

Chillventa Specialist Forums 2024

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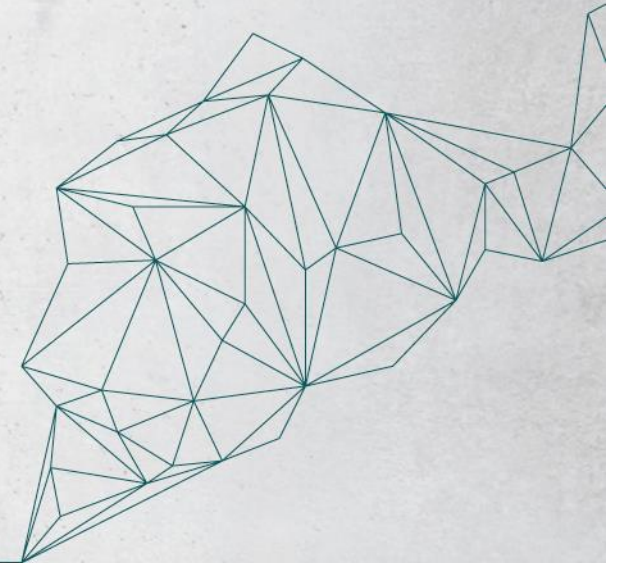
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A Comparison of R-454C, R-449A, and R-744 in Food Retail Refrigeration Systems: Energy Efficiency and System Performance

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INTRODUCTION

Why Refrigeration Systems Efficiency matters?

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About 8%* of global electricity consumption is for food Refrigeration



40% of all food requires Refrigeration



Up to 60% of energy used in small to medium size stores is related to Refrigeration



Indirect emissions accounts for more than 95%



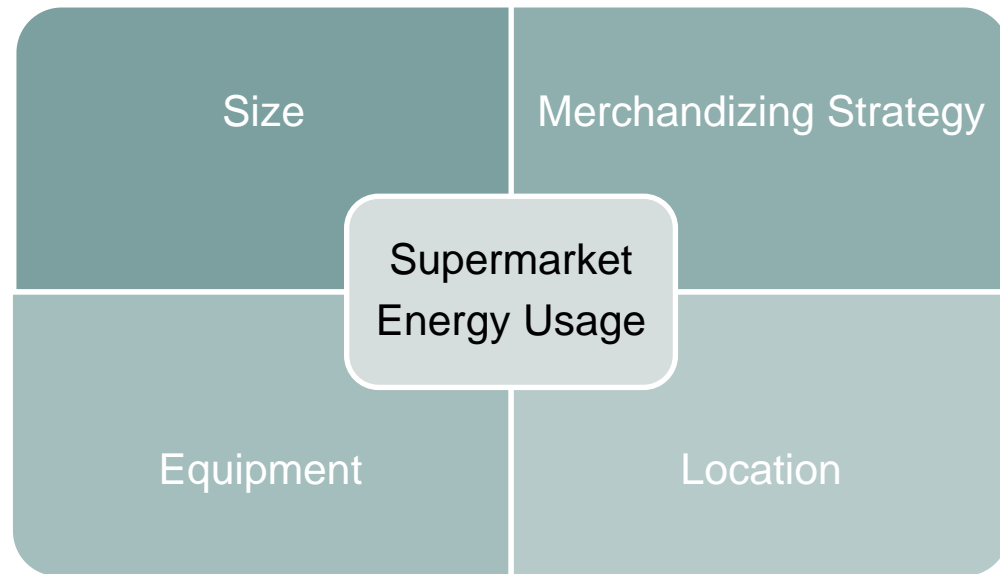
Energy Efficiency of Refrigeration Systems is key to reduce energy consumption and carbon emissions



INTRODUCTION

Why the choice of the Refrigerant is key?

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Montreal Protocol (1987);
Kigali Amendment (2016)



Phase down of high GWP refrigerants



HFCs like R-404A, R-507 and R-134a being replaced



Low GWP alternatives: HFOs like R-454C, R-449A and R-744

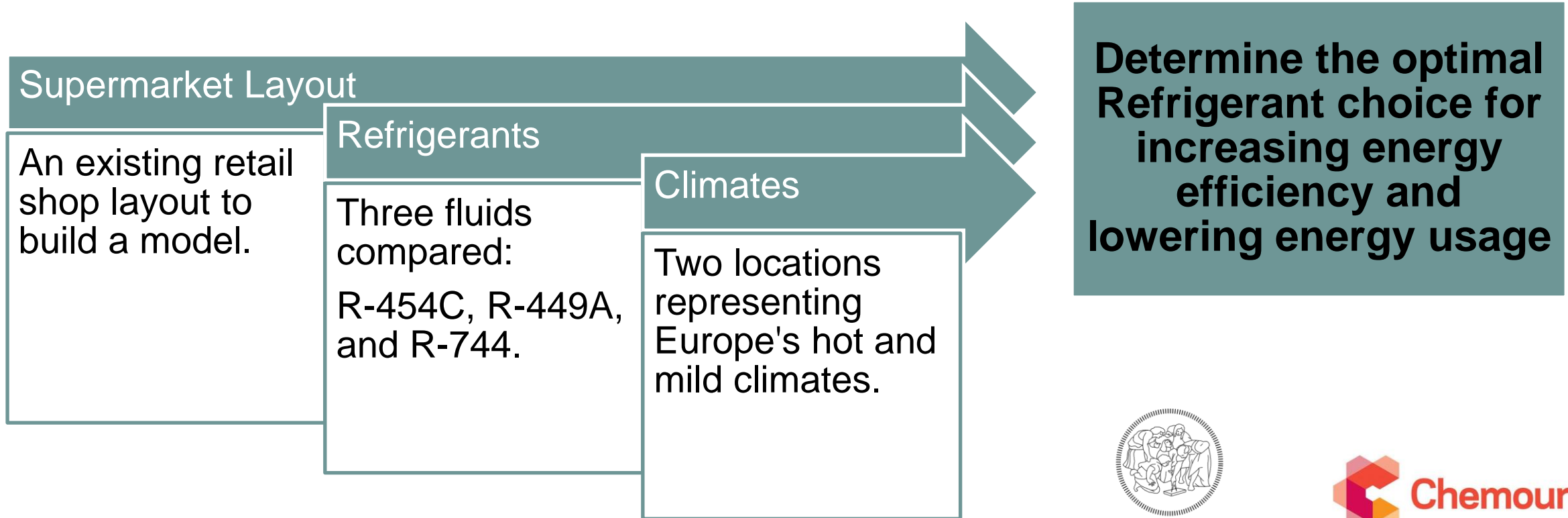


The refrigerant choice has significant impact on the architecture, energy efficiency, and durability of refrigerating system.

SCOPE OF WORK

Which process can determine the optimal technology on a case-by-case basis?

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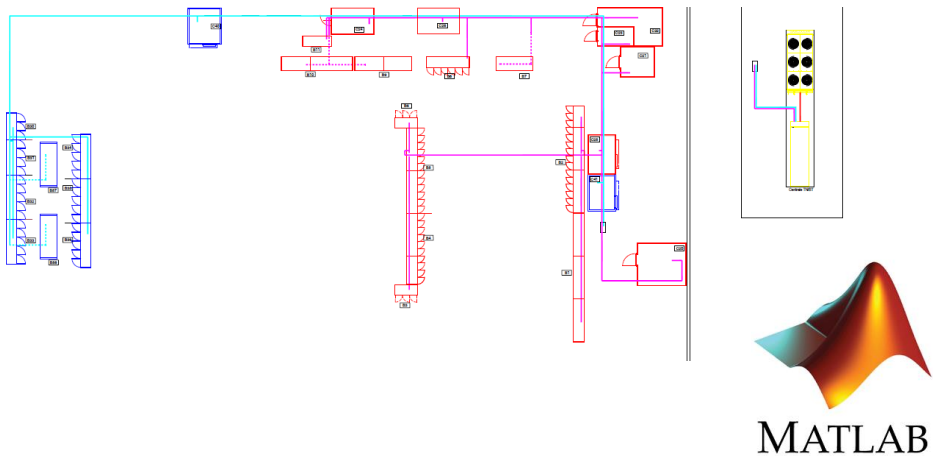


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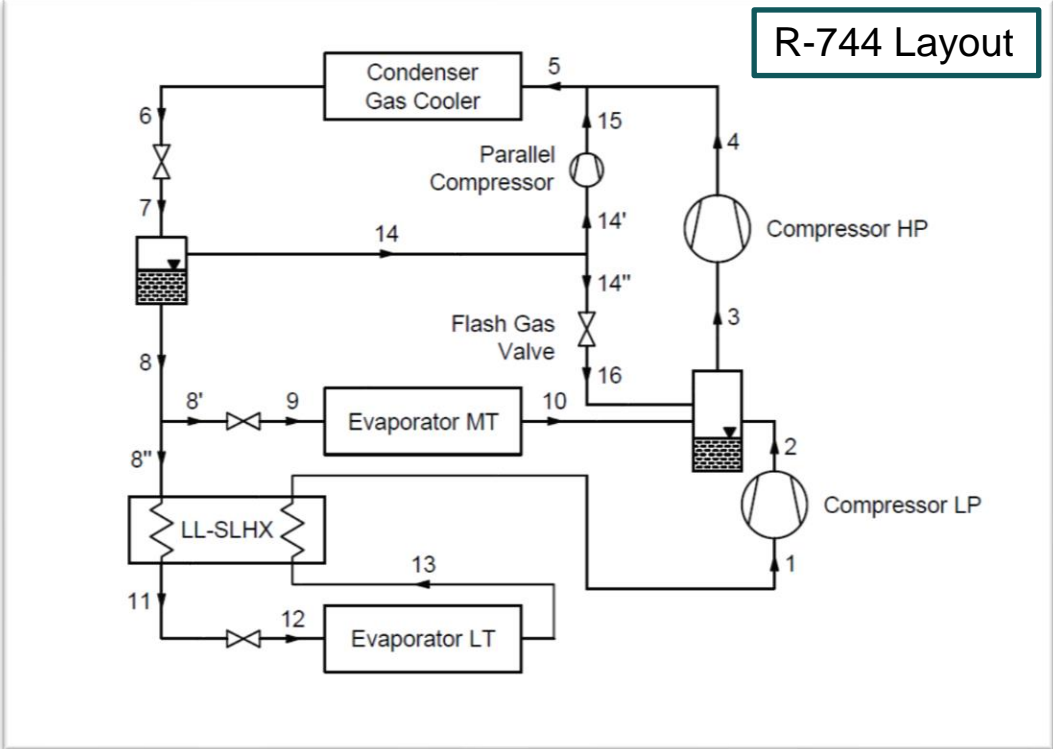
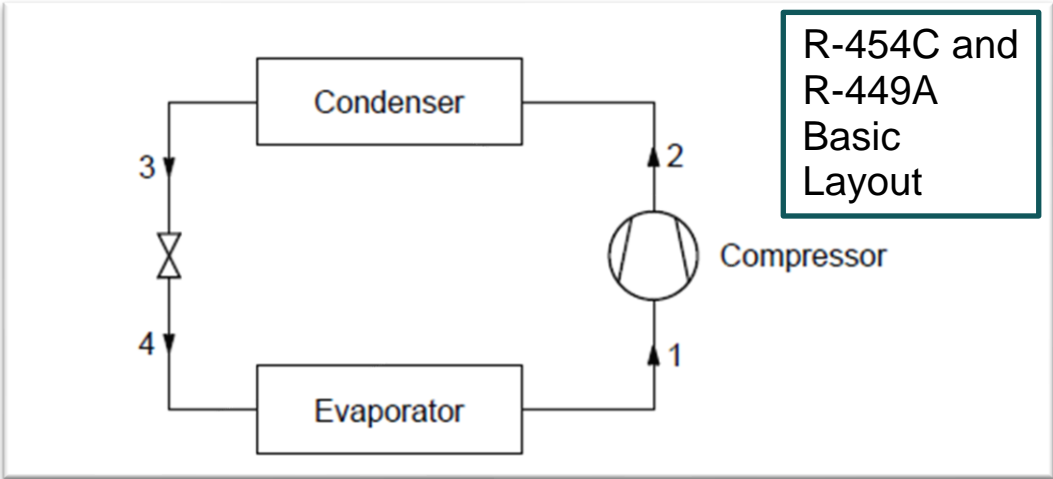
REFRIGERATING SYSTEM MODELLING

How the refrigeration System have been modelled?



Cooling Section	Load [kW]	Evaporating temperature [°C]
MT1	31.88	-2
MT2	33.50	-10
LT	27.42	-35
TOT	92.80	

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REFRIGERANTS



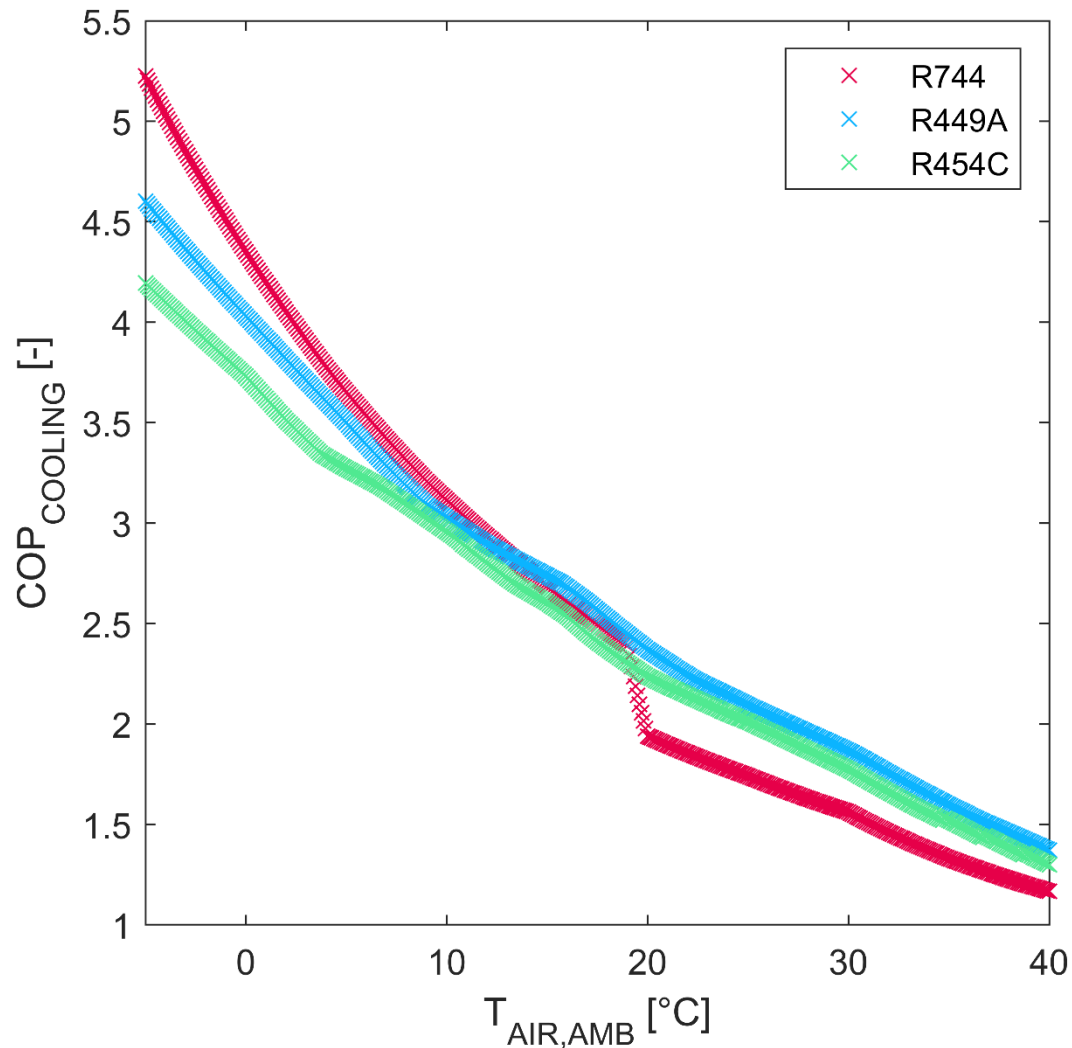
Which properties are relevant for the compared refrigerants?

Name	ASHRAE	GWP	Recoverable	Category	Operating Pressure (Tair=35°C)	Boiling Point	Critical Temperature	Composition
Opteon XL20	R-454C	148	YES	A2L	17 bar	-45,6°C	+85,7°C	R-32 21,5%; R-1234yf 78,5%
Opteon XP40	R-449A	1397	YES	A1	19 bar	-45,7°C	+82,1°C	R-32 24,3%; R-125 24,7%; R-1234yf 25,3%; R-134a 25,7%
Carbon Dioxide	R-744	1	NO	A1	100 bar	-78,46°C	+31°C	CO2

Circular economy is enabling resources conservation by avoiding destruction of used refrigerants

RESULTS

How efficiency (COP) relates to Ambient Temperature?



Basic Layout R-454C and R-449A:

Gradual improvement in energy efficiency as external temperatures decrease

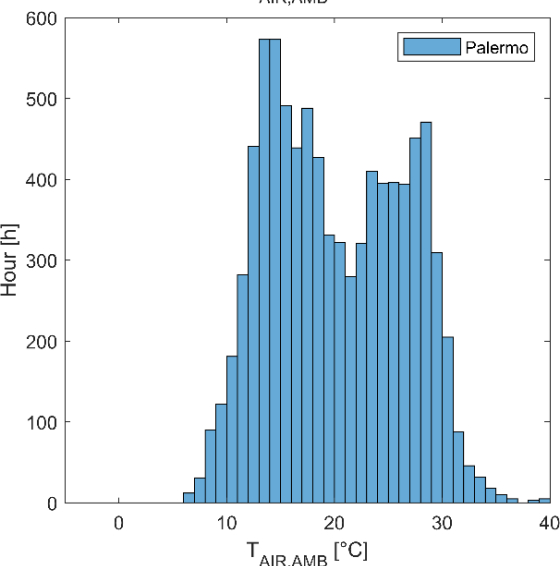
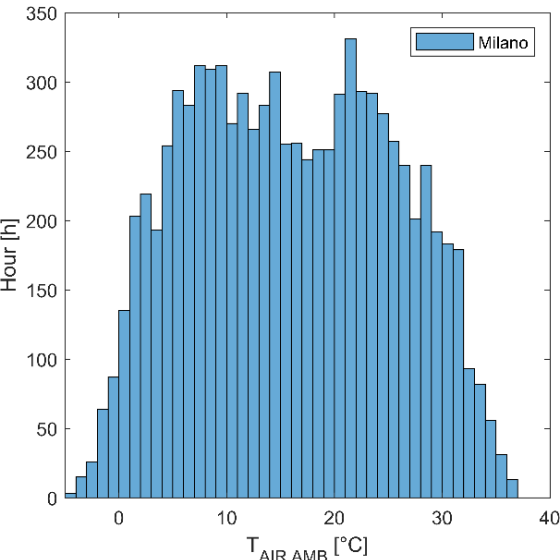
Advanced R-744:

Significant drop in energy efficiency at outdoor temperatures beyond 20 °C, correspondent to transcritical mode operation

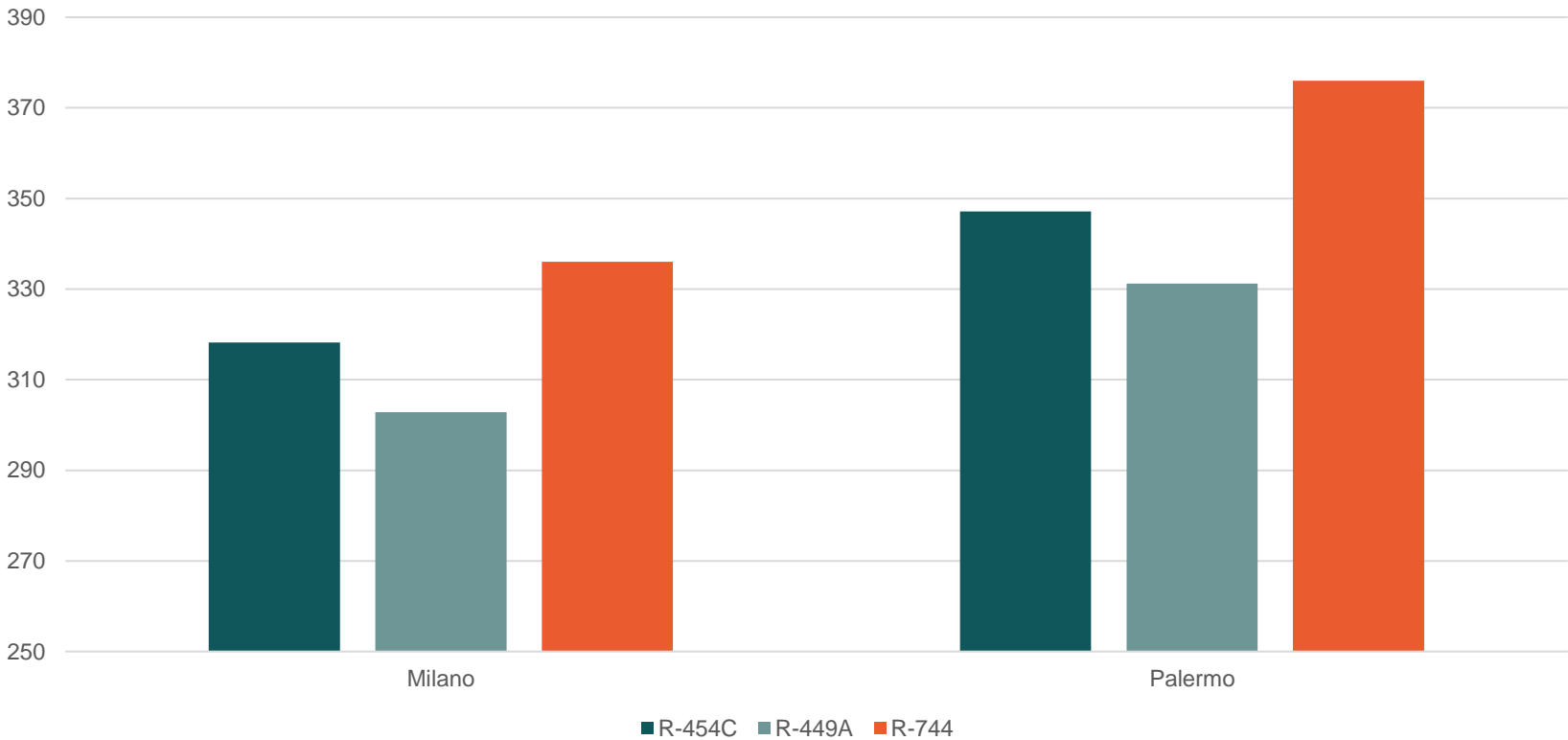
With outside temperatures above 15°C R-454C and R-449A outperform R-744 system

RESULTS

How much energy can be saved?



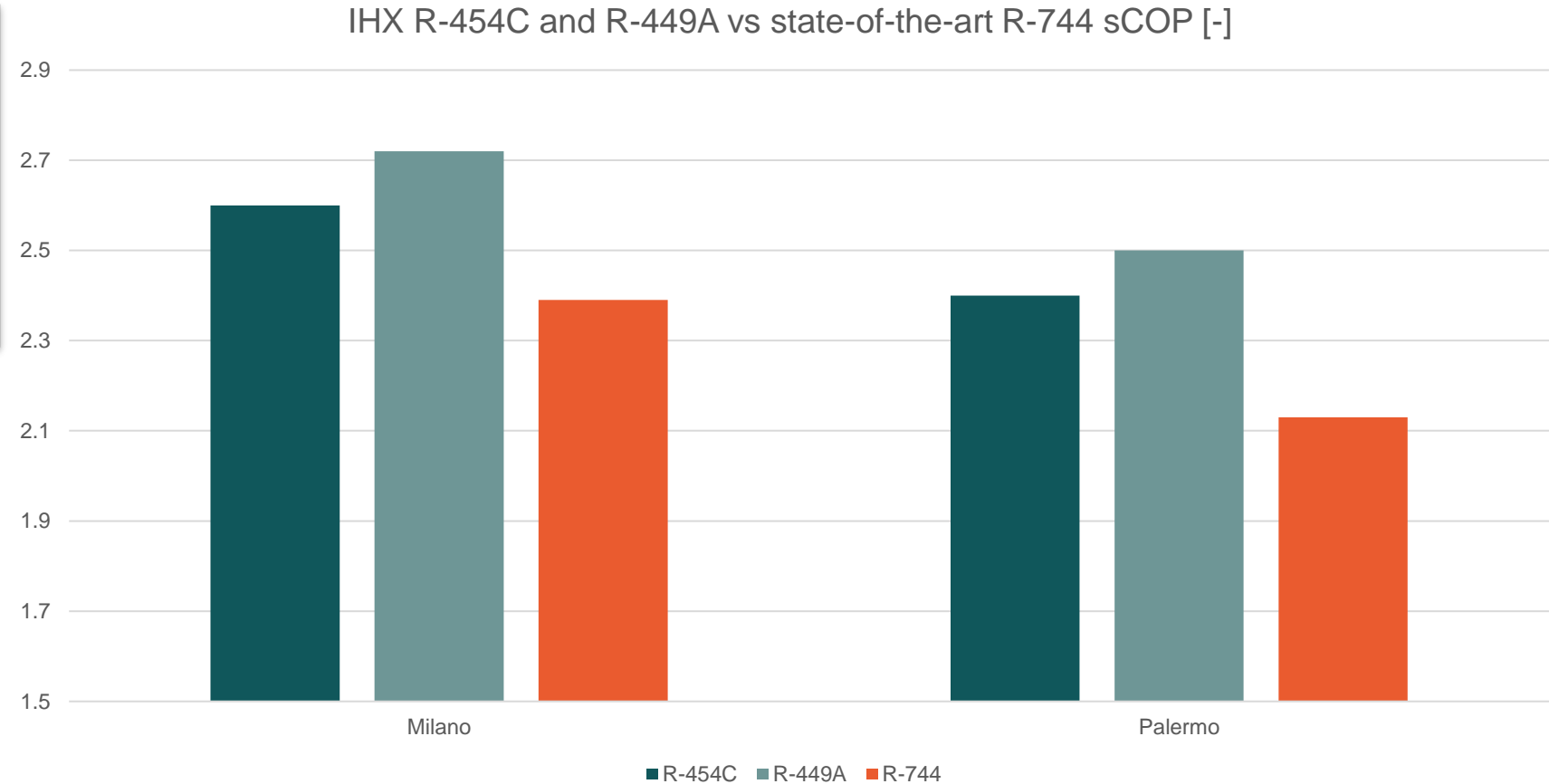
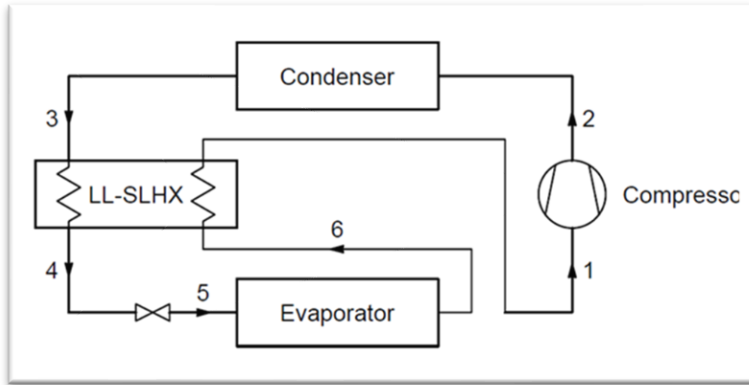
Basic R-454C and R-449A vs state-of-the-art R-744
Annual Energy Consumption [MWh]



In Mild climate, R-454C and R-449A performed 5.4% and 10.9% better than R-744
In Hot climate, R-454C and R-449A performed 8.5% and **13.6%** better than R-744

RESULTS

What about improving the basic system layout?



In Mild climate, R-454C and R-449A performed 8.8% and 14.2% better than R-744
In Hot climate, R-454C and R-449A performed 12.7% and **17.4%** better than R-744

RESULTS

How this translates in cost savings and emissions?

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This means up to
17,4% better sCOP*

Up to **€18.674 yearly
energy bill savings** for a
single supermarket**



If all supermarkets in Italy
chose HFOs over CO₂,
yearly energy savings would
be equivalent to
4.000 electric vehicles,
each **traveling 1.000 km.**

CONCLUSION

What have we learnt from this study?

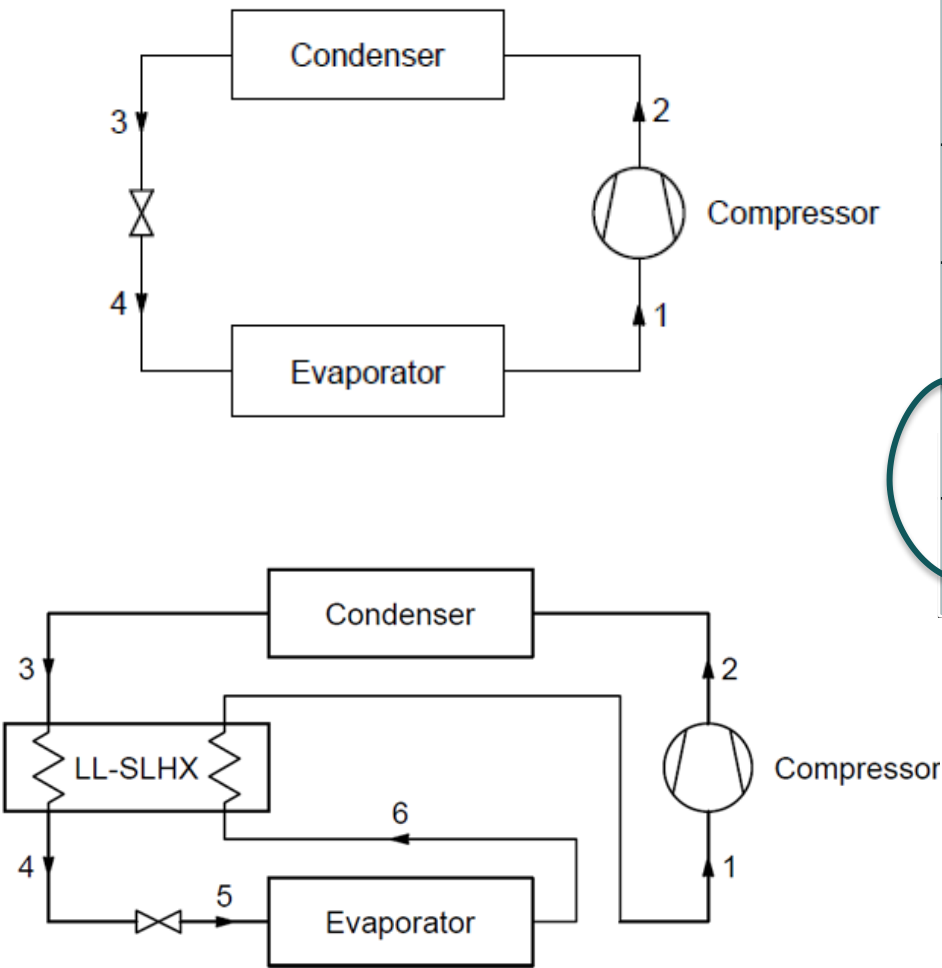
Results

- R-454C and R-449A basic systems have a higher COP starting from outdoor ambient temperatures above 15 °C, when compared to advanced R-744 systems.
- In terms of sCOP the R-744 system performed worse than R-454C and R-449A in both locations.
- In a mild-climate, R-744 sCOP is 8.8% and 14.2% lower than R-454C and R-449A,
- In a hot climate, R-744 performed 12.7% and 17.4% worse than R-454C and R-449A

Takeaways

- A careful evaluation of all available technologies is needed to design food preservation refrigeration systems that reduce energy consumption and related emissions for each store size and climatic condition
- R-454C and R-449A refrigeration systems are able to outperform more complex R-744 systems while maintaining layout simplicity, robustness and ease of maintenance

Outlook: How to further increase the efficiency and capacity of HFO systems



COOLING IMPROVEMENTS	Modification	COP Improvement (%)	Cooling capacity Improvement (%)
Measure	Compressor	+0 ...+6.5	+0 ... +4.6
Measure	IHX opt. vs. IHX std.	+4 ... +14	+1 ... +17
Measure	SH control	+2 ... +22	+3 ... +25
Measure	IHX + SH Control	+6 ... +36	+4 ... +42

Hardware & Software changes enable tremendous energy savings.
Talk to us! We will be happy to support you!

THANK YOU
for your kind attention

Q&A?

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