

Climate Change Regulation and the Next Generation of Refrigerants

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Increasing Global Threats to the HFC's

- R-134a banned from autos in Europe in 2013
- R-134a “incentivized” out of use in autos in US in 2016
- European countries such as Denmark, Austria, and Switzerland have already banned most uses of HFC's.
- Refrigerant manufacturers are aggressively working to develop a new generation of lower GWP refrigerants (HFO's) to replace current generation of HFC's (R-134a, R-410A, R-407C)
- USA/Mexico/Canada proposal to the Montreal Protocol to phase down HFC's (70% reduction by 2029)
- US formation of CCAC (Climate and Clean Air Coalition)- now with 50 member nations
- Aggressive “GWP” taxes in Australia, Norway, Denmark, Sweden, Germany
- EU proposing phase down/phase out of HFC's in EU, calls to reduce HFC's 79% by 2030
- Foam manufacturers making transition now out of high GWP HFC's



Why Go After HFC's?

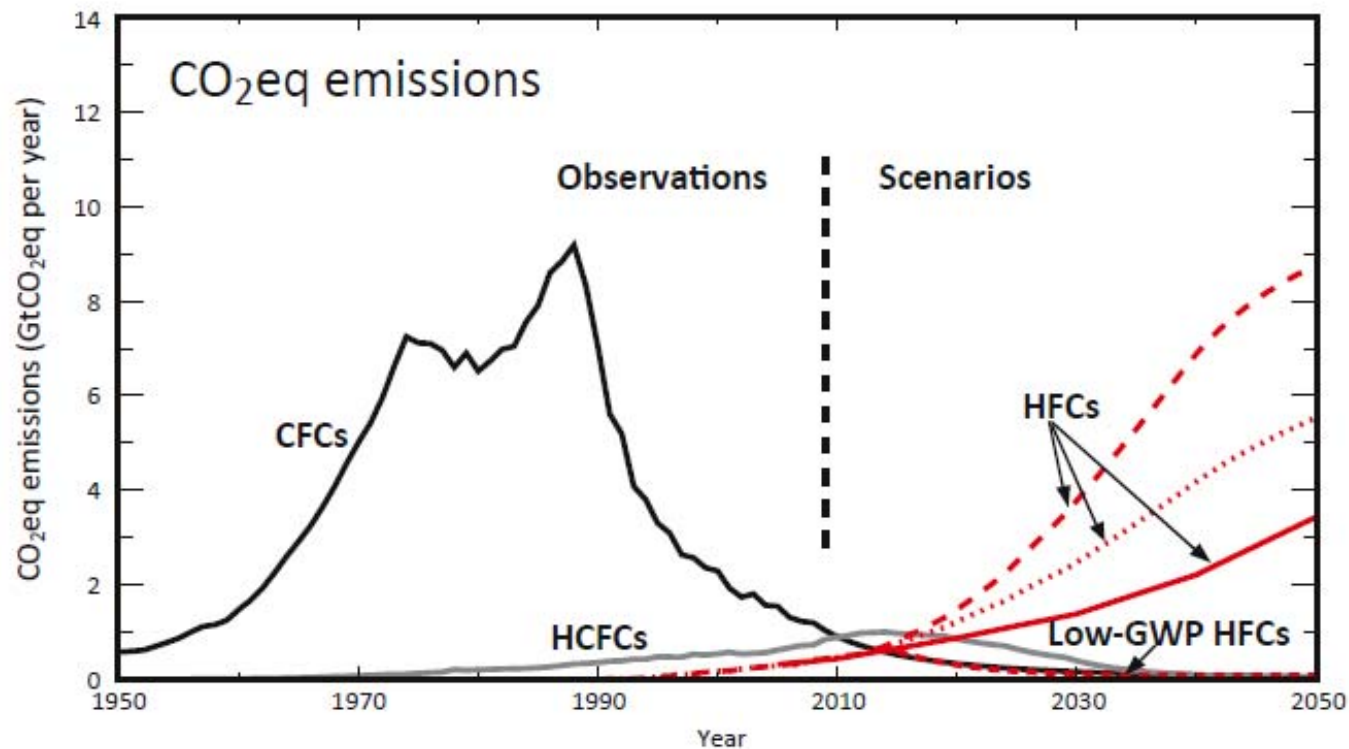
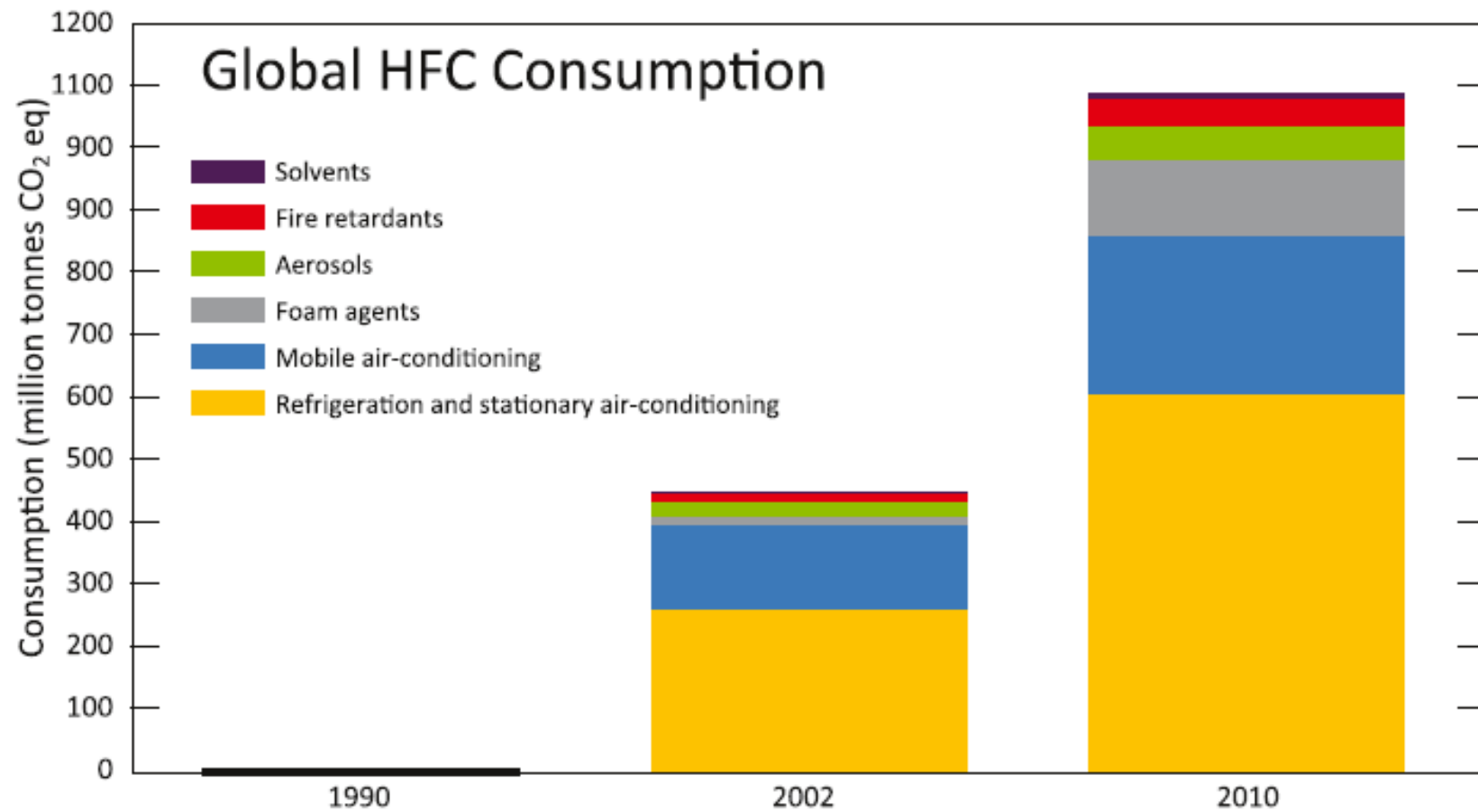


Figure ES 2. Trends in CO₂eq emissions of CFCs, HCFCs, and HFCs since 1950 and projected to 2050. The HFC emissions scenarios are from Velders et al. (2009) and Gschrey et al. (2011). The low-GWP HFC line represents the equivalent HFC emissions for a scenario where the current mix of emissions (with an average lifetime of HFCs of 15 years and an average GWP of 1600) was replaced by a mix of low GWP HFCs (with an average lifetime of less than 2 months or GWPs less than 20).

Why Go After HFC's?



Methods of Phasing Out/Phasing Down HFC's

- **Outright ban on HFC's**
 - ▶ Tried in some EU countries
- **Regulatory phase down**
 - ▶ Several proposals being evaluated globally
- **Voluntary phase down (with incentives)**
 - ▶ Popular method for the US
- **GWP or Carbon Taxes**
 - ▶ Popular method for the EU



EU Proposed Regulation

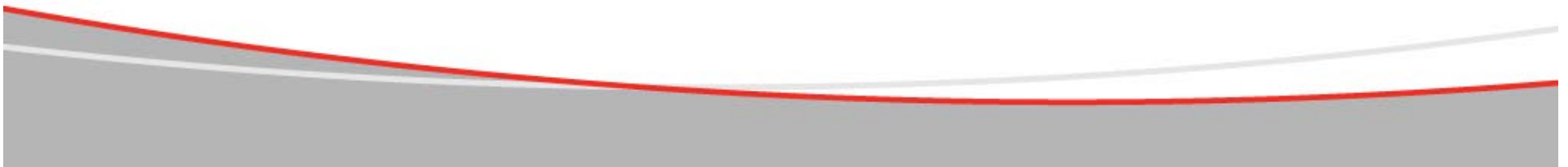
- **Combination of bans and phase downs**
 - ▶ Aggressive where alternative already exist (Domestic Refrigerators)
 - ▶ Aggressive on very high GWP fluids (R-404A)
- **Specific Bans**
 - ▶ Domestic refrigerators (GWP>150) ban on 1/1/15
 - ▶ Commercial ref and freezers (GWP>2500) ban on 1/1/17
 - ▶ Service for comm. ref and freezers (GWP>2500) ban on 1/1/20
 - ▶ Moveable room A/C (GWP>150) ban on 1/1/20
 - ▶ Ban on pre-charged equipment 3 years after law passes
 - ▶ No specifics yet on stationary A/C
- **General HFC phase down**

2015	100%
2016-2017	93%
2018-2020	63%
2021-2023	45%
2024-2026	31%
2027-2029	24%
2030	21%

- **Agreement expected before summer 2014**

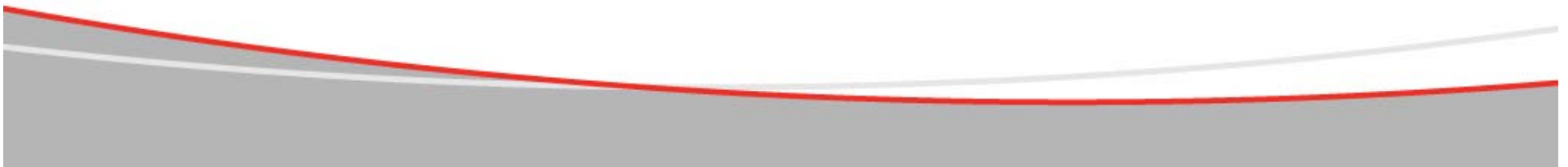
Outright Ban on HFC's

- **Several countries have attempted this already**
 - ▶ Denmark
 - ▶ Austria
 - ▶ Switzerland
 - ▶ Luxembourg
- **Complete ban is a challenge for all applications**
 - ▶ Automotive was a challenge by country
 - ▶ Critical use exemptions (medical)
 - ▶ Safety (toxicity and flammability of available alternatives)
- **Alternative to outright ban is a combination of taxes, and application specific bans**



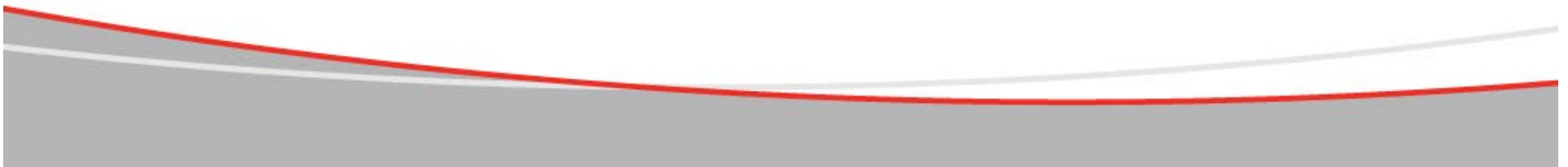
Regulatory Phase Down of HFC's

- **US/Canada/Mexico Phasedown of HFC's**
 - ▶ Calls for global phasedown of HFC's- 30% by 2030
 - ▶ Approx 5 year delay for developing countries
- **EU Phase out/phase down proposal**
 - ▶ Calls for 79% phasedown of HFC's by 2030 in EU
 - ▶ Bans servicing of some HFC's as early as 2020



Voluntary Phase Downs

- **Regulatory “Carrots”**
 - ▶ US Automotive Café standards give MPG incentive for using low GWP refrigerants
- **Voluntary Phase downs**
 - ▶ Kyoto Protocol
 - ▶ CCAC (Climate and Clean Air Coalition)



Taxing our Way to New Refrigerants

- **GWP based HFC's taxes are becoming common overseas**
- **Effective way to make newer, more expensive technologies more competitive**
- **No consideration given to efficiency**

Taxes today on HFC's (R-134a Baseline)

- Australia- \$25/lb
- Denmark- \$28 EU/kg
- Norway- 39 EU/kg
- Sweden- 35 EU/kg
- Germany- currently considering

Taxes based on GWP

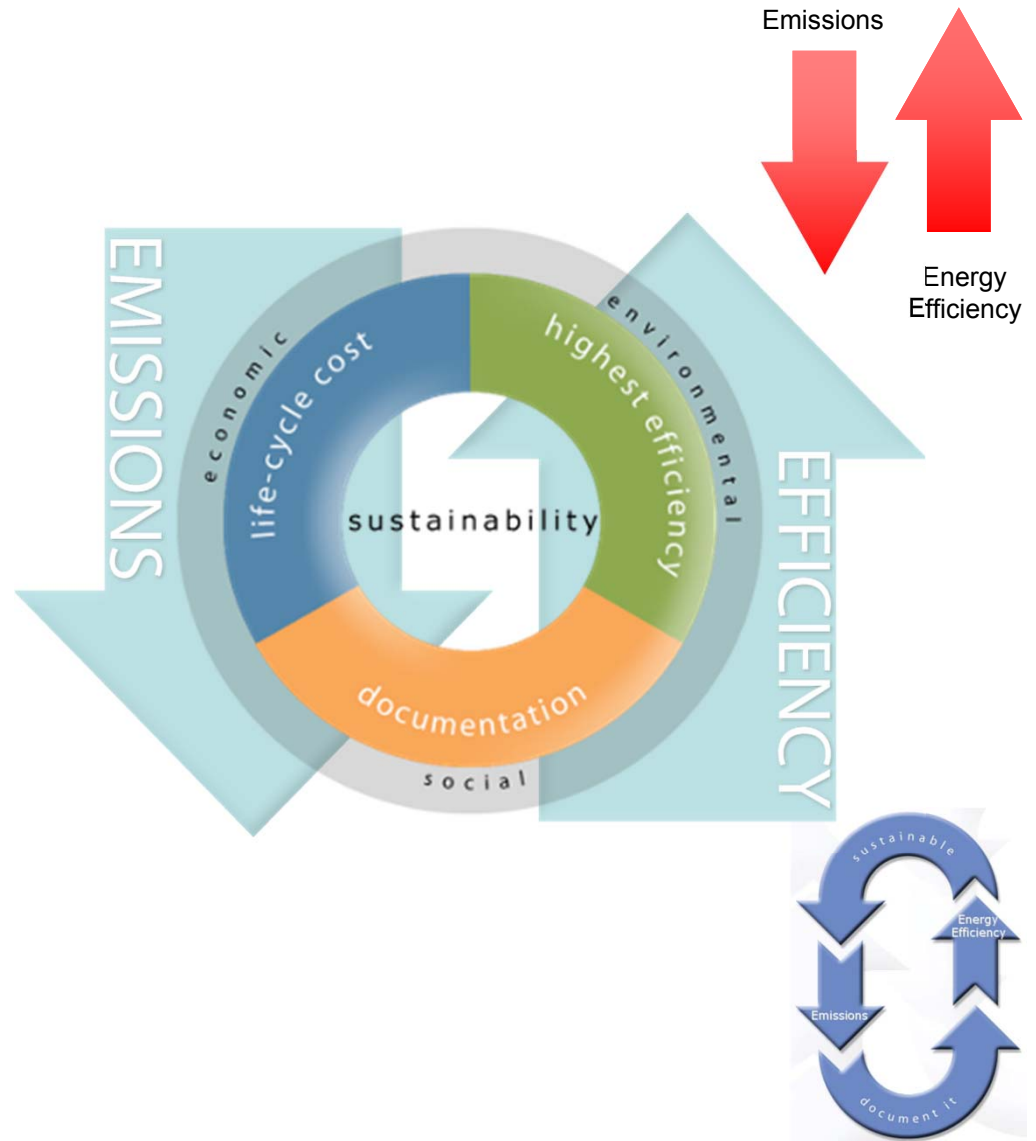
- R-32- GWP= 675
- R-134a- GWP= 1430
- R-407C- GWP= 1800
- R-410A- GWP= 2100
- R-404A- GWP= 3900



The Future Direction

Focusing on Emissions and Efficiency is fundamental to doing what's right both for business and the environment.

1. Low ODP
(Ozone Depletion Potential)
2. Low GWP
(Global Warming Potential)
3. High operating efficiency
4. Short atmospheric life
5. Low leakage rates

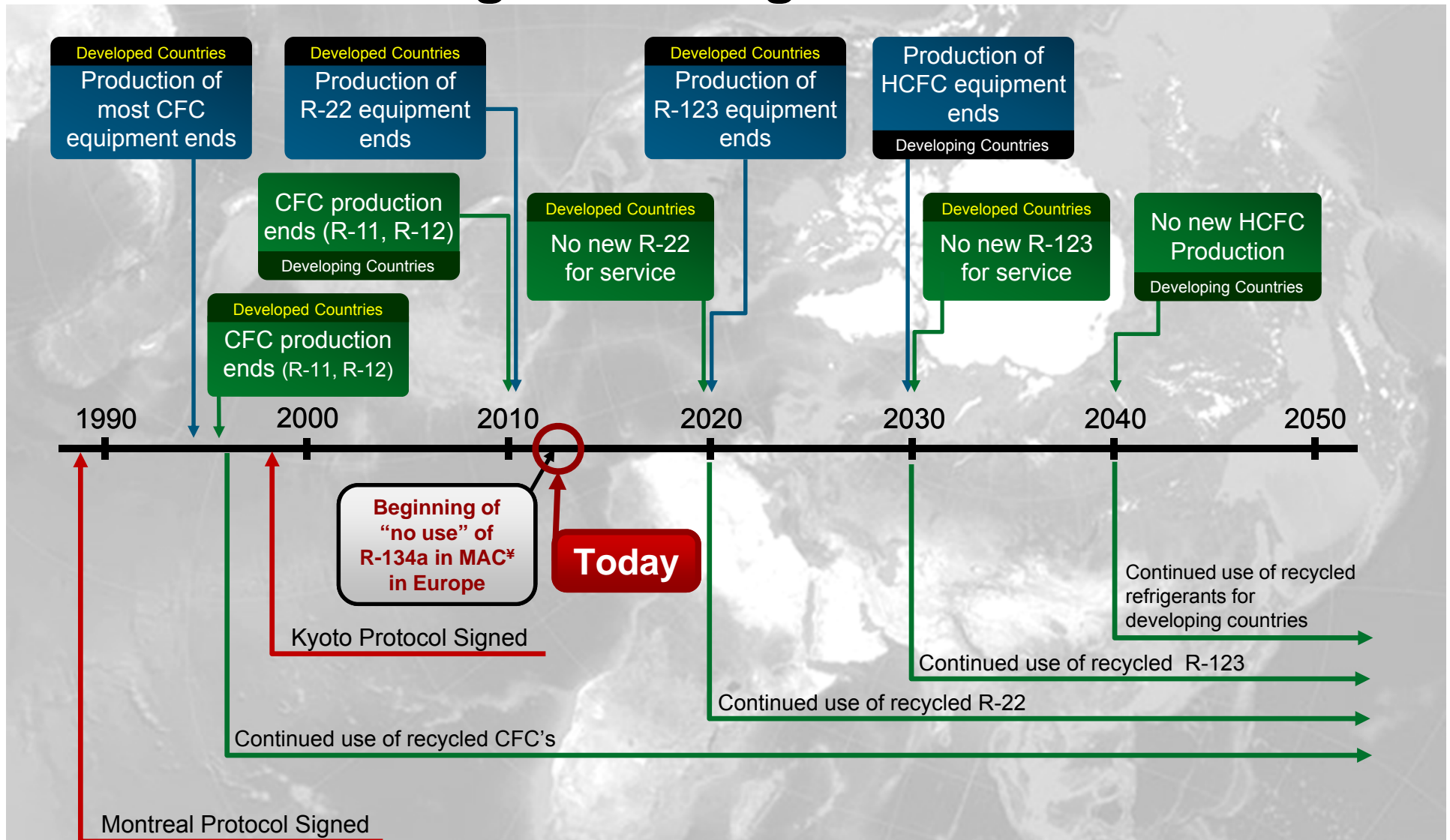


The Best Environmental Solution

Availability and Timing



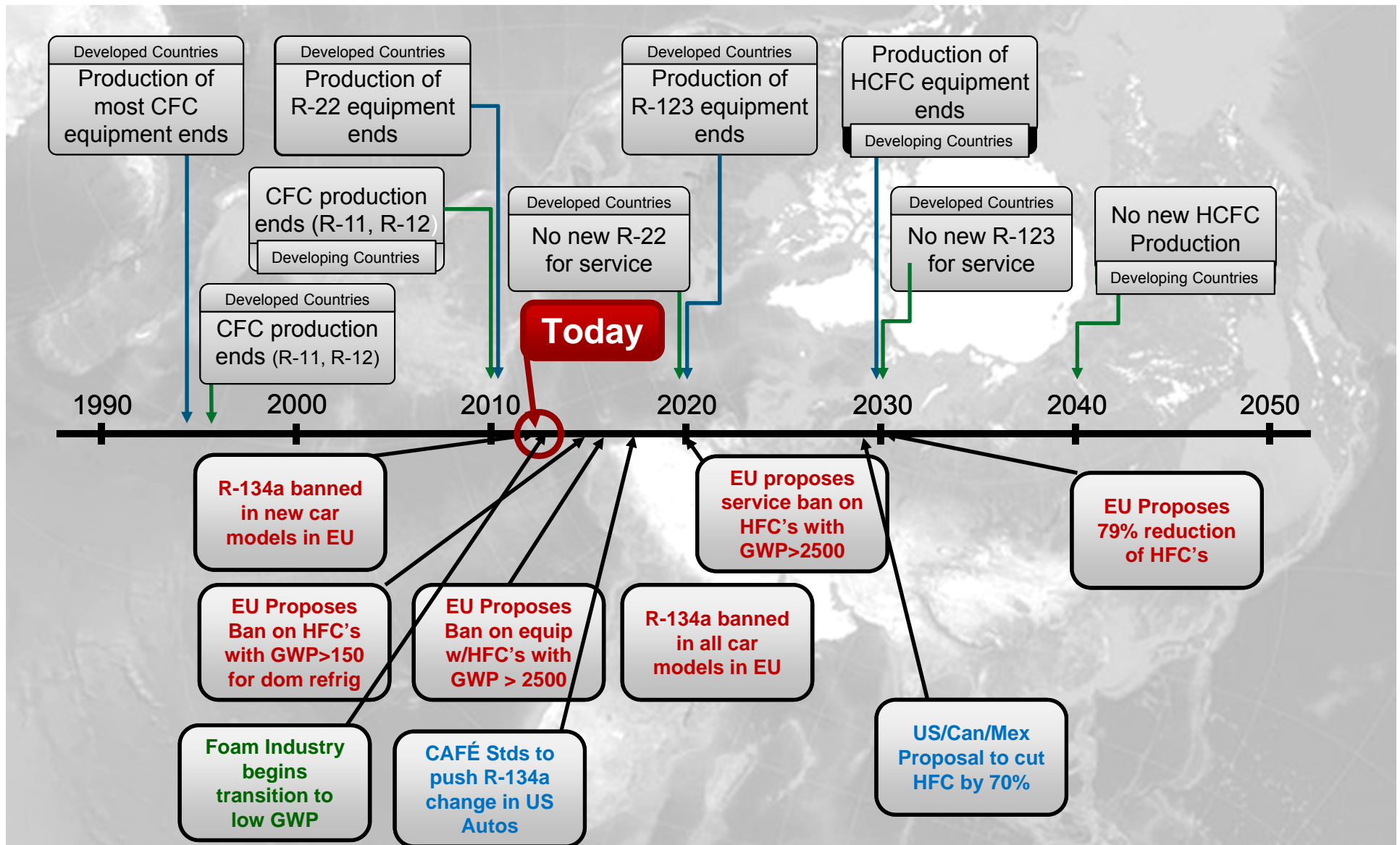
Timeline of Refrigerant Usage



* MAC: Mobil Air Conditioning

Note: Included in the use of "recycled" refrigerants is also the use of stockpiled supplies of the refrigerant produced before the phase out date. In addition, there is no restriction on the importation of recycled and recovered supplies of refrigerants.

Timeline of HFC Phasedown Regulations and Proposals



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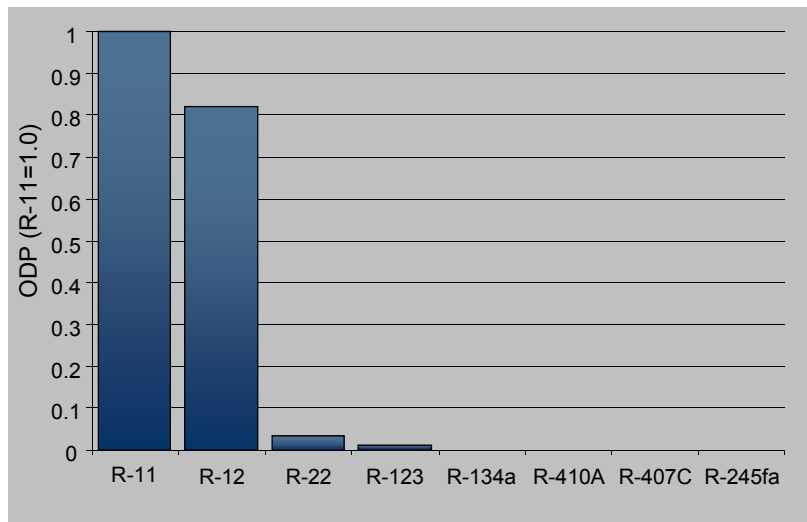
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New Technology and Refrigerants

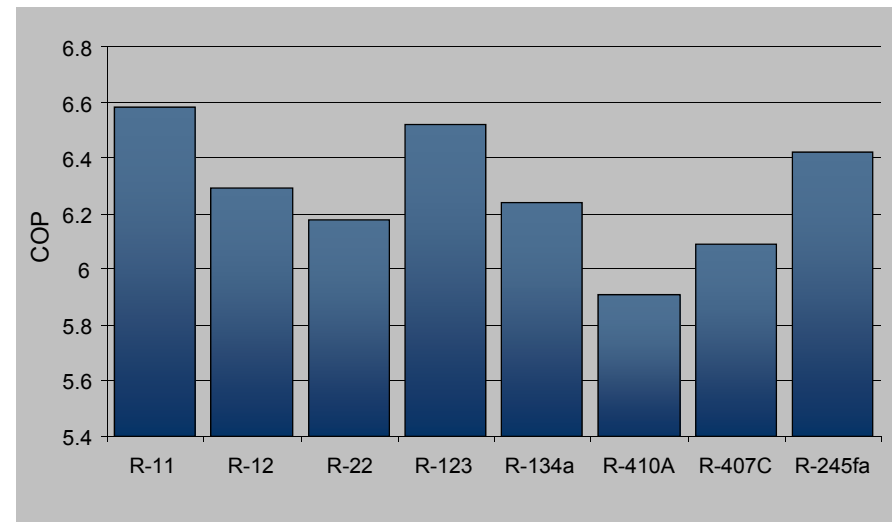


Comparing Today's Alternatives

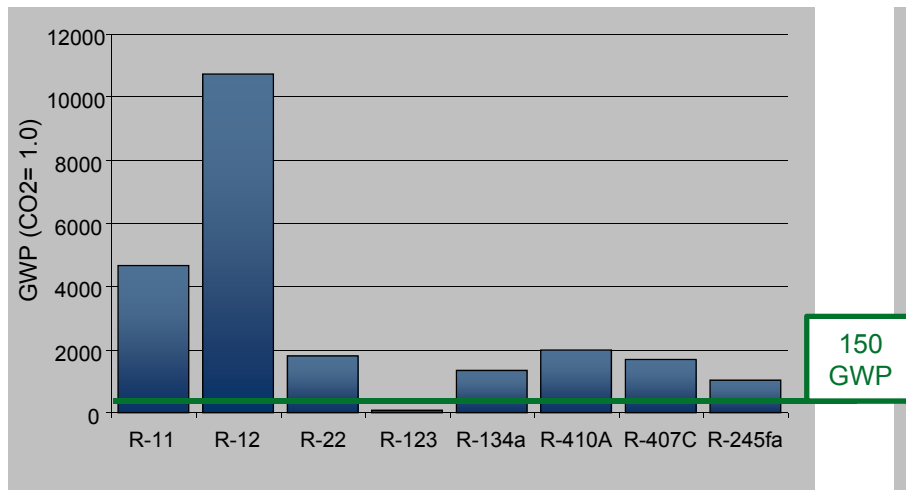
Ozone Depletion Potential (ODP)



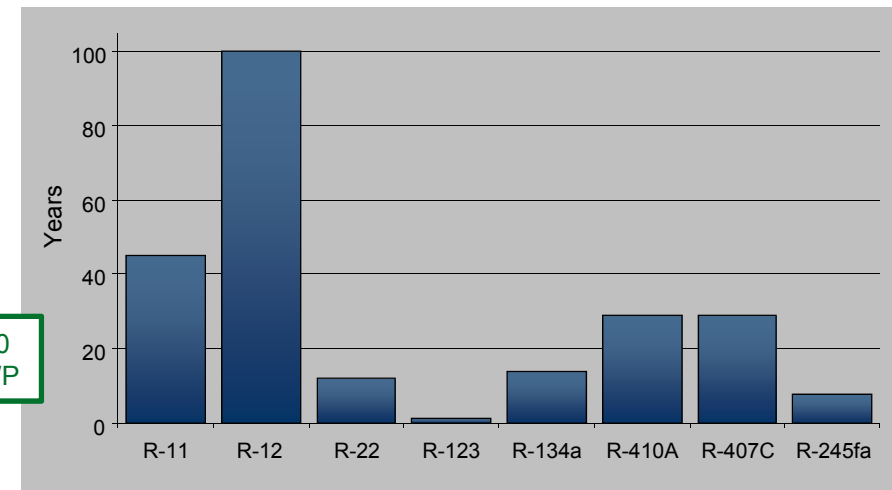
Water Cooled Chiller Efficiency (COP)



Global Warming Potential (GWP)



Atmospheric Half-Life (Years)

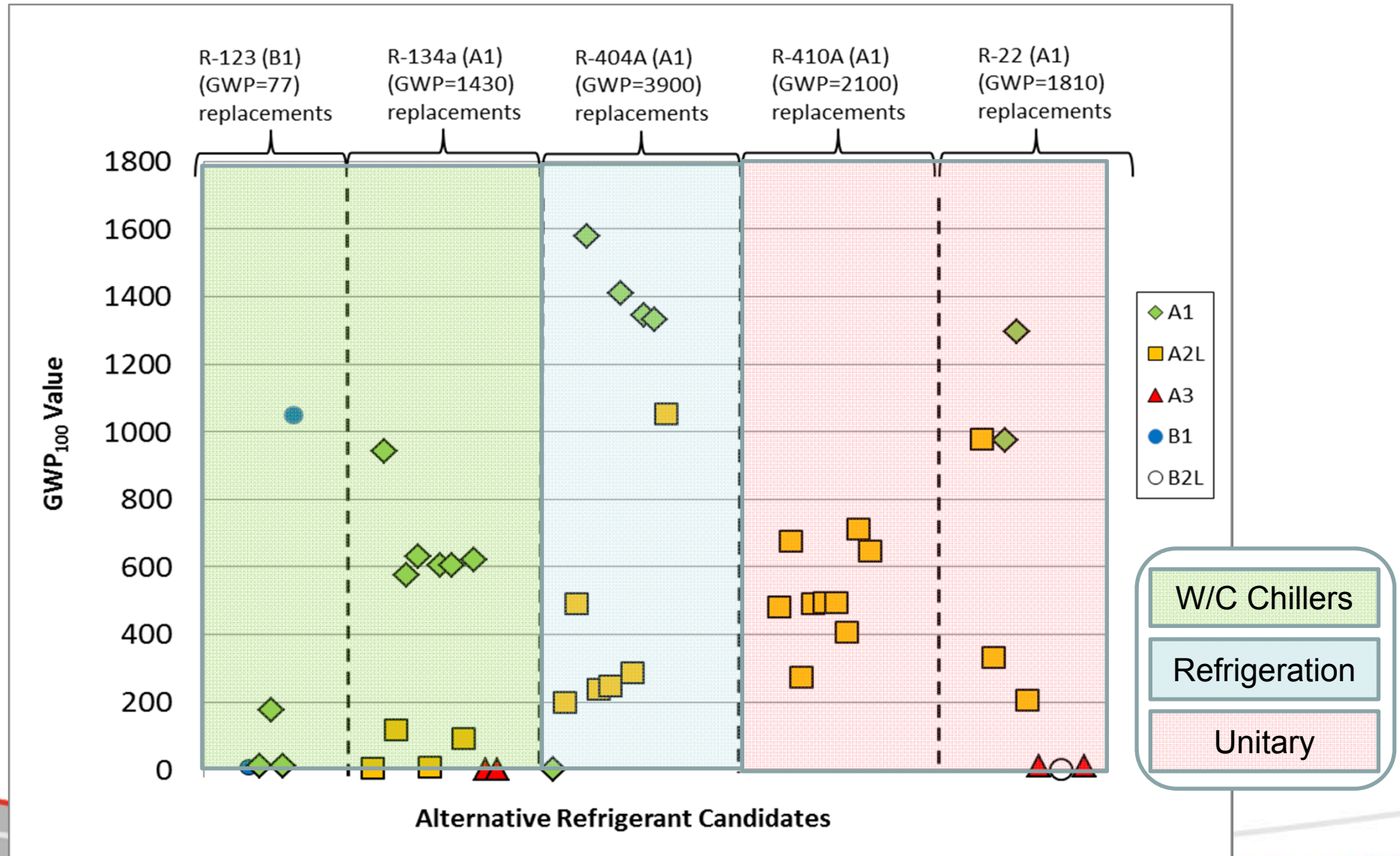


Time Spent in Atmosphere... Effects ODP & GWP Impact

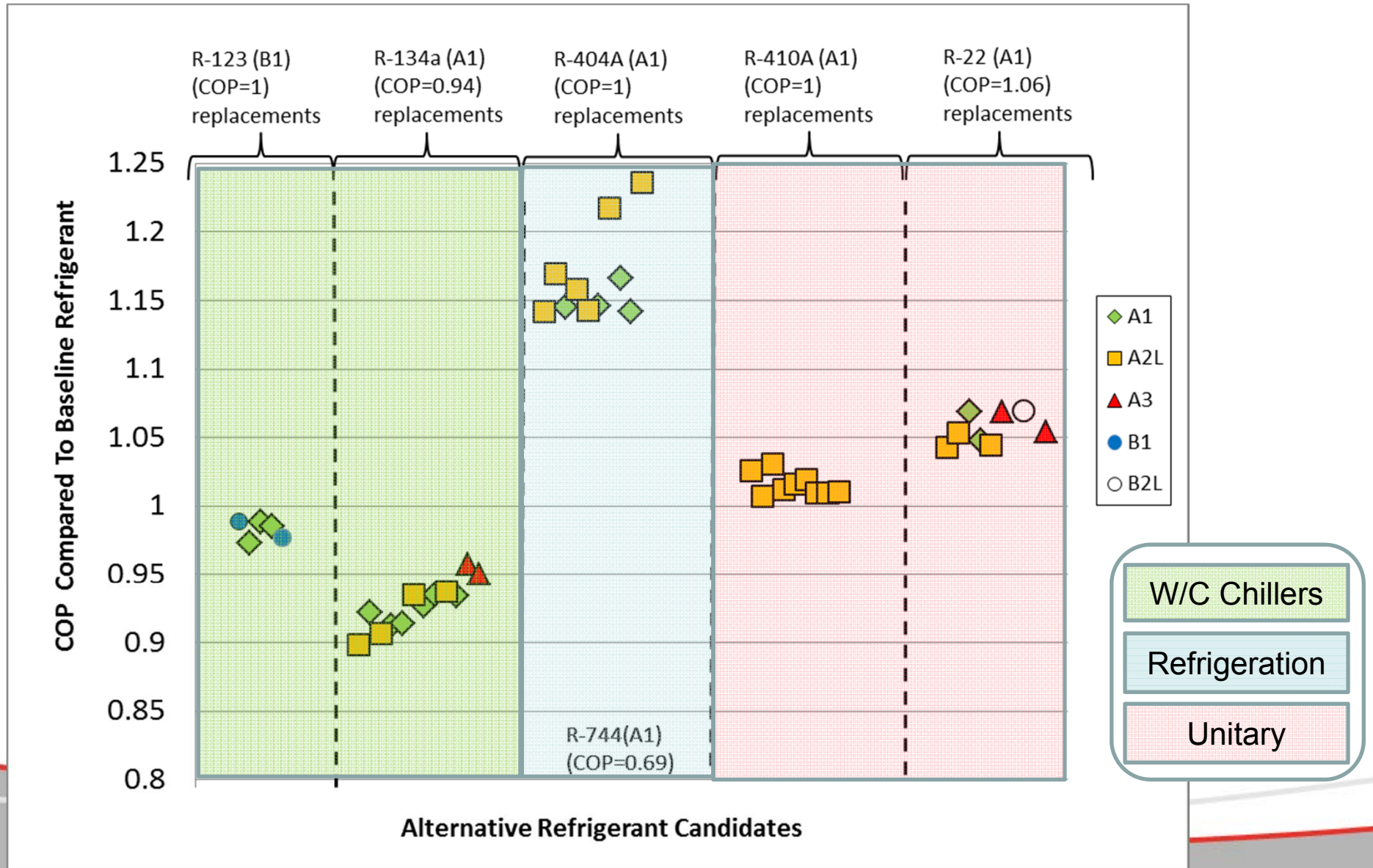
Considerations for a New Refrigerant



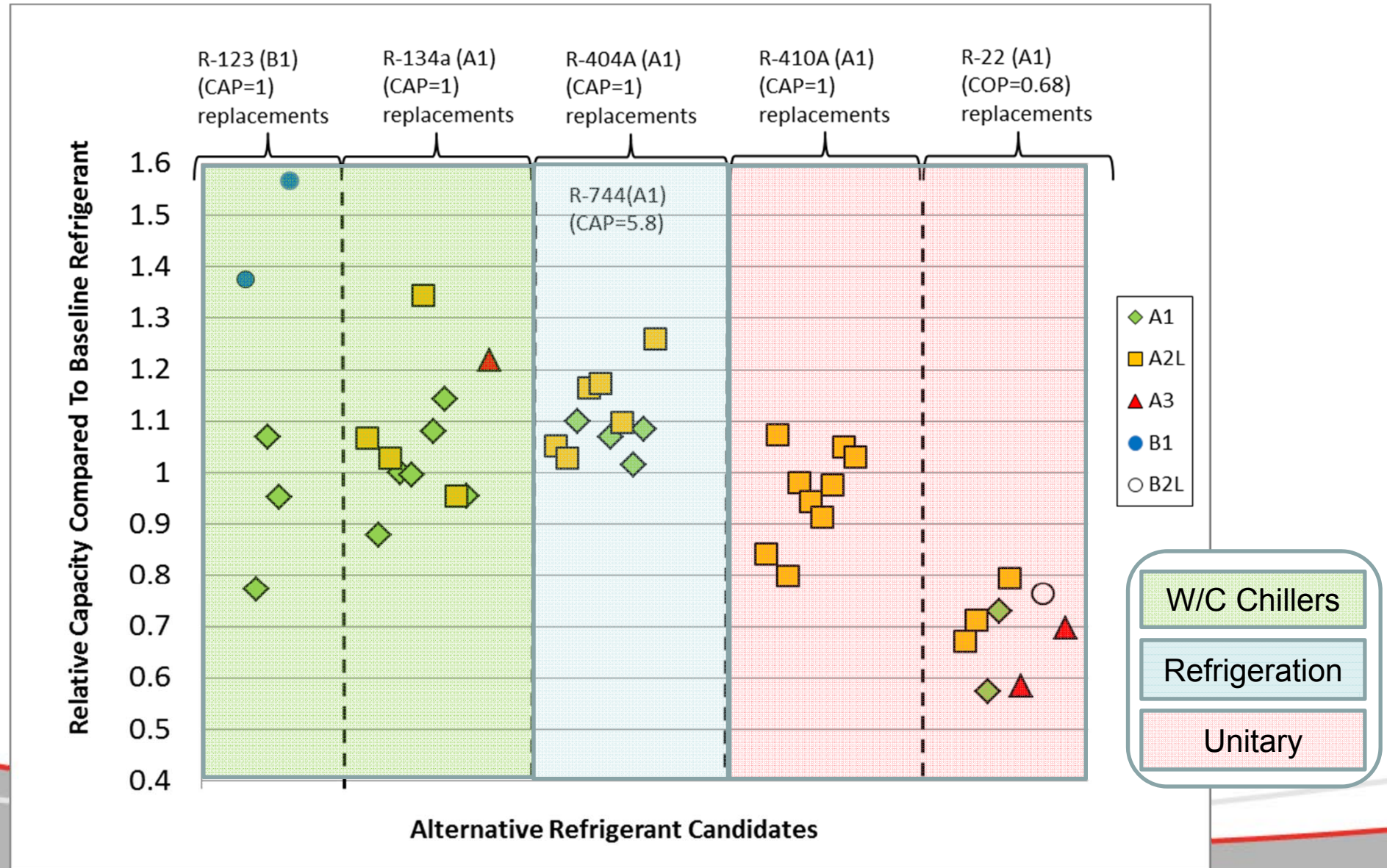
Are There Low GWP Options?



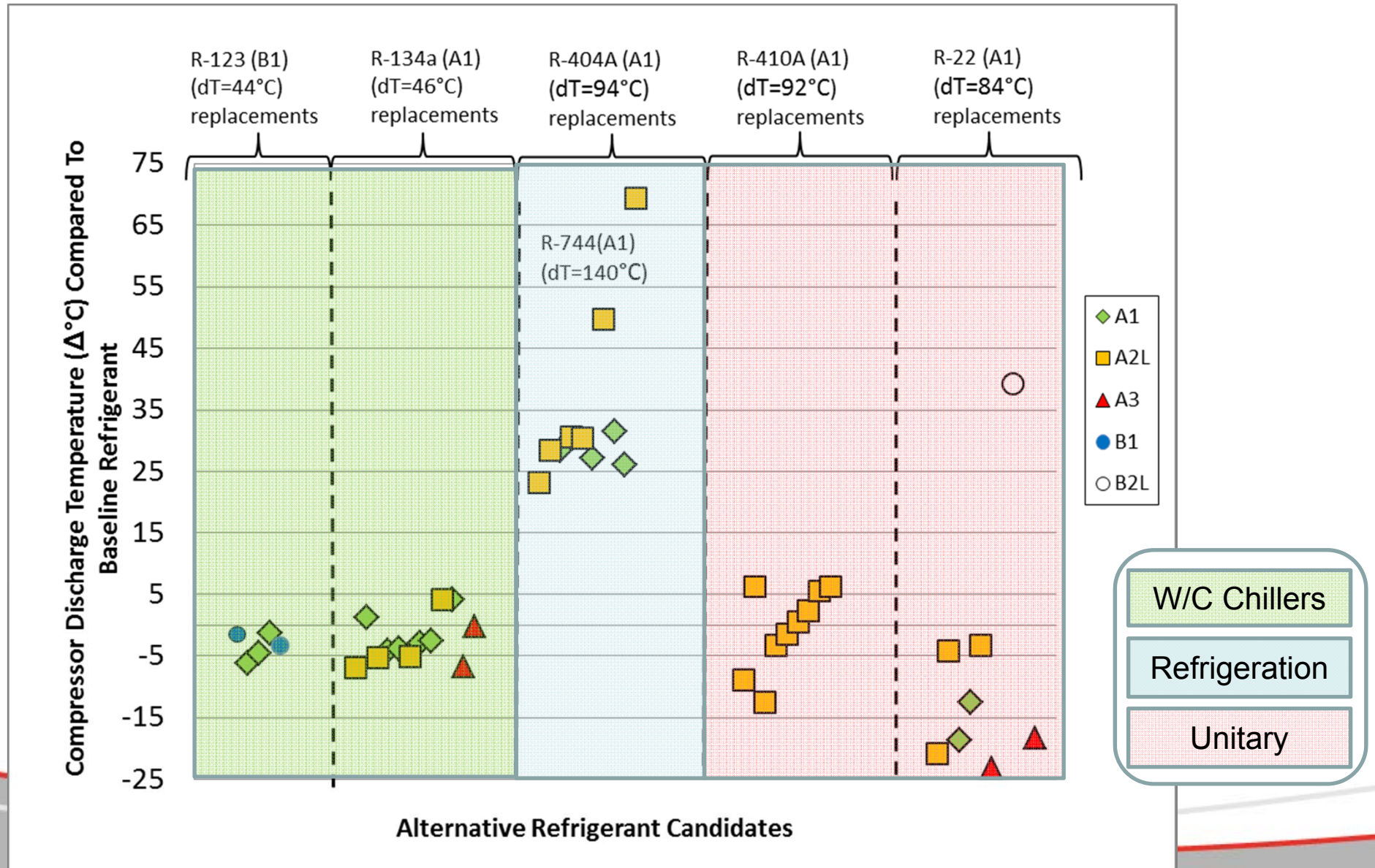
Efficiency Comparison of New Alternatives



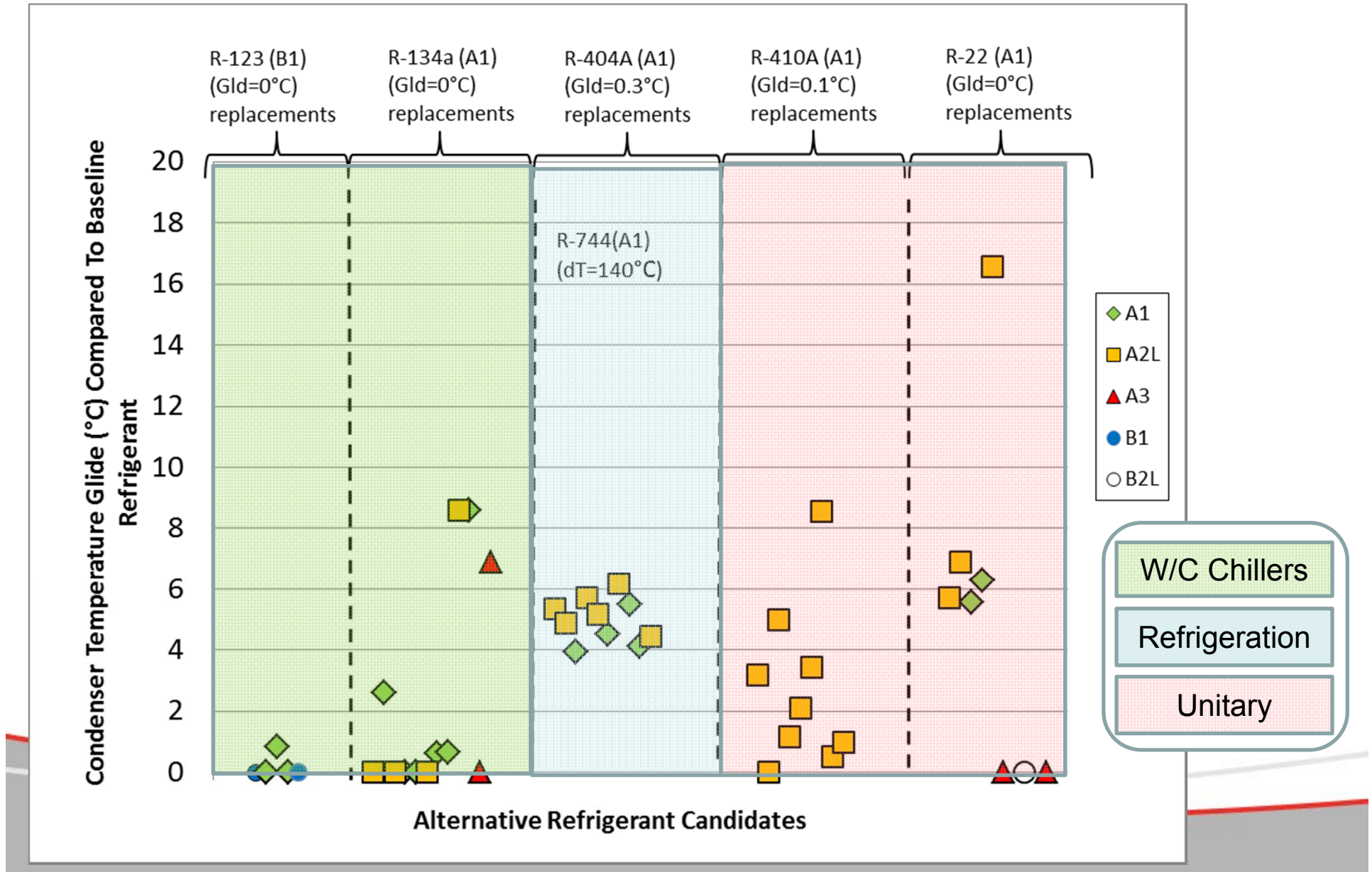
Capacity Can Vary Among Replacements



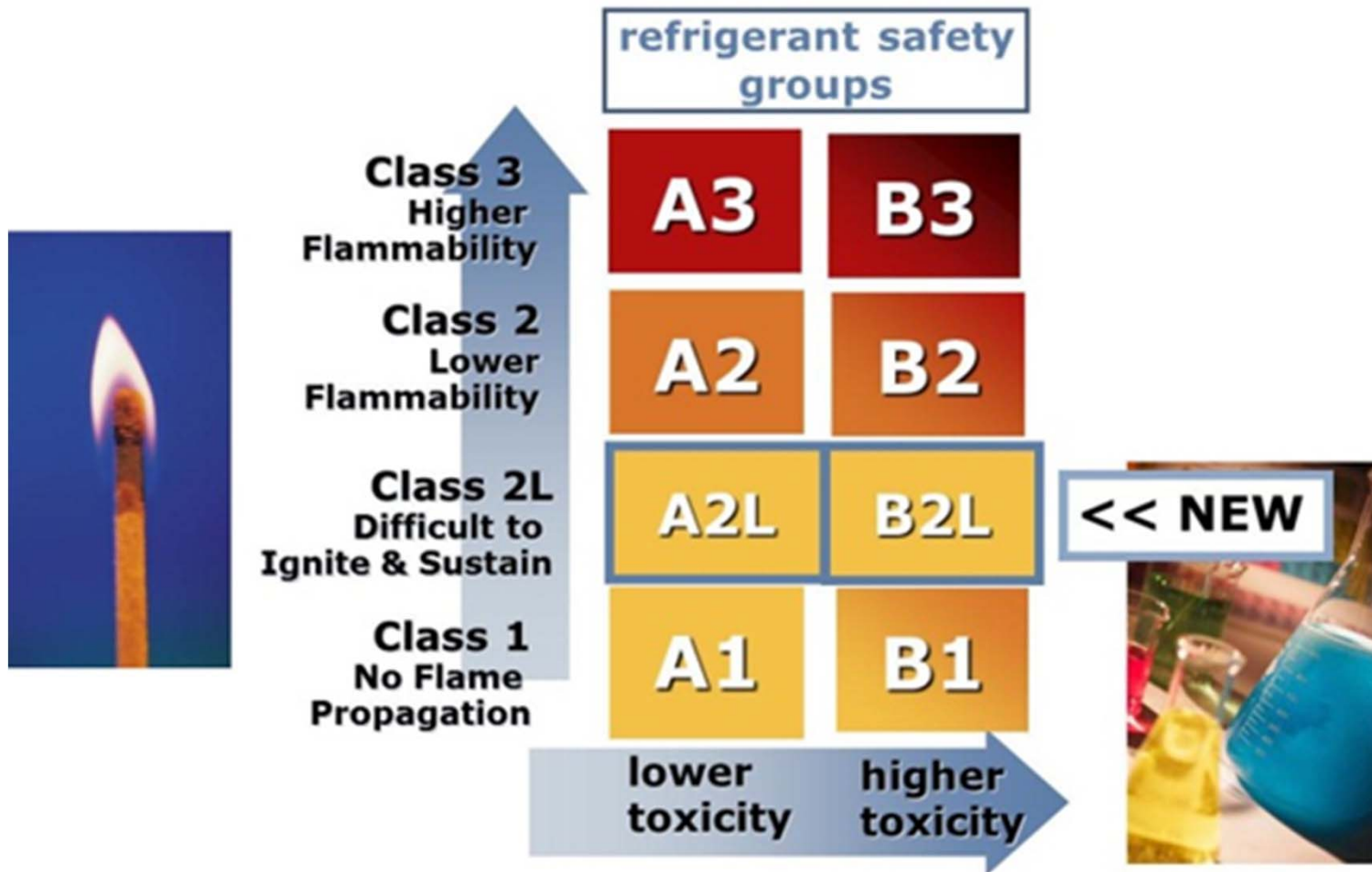
Compressor Discharge Temp



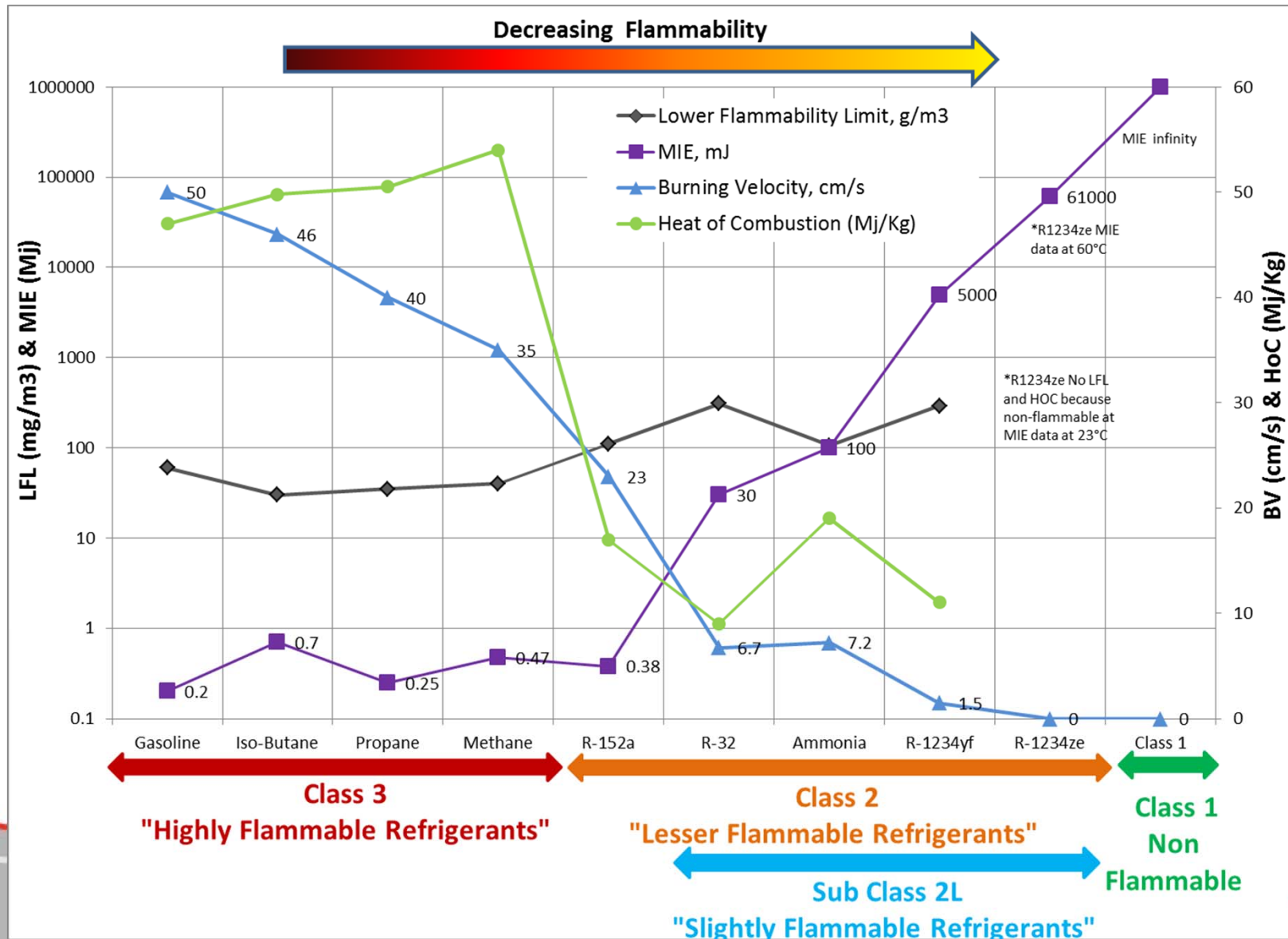
Glide (Variation of Boil. Pts. Among Blend Components)



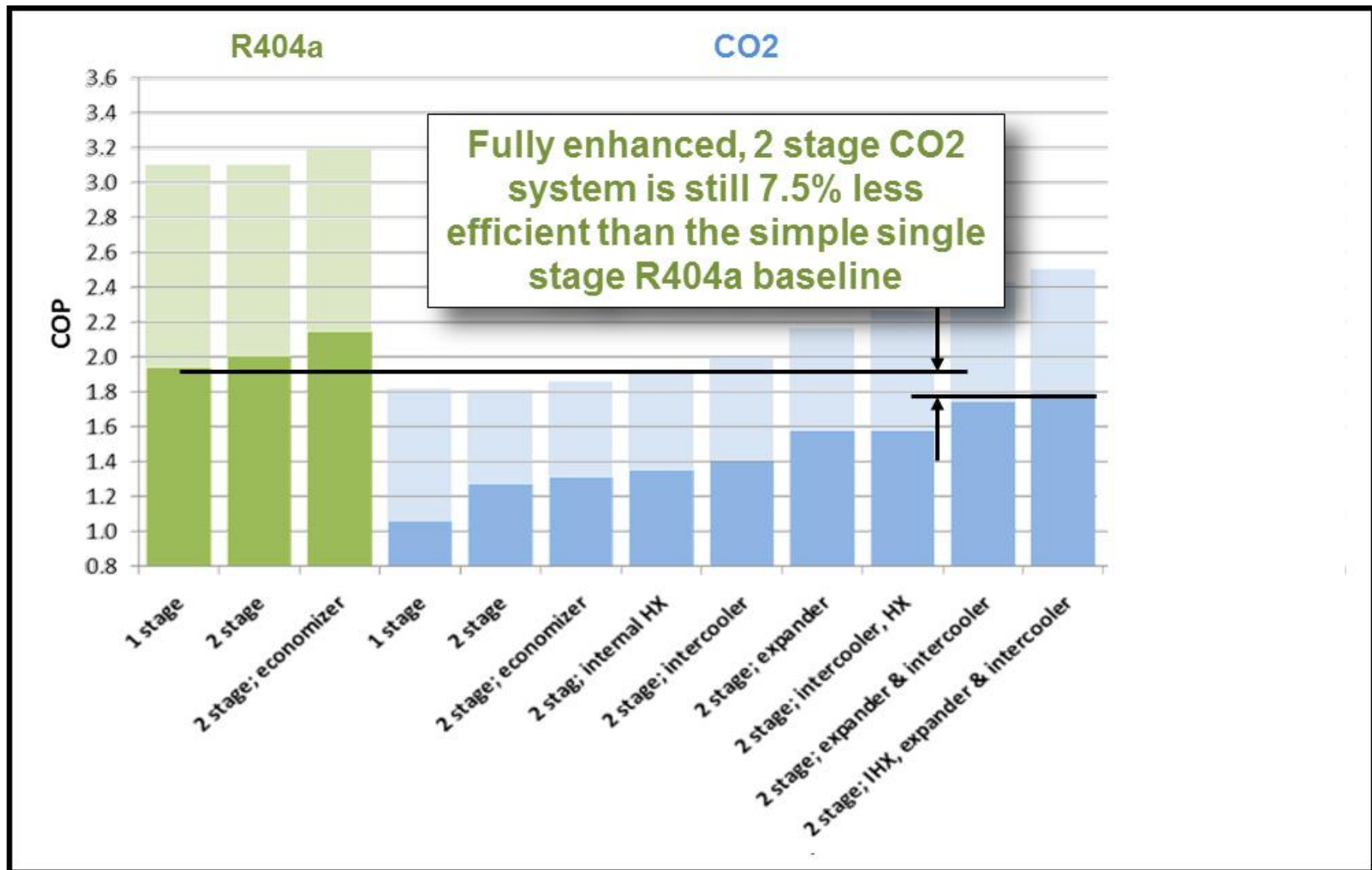
New Definitions for “Slightly Flammable” Refrigerants



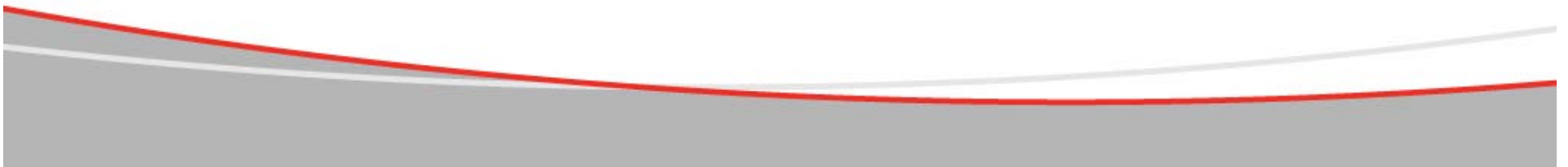
Various Risk Factors for Refrigerant Flammability



What About Natural Refrigerants like CO2?



Why Use Low Pressure Refrigerants for Centrifugal Chillers?



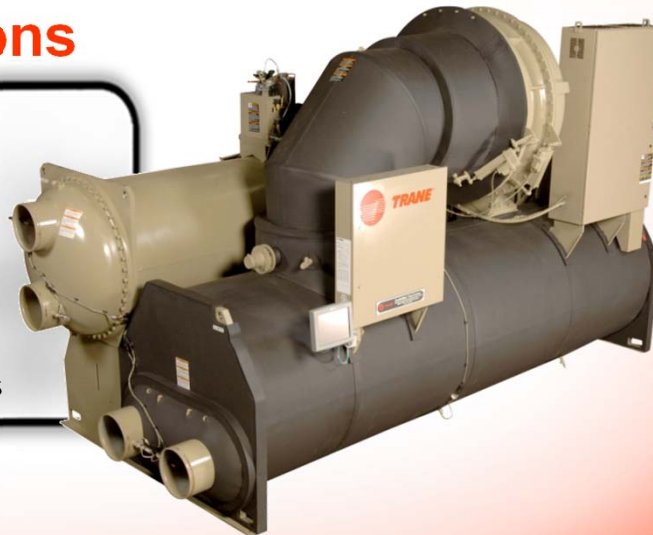
CenTraVac: Design Fundamentals

MORE INFO

Commitment to delivering:

- Reliability
- Efficiency
- Lowest Emissions

Direct Drive
Multi-Stage
Semi-Hermetic
Low Pressure
with Integrated Unit Controls



2008



1998



1996



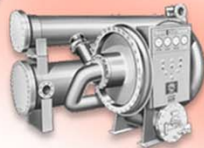
1994



1938



1951



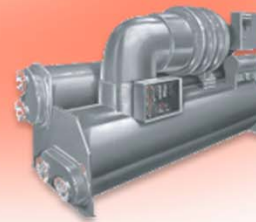
1963



1964



1982

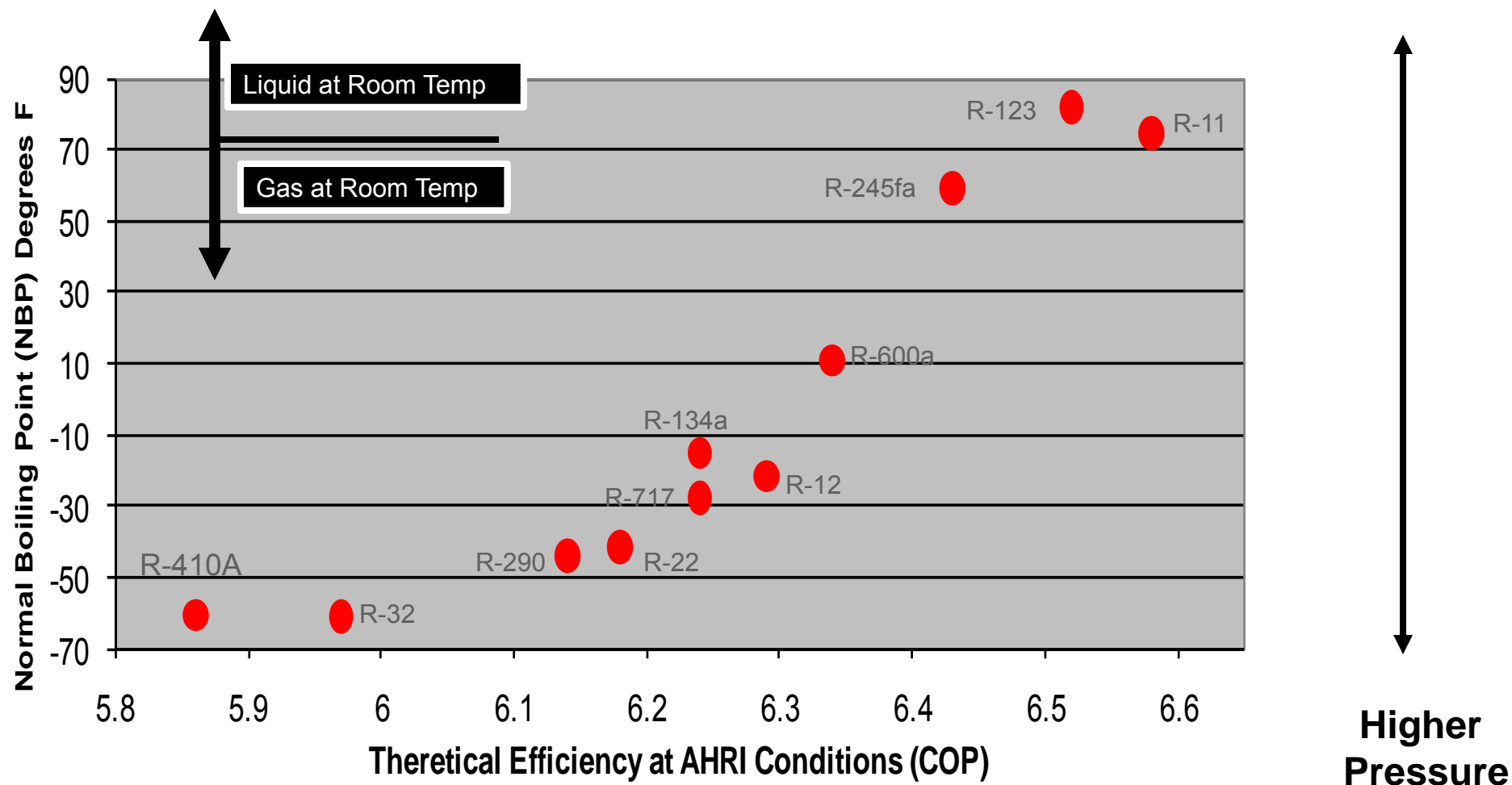


Product
Portfolio

Trane CenTraVac Remains the Best Chiller Made!

CONFIDENTIAL AND

Efficiency and Operating Pressure



Centrifugal Compressor: Technology Comparison

MORE INFO 



**Gear Drive
Single Stage**



**Direct Drive
Multi-Stage**

Other Designs 

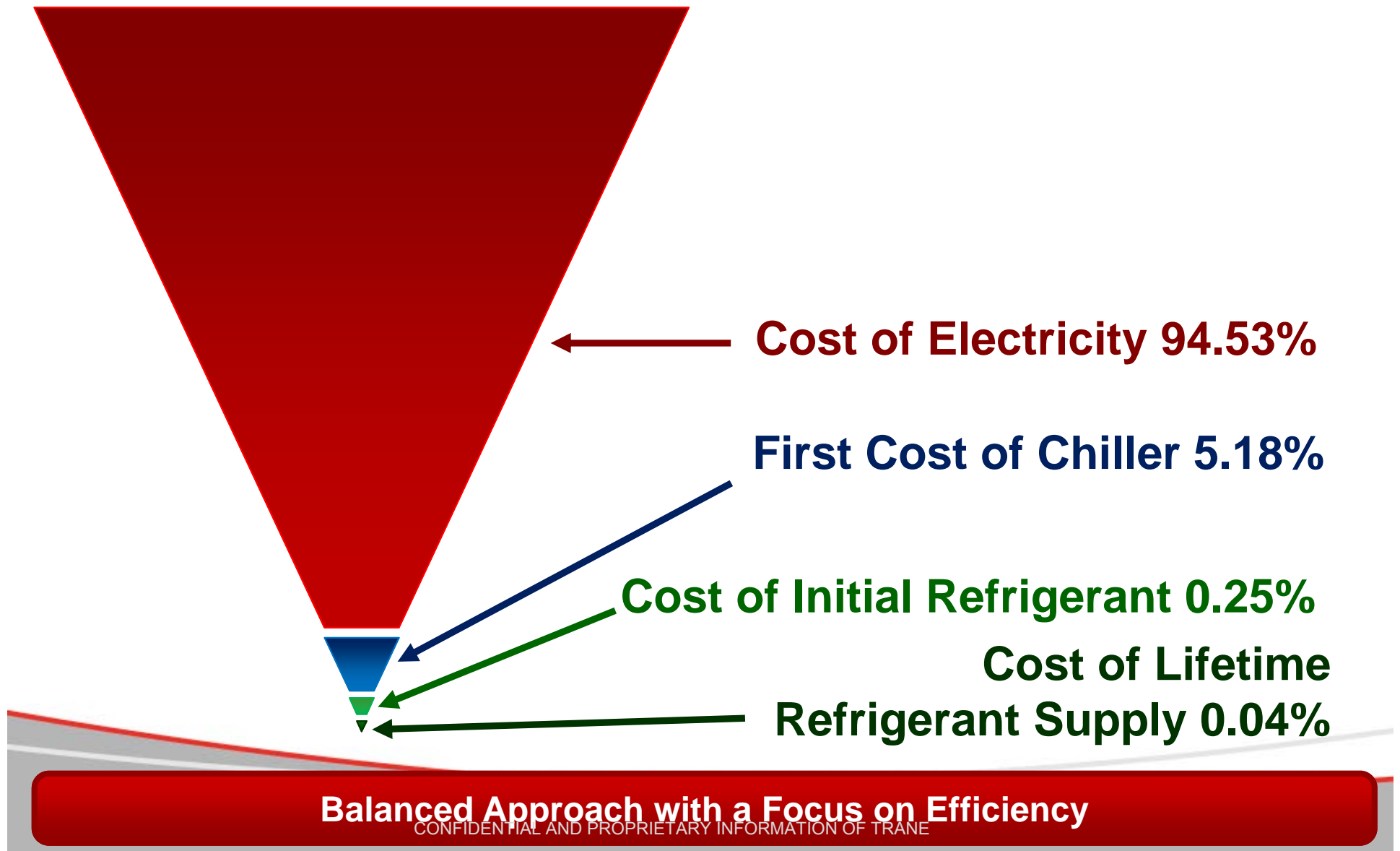
Choices Drive Different Outcomes

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Summary



What is Really Important Over the Life of the Chiller?



Options For HVAC Refrigerants

Ozone Depleting Substances (Montreal Protocol)	High (CFCs)	R-11	ODP	GWP	R-113	ODP	GWP
		R-12	ODP	GWP	R-500	ODP	GWP
Global Warming (Kyoto Protocol)	Low (HCFCs)	R-22	ODP	GWP			
		R-123	ODP				
	High (HFCs > 1,000)	R-134a		GWP	R-407C		GWP
		R-410A		GWP	R-245fa		GWP
	Moderate (HFCs > 150 to 1,000)	R-32		GWP			
	Low (HFCs & HFOs ≤ 500)	R-1234yf			R-152a		
		R-1234ze					
	Natural & Hydrocarbons	Propane			CO ₂		
		Butane			Ammonia		

Concerns

- ODP Ozone Depletion Potential
- GWP Global Warming Potential
- Flammable
- Slightly Flammability 2L
- Efficiency
- Cost
- Toxicity

Today's Chemicals: No Perfect Refrigerant

What Actions Should I Take?

- Make sure equipment, system, and controls are working together, and are maximizing the system efficiency
- Maintain your existing equipment to peak efficiency
- Monitor, track, repair any leaks to your system
- Take a balanced approach to refrigerant selection
 - ODP
 - GWP
 - Full and part load efficiency (chiller and system)
 - Minimal refrigerant usage, minimal leaks

