

# Sustainable Refrigerant Solutions for HVAC-R

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# Learning Objectives

- **1. Design refrigeration and air-conditioning systems with respect to the thermodynamic properties of the new, low-GWP refrigerants, in comparison with the past and current refrigerants.**
- **2. Assess the overall economic aspects of the vapor-compression systems according to the performance of the refrigerant in vapor-compression cycles, accounting for the cycle efficiency, heat transfer, pressures, and material compatibility.**
- 3. Outline the design aspects of the refrigeration and AC systems with respect to the solubility of refrigerants and lubricants and their heat transfer characteristics.
- 4. Explain how the molecular formula and structure of the refrigerants determine their thermodynamic properties, thermal stability, and their relationship with lubricants and construction materials.
- 5. Describe the correlation between the chemical composition and molecular structure of the refrigerants and their environmental characteristics.
- 6. Associate the composition of the refrigerant blends with their potential flammability, environmental impact, and performance in refrigerating and air-conditioning equipment.

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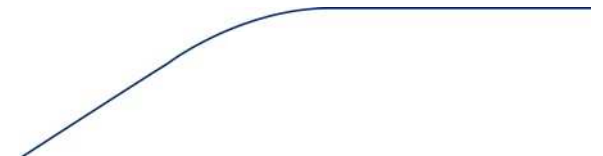


# Thank You

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# Agenda

- **Why new refrigerants are needed?**
- **Refrigerant developments**
- **HFO blends for different market needs**
- **Summary**



# Regulatory Policy on refrigerants

## European Union F-gas : Reduction of CO2 emission by 2/3 by 2030

- 1 January 2015 : entry into force of the new F-Gas regulation
- Main measures
  - Cap and Phase Down
  - Selected use bans

Applications	Date of ban
Refrigerators & Freezers for commercial use (Hermetically sealed systems) with GWP > 2500	2020
Stationary refrigeration with GWP>2500	2020
Multipack centralised refrigeration systems for commercial use with CAP>40kW : GWP>150	2022
Single split AC (<3kg) with GWP >750	2025

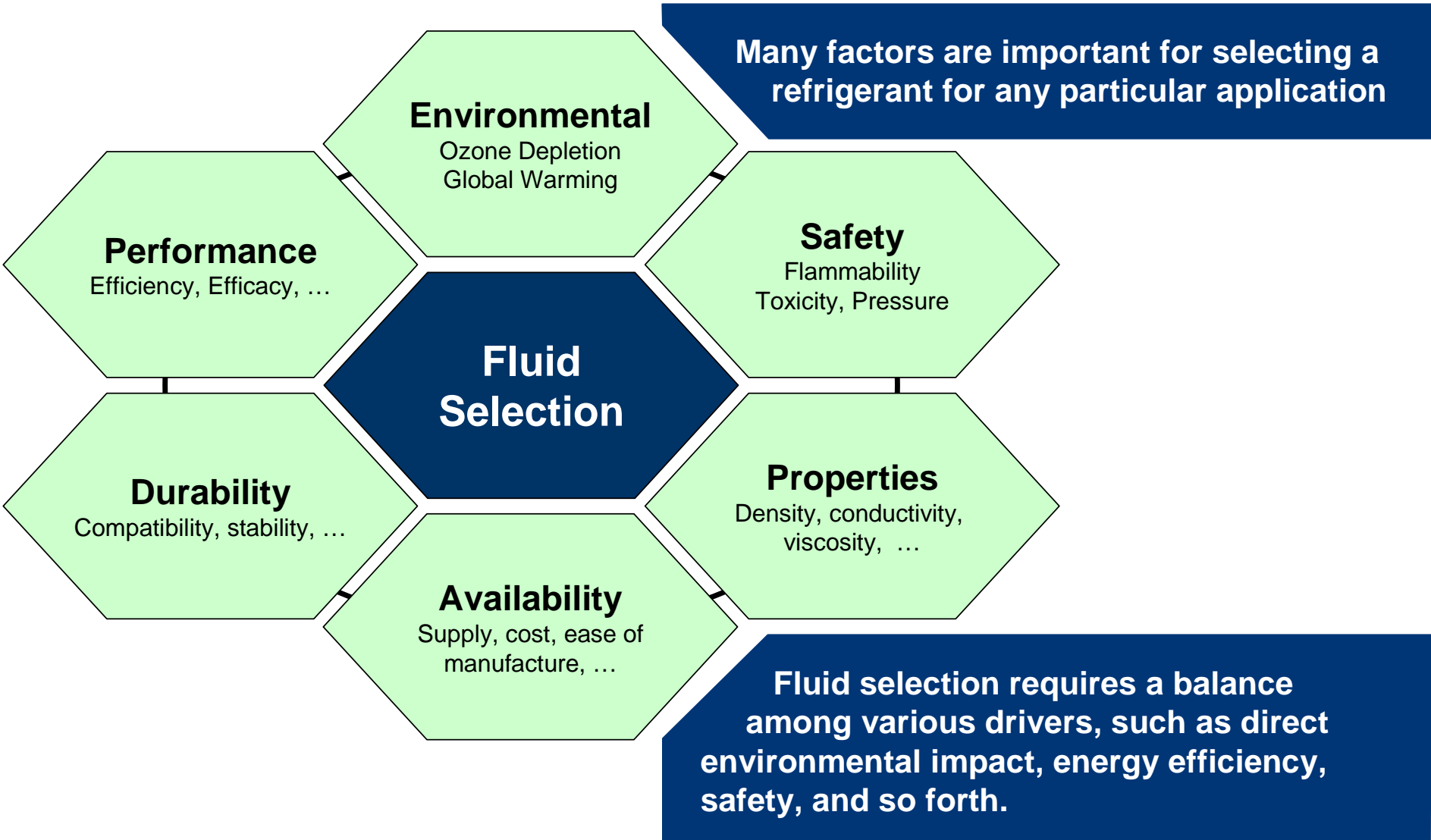
## EPA Proposal

- Notice of Proposed Rulemaking (NOPR) to be issued in Summer 2014 to change the status (delist) materials
- Would ban the use of some high GWPs in application likes vending machine or multiplex supermarkets systems.
- Timing unclear

**Global regulatory policy on HFCs picking up momentum**



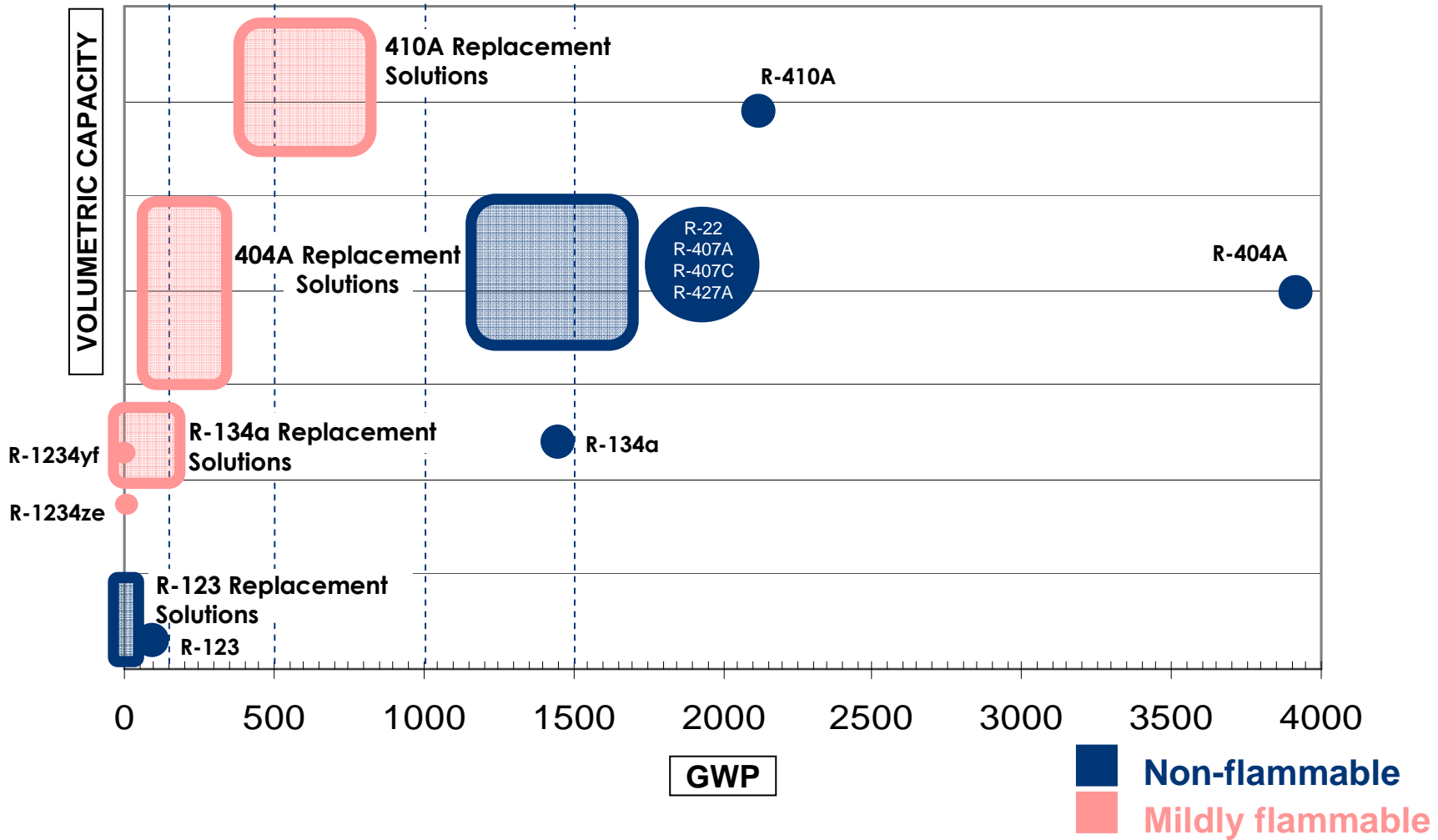
# Considerations in Fluid Selection





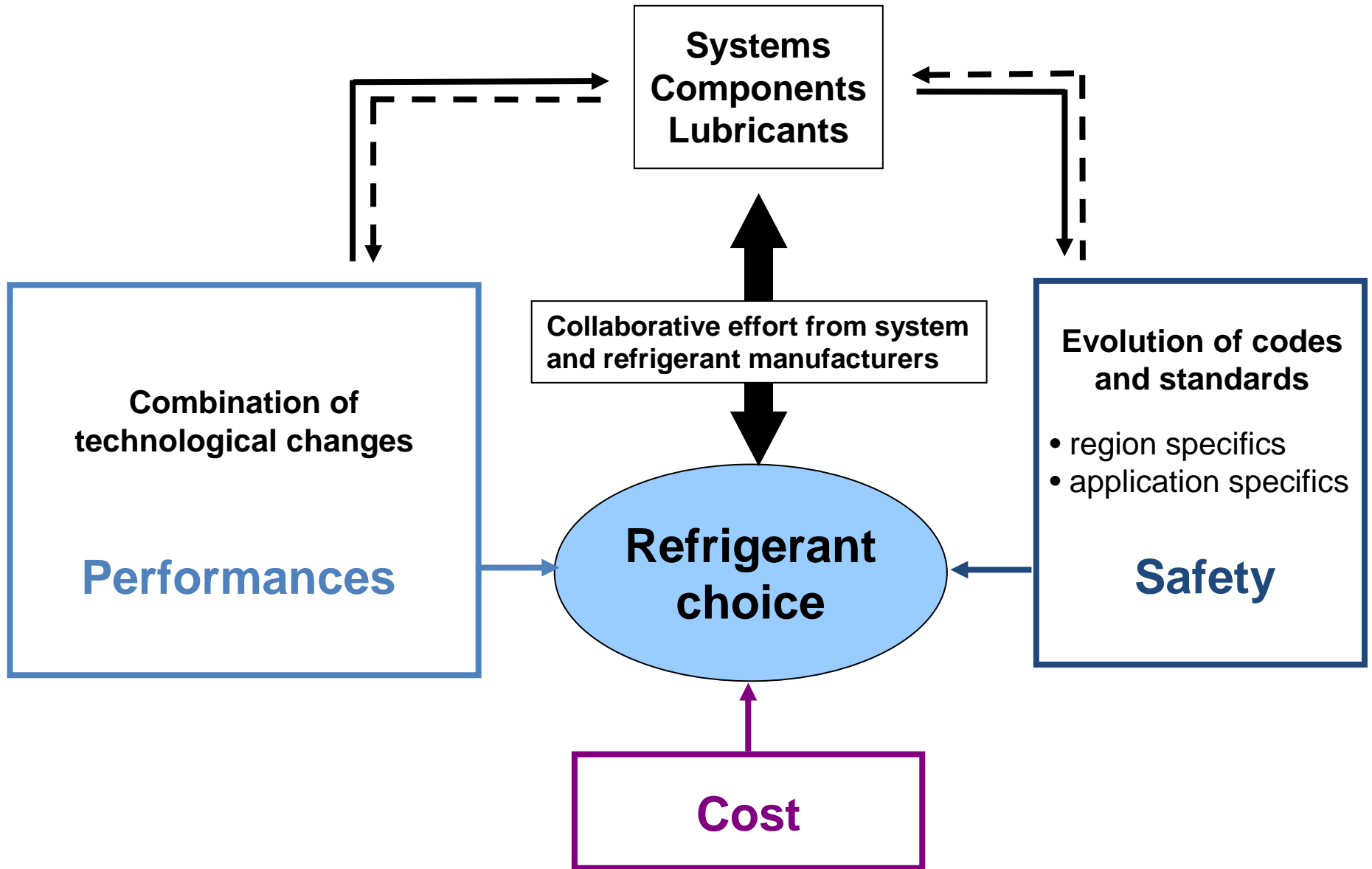
# Next Generation Refrigerants

## For Low, Medium and High Pressure Applications





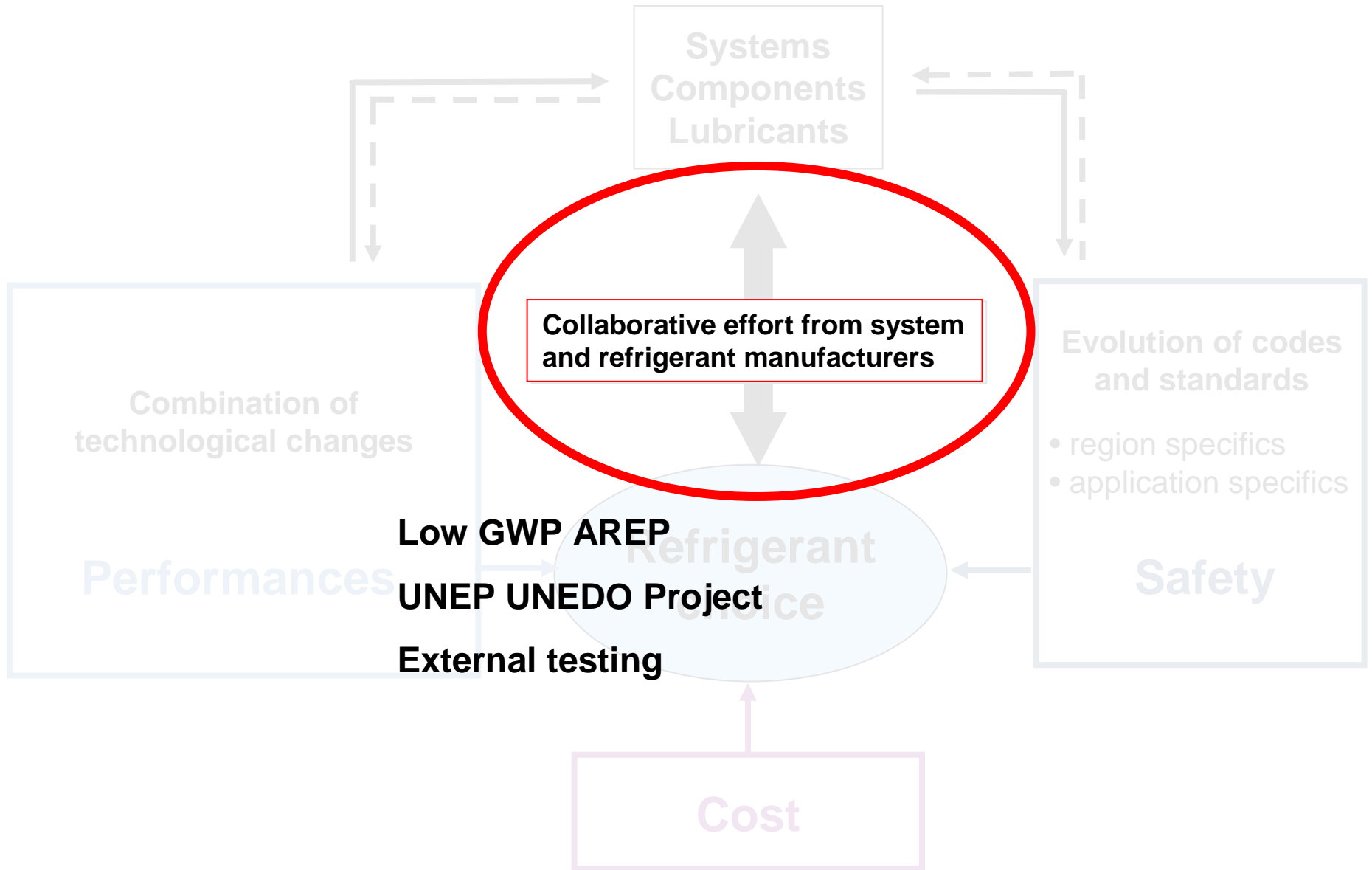
# HFO technology implementation







# HFO technology implementation





# Initial Low GWP developments

		Proposed solutions
R-134a	Small Stand-Alone Med Temp	ARM-41 (~ 950)
	Liquid chillers (MP)	ARM-42 (< 150)
R-404A	MT and LT Refrigeration: DX Systems Transport refrigeration	ARM-30a (~ 200)
		ARM-31a (~ 500)
		ARM-32a (~ 1500)
R-410A	A/C Heat Pumps Chillers (HP)	ARM-70a (< 500)
R-123	Liquid chillers (LP)	ARC-1 (<13)



# Initial Low GWP developments

		Proposed solutions	
R-134a	Small Stand-Alone Med Temp	ARM-41 (~ 950)	
	Liquid chillers (MP)	ARM-42 (< 150)	
R-404A	MT and LT Refrigeration: DX Systems Transport refrigeration	ARM-30a (~ 200)	GWP too high for upcoming regulation
		ARM-31a (~ 500)	
		ARM-32a (~ 1500)	Not optimized for R-404A - Not all applications
R-410A	A/C Heat Pumps Chillers (HP)	ARM-70a (< 500)	Significant loss of capacity
R-123	Liquid chillers (LP)	ARC-1 (<13)	



# Current Low GWP developmental blends

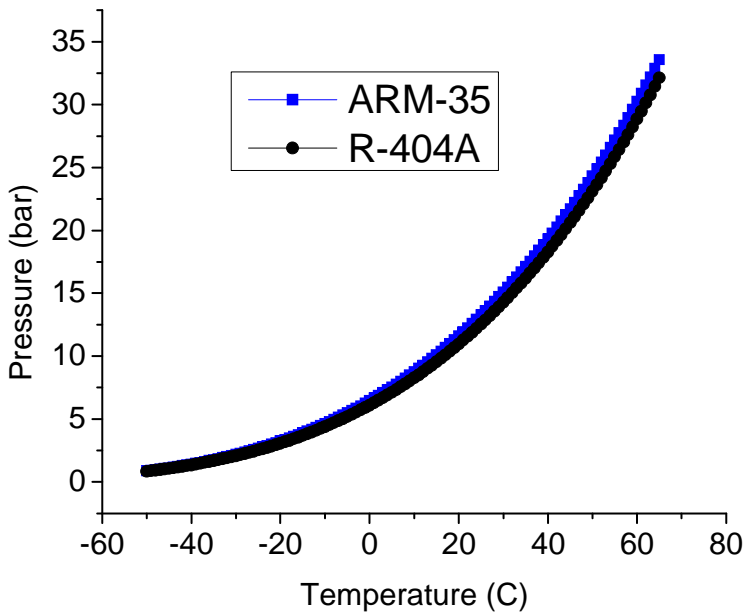
		Proposed solutions	Optimized solutions
R-134a	Small Stand-Alone Med Temp		ARM-41 (~ 950)
	Liquid chillers (MP)		ARM-42 (< 150)
R-404A	MT and LT Refrigeration: DX Systems	ARM-30a (~ 200)	ARM-20a (< 150) ARM-25 (< 150)
		ARM-31a (~ 500)	ARM-20b (~ 250)
		ARM-32a (~ 1500)	ARM-32b (~ 1400)
	Transport refrigeration LT DX systems		ARM-35 (~ 2150)
R-410A	A/C Heat Pumps Chillers (HP)	ARM-70a (< 500)	ARM-71a (< 500)
R-123	Liquid chillers (LP)		ARC-1 (<13)



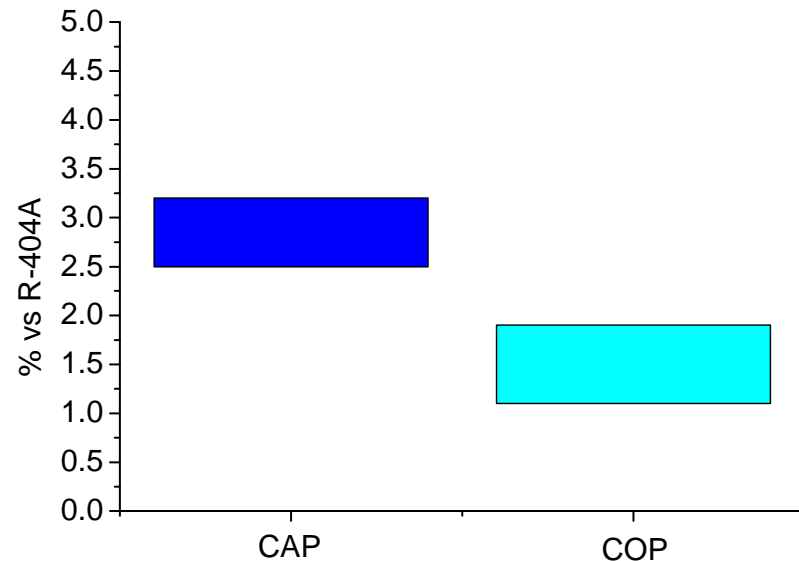
# Transport Refrigeration

- “Current R-404A replacement like R-407 series have much higher discharge temperatures than R-404A.”
- “High Glide Blends may be an issue”
- “Systems have to run at a wide range of temperature conditions”

**Our solution**  
**ARM-35**



**Non-flammable**  
**~45% reduction in GWP**  
**Increase in Discharge T < 10F**  
**Evaporator Glide < 10F**





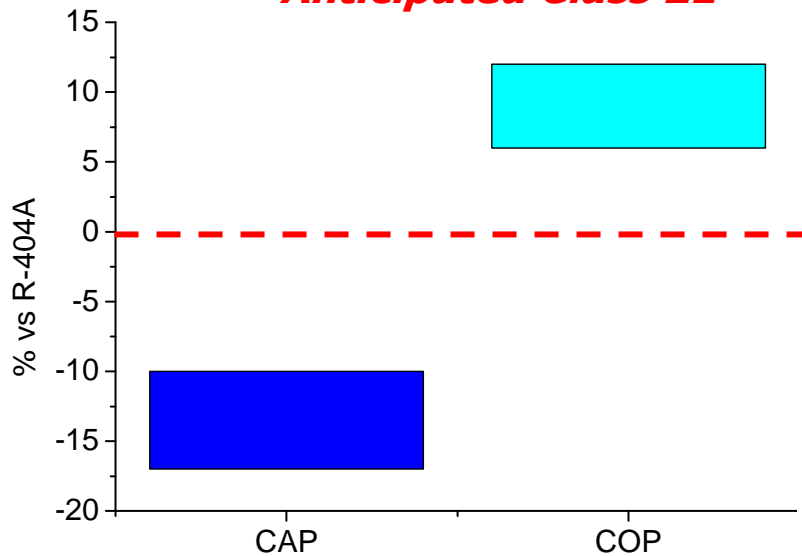
# Very low GWP solutions for R-404A replacements

- “Needs for a refrigerant with GWP < 150 to meet upcoming regulations in Europe”

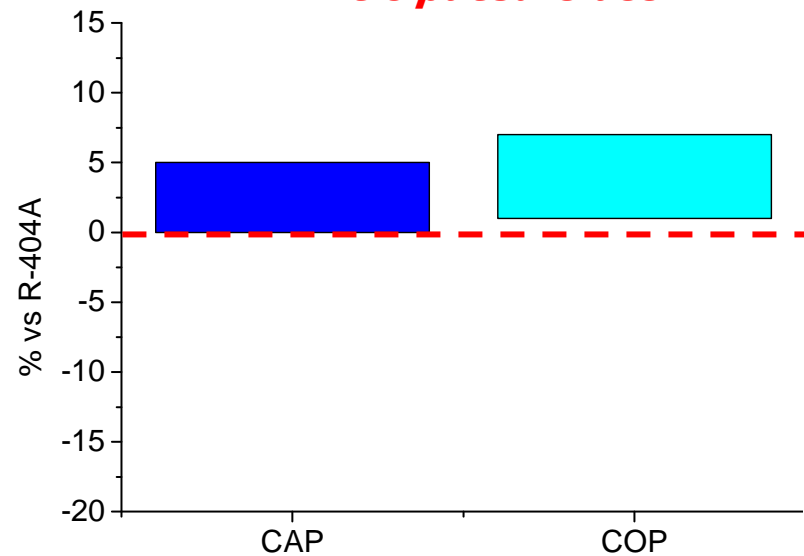
**ARM-20a**      Our solutions      **ARM-25**

*Increase in Discharge T similar or lower to R-407A*

**Evaporator Glide <10F**  
**Anticipated Class 2L**



**Evaporator Glide 10-15F**  
**Anticipated Class 2**







# Summary

**Our commitment to a sustainable future:**

**- Developing next generation solutions for all major applications**

- HFO and new generation molecules.
- Lower-GWP HFO blends for HVAC-R
  - different solutions based on GWP, performances and flammability

**- Active involvement in industry wide effort to replace current HFCs**

- AHRI Low-GWP AREP
- Joint UNEP/UNIDO project for high ambient temperatures (Promoting Low-GWP Refrigerant Alternatives for the Air Conditioning Sector in High-Ambient Countries)





# Questions?



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