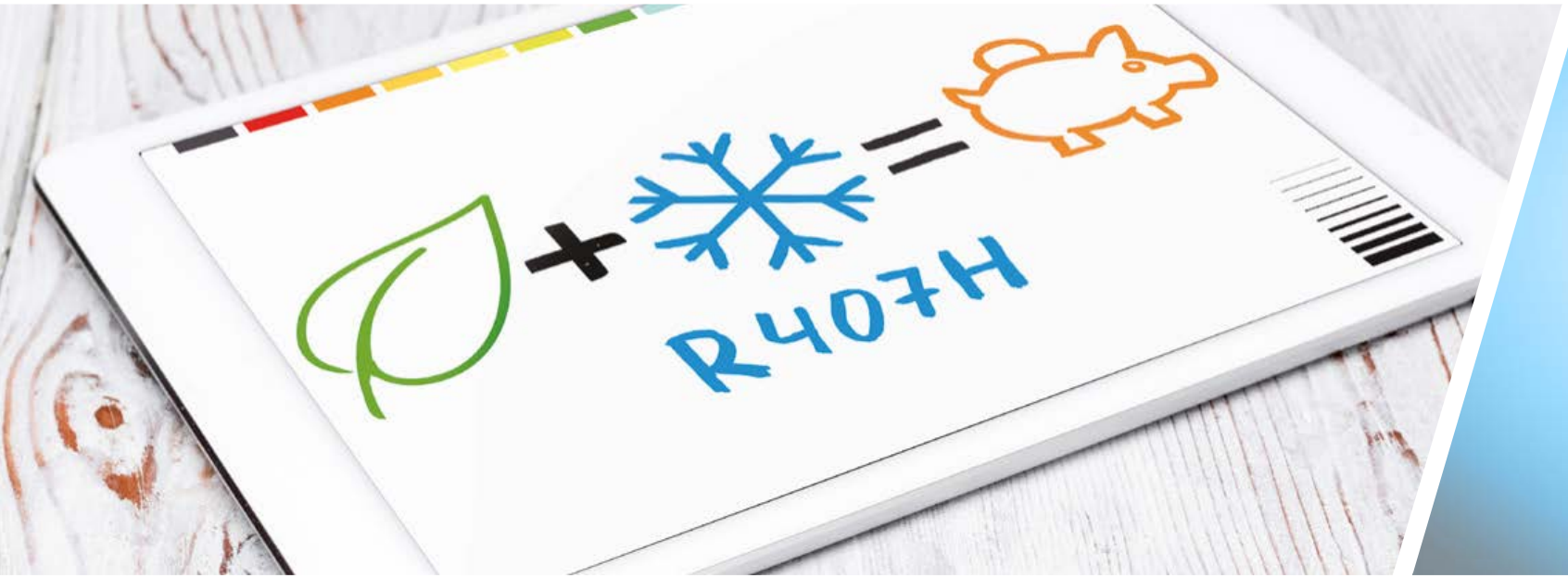
DAIKIN | Positively Innovative



R407H introduction

Daikin Refrigerants Europe
Daikin Chemical Europe

Who are we?

Key figures Daikin Group

Founded 1924

€17 billion turnover (FY2016)

67’000 employees

in 245 subsidiaries worldwide

Daikin's core business: Airconditioning and Chemicals

Who we are

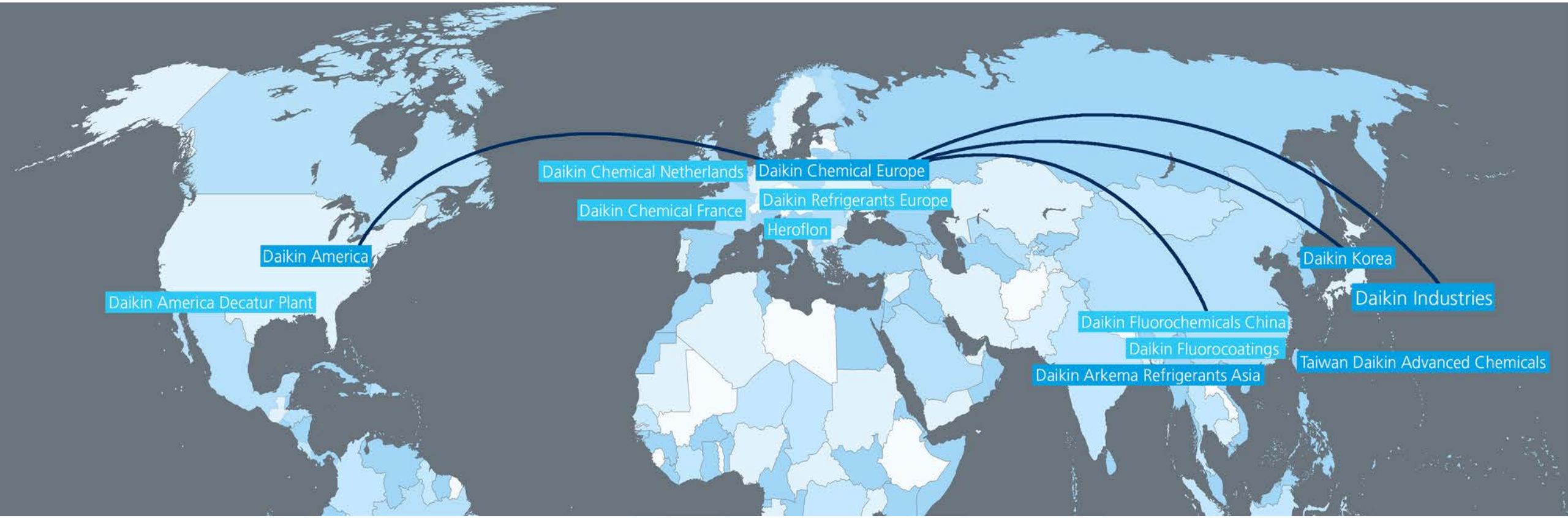
The leading producer of air conditioning / refrigeration equipment in the world

Many of the refrigerants used in air conditioners are based on fluorine

To support our airconditioning business, we have been involved in fluorine research since 1933

Today, we are one of the biggest manufacturers of fluorochemical products in the world

Our global sales and manufacturing network



Sales
Manufacturing

Daikin Refrigerants Europe (Frankfurt, Germany)

A reliable partner for quota-relevant gas and next generation gas supply…

…with a broad portfolio, serving various applications

Residential / Commercial AC

Refrigeration

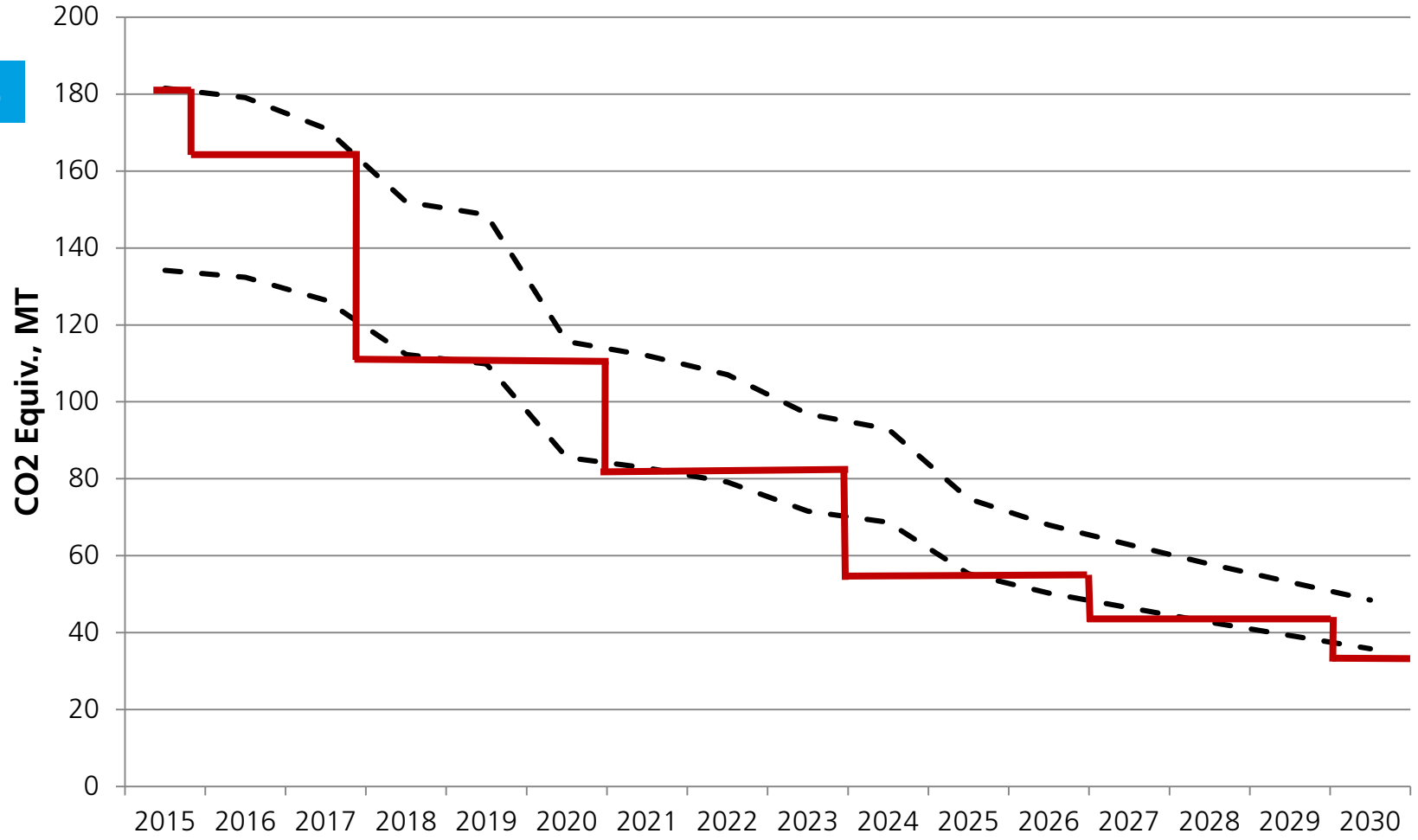
Automotive AC

Pharmaceutical propellants

The EU F-Gas Regulation

EU F-Gas Regulation: Phasedown

2015: 100%



+15%

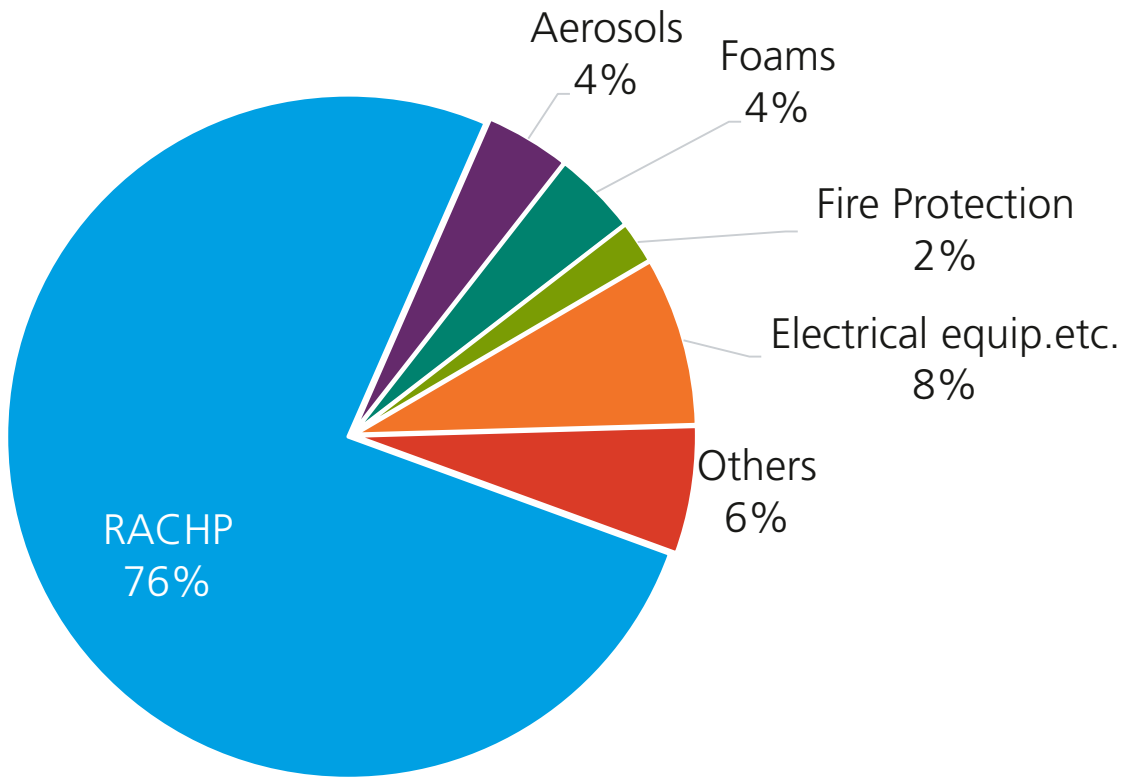
-15%

Corridor of F-Gas consumption variation as experienced during 2009 - 2012

2030: 21%

Refrigerant contributors to EU F-Gas emissions (1/3)

Markets using F-Gases, % of CO2 tons (2014)[1]

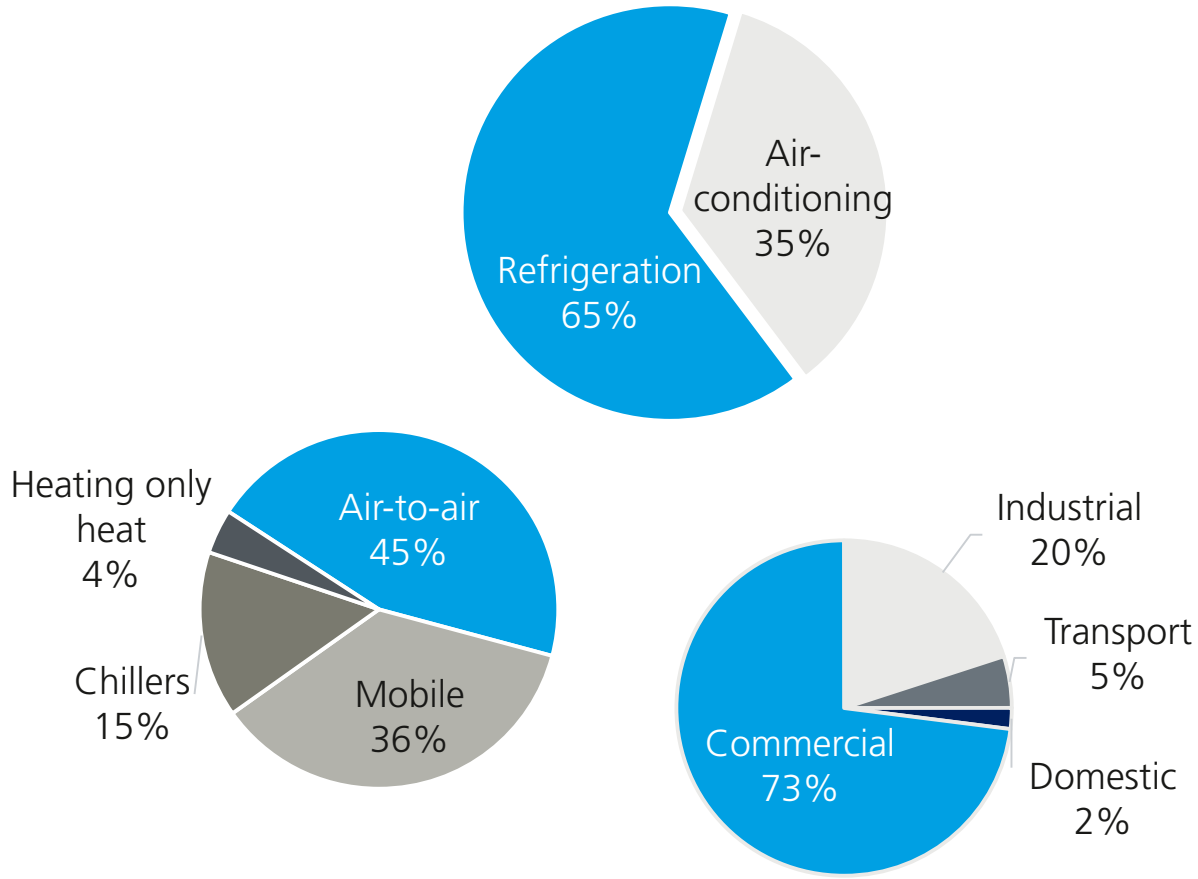


76% of released F-Gases are coming from the RACHP sector

1) Source: EEA, 2015

Refrigerant contributors to EU F-Gas emissions (2/3)

Global HFC use in RACHP sectors (GWP-weighted) 2012[2]

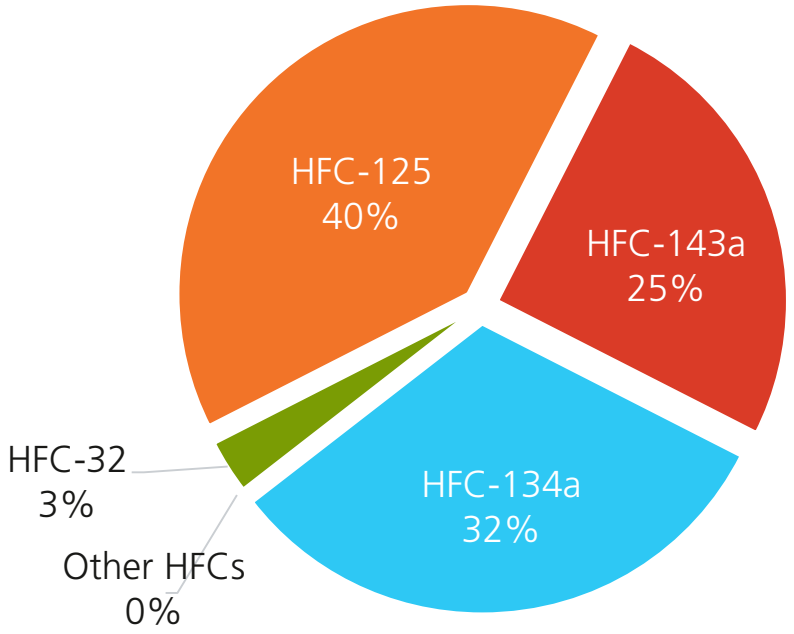


Highest priority for:
- Refrigeration
- Air / Air AC + HP

2) Source: Gluckman Consulting, Bangkok 04/2015

Refrigerant contributors to EU F-Gas emissions (3/3)

Split of EU HFC consumption, CO2 tons (2014)[1]



>90% of CO_2-equivalent emissions by R134a / R125 / R143a

1) Source: EEA, 2015

Main use of R125 / R134a / R143a

Refrigerant	Component for	GWP	Safety Class	NBP, °C	Remarks
R125		**3500**	**A1**	**-48.1**	
	R404A* (44%)	3920	A1	-46.6	LT commercial / supermarkets / transport / industry
	R407C (25%)	1700	A1	-43.8	Stationary A
	R410A (50%)	2100	A1	-51.6	
R134a		**1430**	**A1**		
	pure refrigerant	1430	A		ercial / MT supermarket / Chiller / port
	R404A* (4%)	3920			LT commercial / supermarkets / transport / industry
	R407C (52%)	1700	A	-43.8	Stationary AC
R143a		**4470**	**A1**	**-47.2**	
	R404A* (52%)	3920	A1	-46.6	LT commercial / supermarkets / transport / industry

Replacements are needed for:
R404A / R507
R407C / R134a

* R507 is considered under R404A

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Refrigerants and their replacements under EU F-Gas Regulation

Service

Purpose: Service refrigerants, which are reducing the use of high GWP refrigerants in existing systems as a quick solution for 2018-2024 phase down and which can be applied without major changes on the system

Requirement: Same pressure, same safety class, highest possible performance, lowest possible GWP, low cost.

Refrigerant	Replacement	Safety Class	Application
R134a	R513B	A1	Chiller / MT applications
R404A / R507	R407H	A1	LT*/MT applications

Retrofit / New Systems

Purpose: Refrigerants for systems fitted to the new refrigerant and new systems for the same applications.

Requirement: Highest possible performance, lowest possible GWP, low cost

Refrigerant	Replacement	Safety Class	Application
R134a	R1234yf	A2L	MAC and other stat. applications
R404A / R507	R454A / R407H*	A2L	LT / MT refrigeration
R410A	R32	A2L	Stationary AC/ Heat pump

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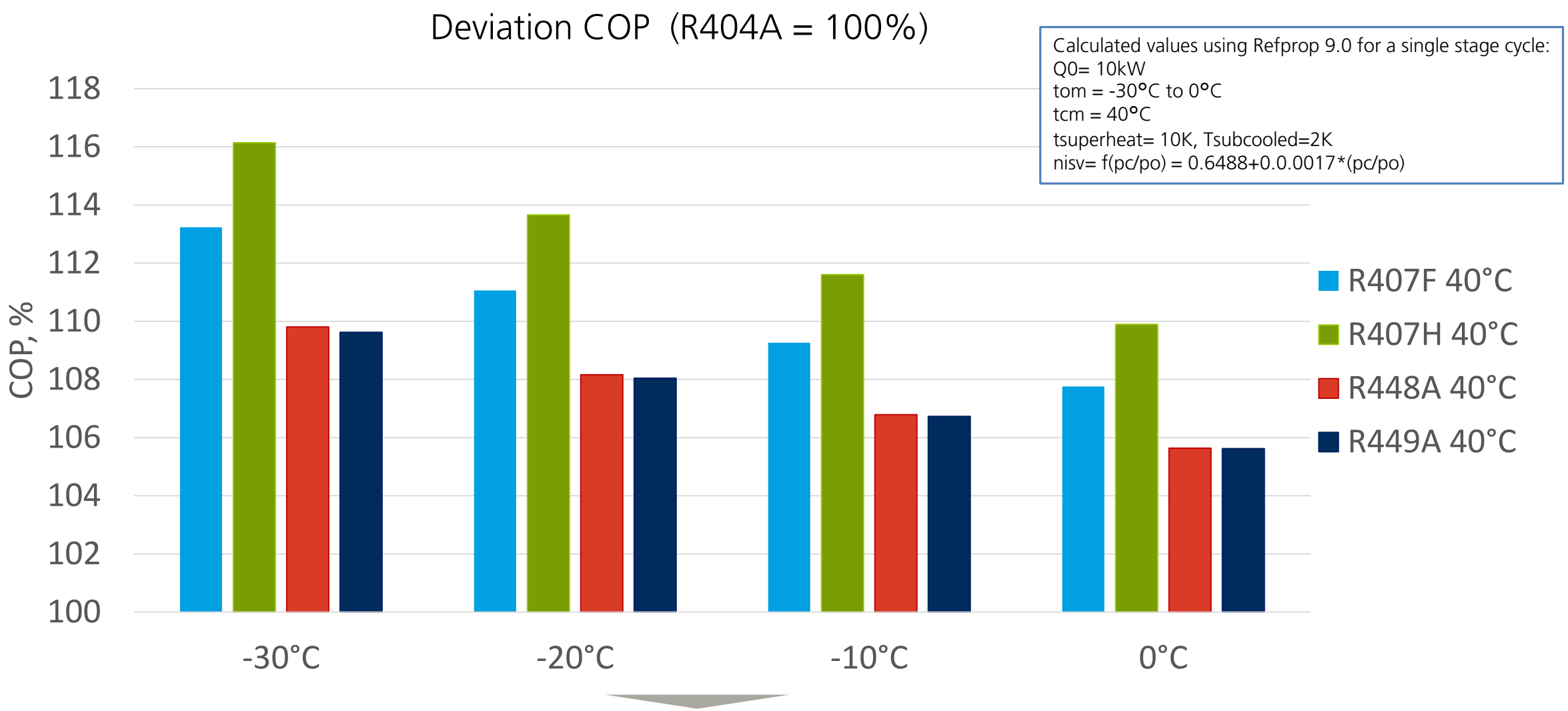
*partly

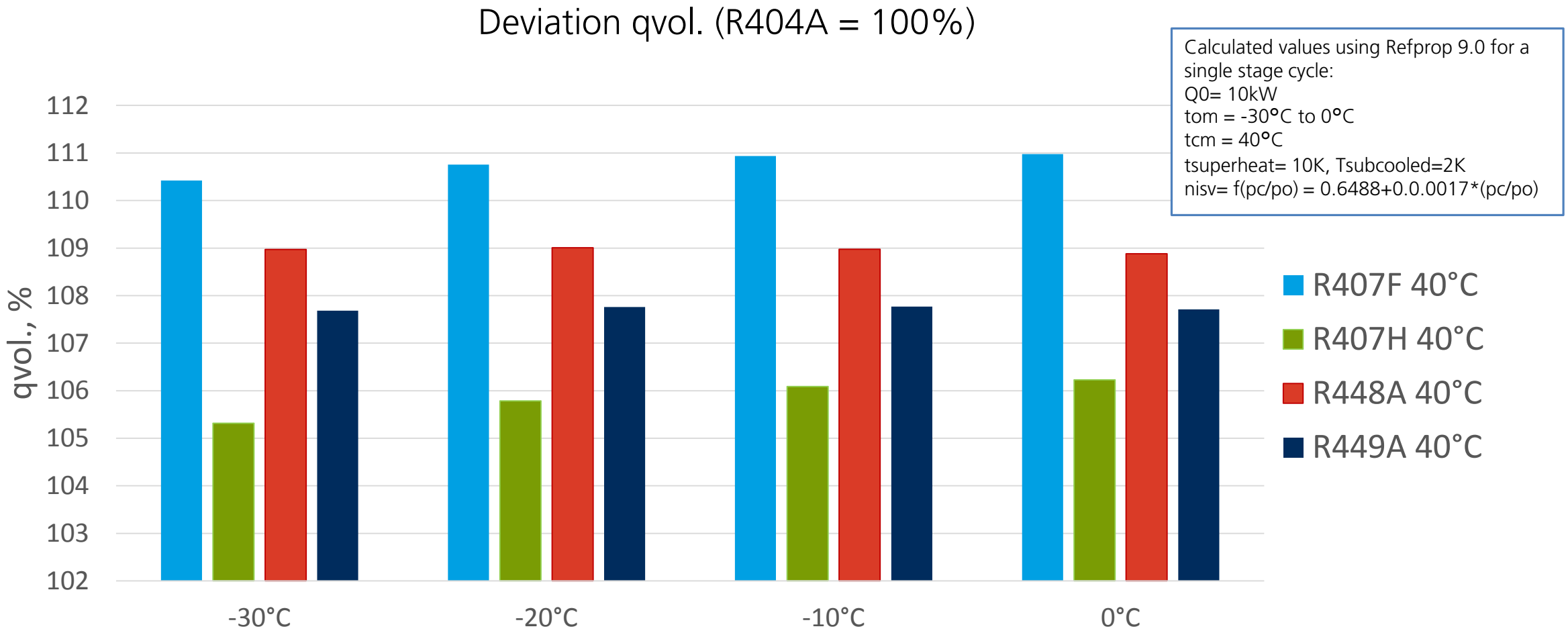
R407H

R407H performance comparison: COP%



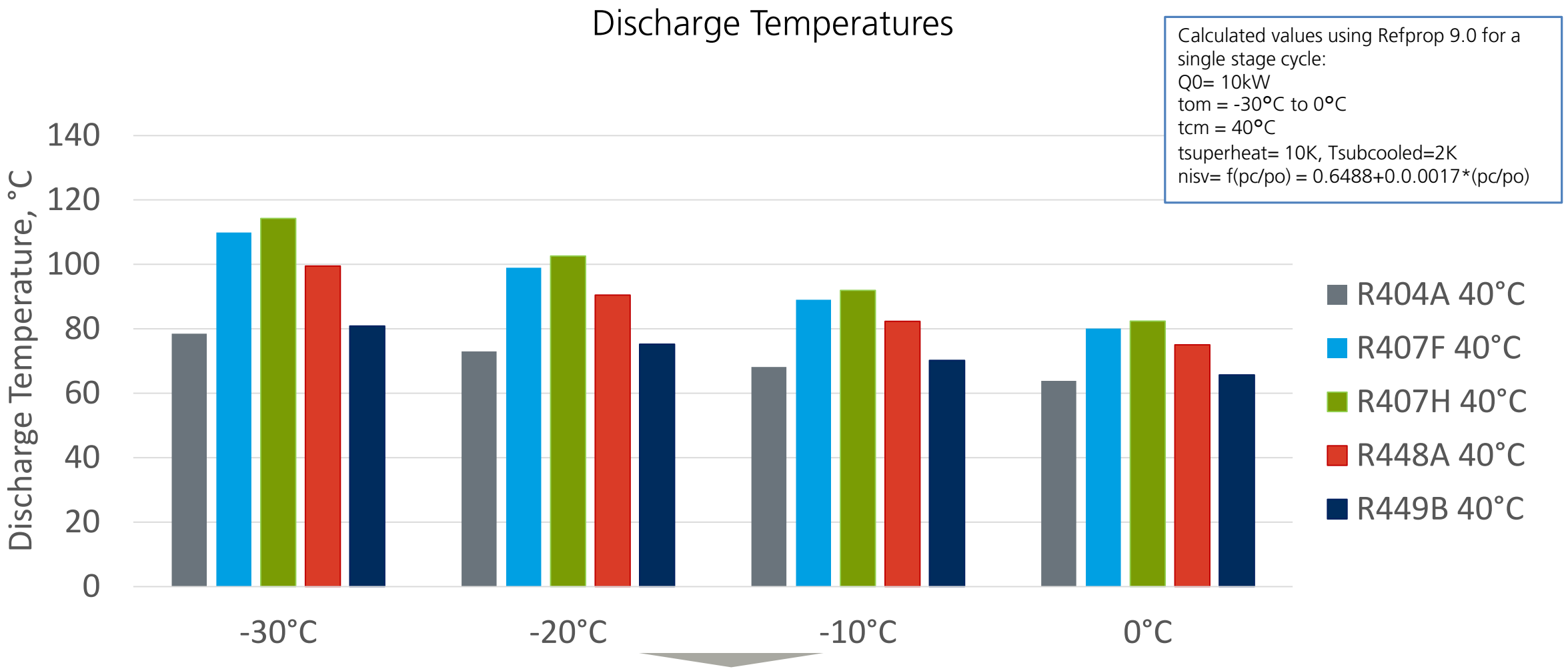
Comparison of different R404A replacements
R407H has the highest efficiency, HFO based blends fall behind…

R407H performance comparison: Deviation qvol.



R407H shows the lowest capacity, but still more then R404A. Since R407H is used as a replacement for R404A in existing systems, it is ensured that the converted system delivers enough capacity.

R407H performance comparison: Discharge temperature



R407H has the highest discharge temperatures but below 120° C, which is the typical limit in semi-hermetic and open compressor systems.

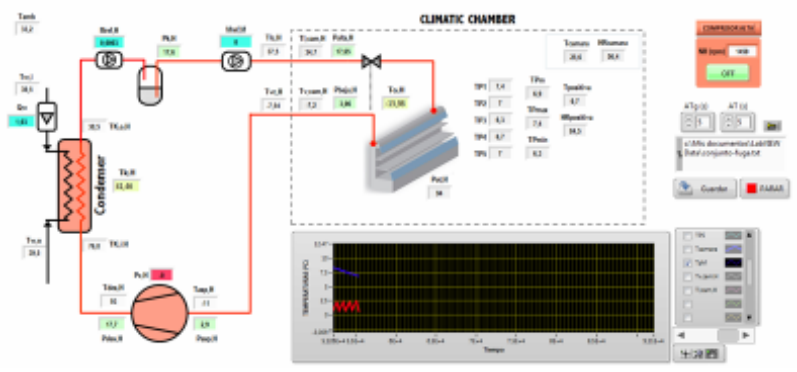
R407H vs R404A: practical MT test results

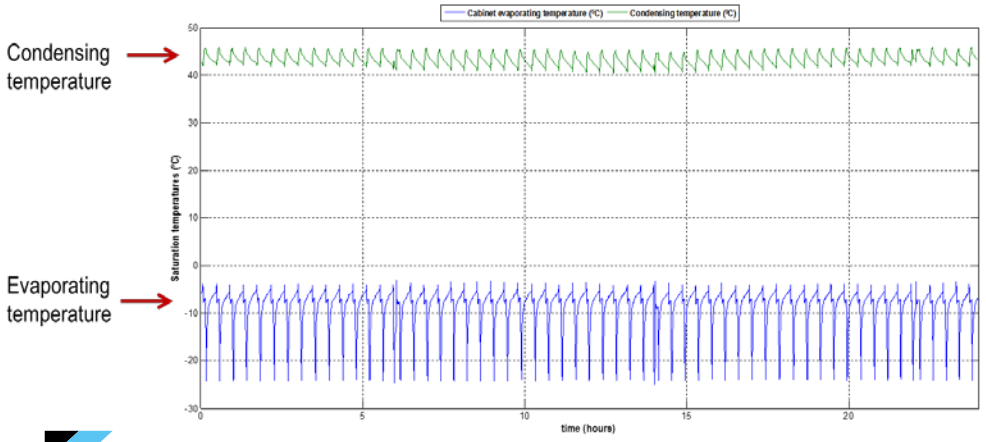
Experimental set up
Measurement system

Cycle
- 1 Coriolis mass flow meter
- 1 Magnetic volumetric flow meter
- 9 T-type thermocouples
- 3 pressure gauges
- 1 wattmeter

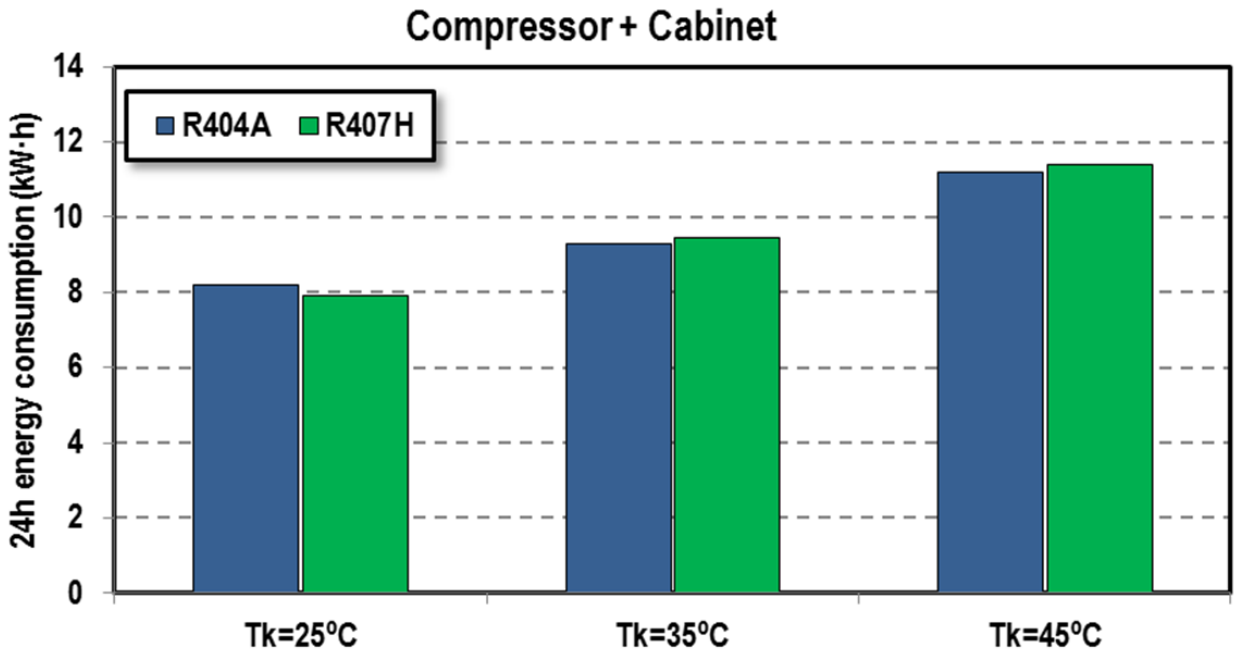
Cabinet
- 1 Coriolis mass flow meter
- 2 T-type thermocouples
- 5 M-test packages with T-type thermocouples
- 1 wattmeter
- 1 humidistat

Climatic chamber
- 1 humidistat
- 1 temperature gauge





Parameter	R404A Tk=25°C	R404A Tk=35°C	R404A Tk=45°C	R407H Tk=25°C	R407H Tk=35°C	R407H Tk=45°C
Average condensing temperature (°C)	**25.7**	**34.5**	**45.1**	**25.7**	**35.1**	**45.0**
Deviation during test	0.3	0.6	0.8	0.5	0.7	1.1
Average product temperature (°C)	**1.9**	**2.0**	**2.0**	**2.1**	**2.0**	**2.0**
Deviation during test	0.1	0.1	0.1	0.1	0.1	0.1
Average climatic chamber temperature (°C)	**25.0**	**25.0**	**25.1**	**24.9**	**24.9**	**24.9**
Deviation during test	0.7	0.7	0.7	0.6	0.7	0.7
Average climatic chamber RH (%)	**58.9**	**58.7**	**58.4**	**57.5**	**57.5**	**57.3**
Deviation during test	5.2	5.3	5.3	4.6	4.8	4.9



Summary

- The EU F-Gas regulations forces a 79% reduction of CO_2 related consumption of F-Gases
- The RACHP sector is the biggest contributor with 75%
- More than 92% of the consumption comes from R125 / R134a / R143a
- The main refrigerants from these components are R404A / R407C / R410A

	R404A	R134a	R410A
A1 alternative	R407H GWP 1495	R513B GWP 596	-
A2L alternative	R454A GWP 239	R1234yf GWP 4	R32 GWP 675

Note: all GWP values acc. IPCC AR4

Thank you for your attention!