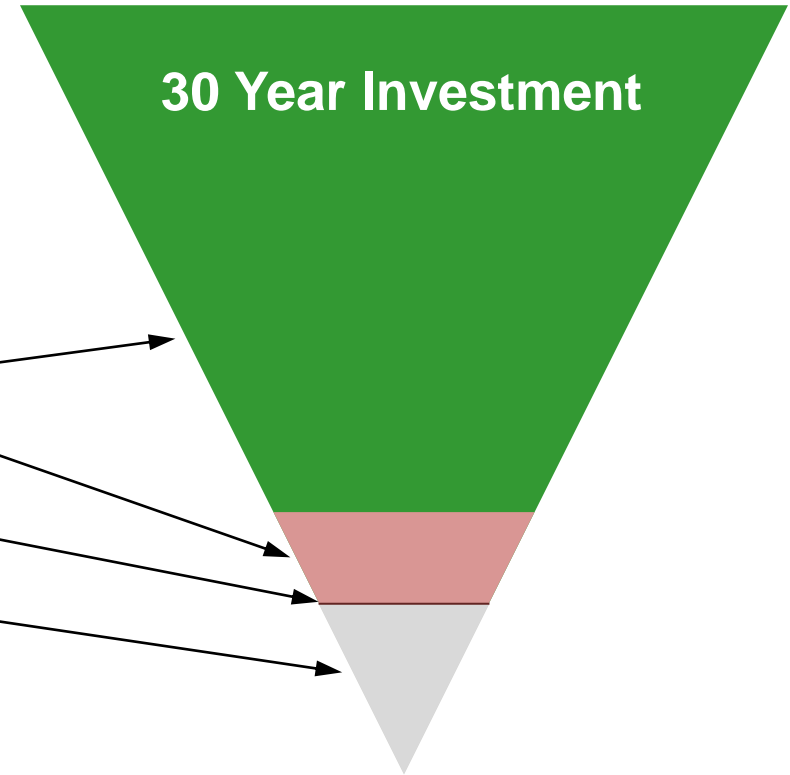
How Can I Protect My Investment?

All refrigerants use today are and will be – available for the life of the equipment.

Focus on reliable, efficient designs

Lifetime of Electricity	88.51%
Lifetime of Service	6.53%
Lifetime Refrigerant Supply	0.04%
“First Cost” Chiller/Refrigerant	4.92%

Let us worry about the refrigerant!



A Balanced Approach, with a Focus on Efficiency