



RAC Systems at the Center of Our Society

Examples of cooling intelligence (Data centers, Hospitals),
focusing on energy efficiency and safety.
Europe wants to lead the way

Marco Buoni

Centro Studi Galileo – *Director Italian Training Institute*
AREA – *Former President w/ international affairs*



About AREA



Established in 1989

26 national associations

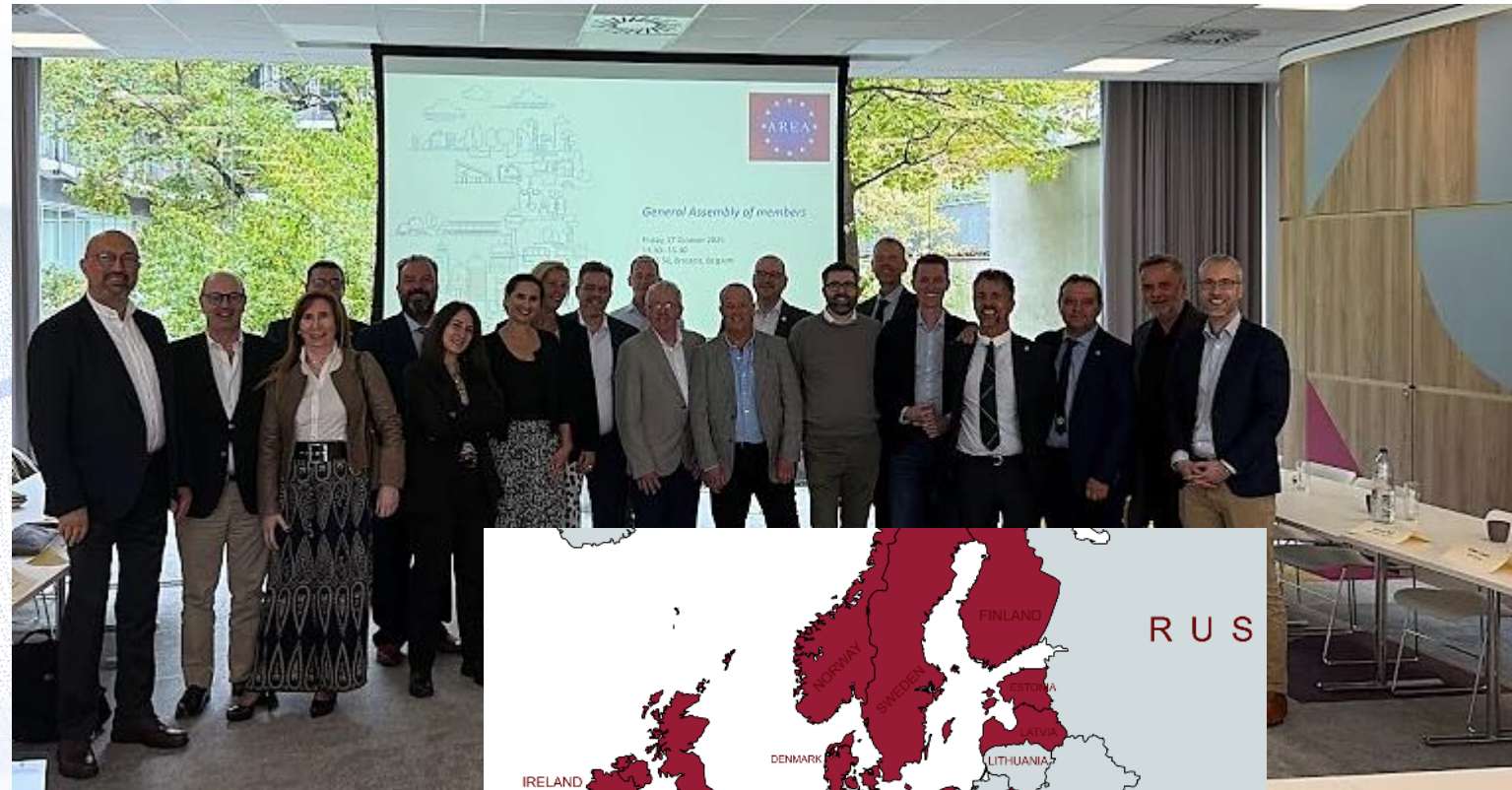
23 countries

13,000 companies

110,000 people

€23bn annual turnover

Contractors are the essential link between end users and manufacturers. They design, install and maintain RACHP equipment using every available solution with complete neutrality towards equipment and refrigerants, in the sole aim of ensuring the highest level of reliability, energy efficiency and cost-effectiveness.



About Centro Studi Galileo

Education through seminars and conferences: **UNEP-IIR-ATF-CSG**
21st European Conference,
June 2025
Next in 17-18 June 2027

Among the founding partners of **Real Alternatives for Life** – EU project aimed at creating and expanding a **free e-learning platform** for easy and digital approach to new, alternative technologies in the RAC sector

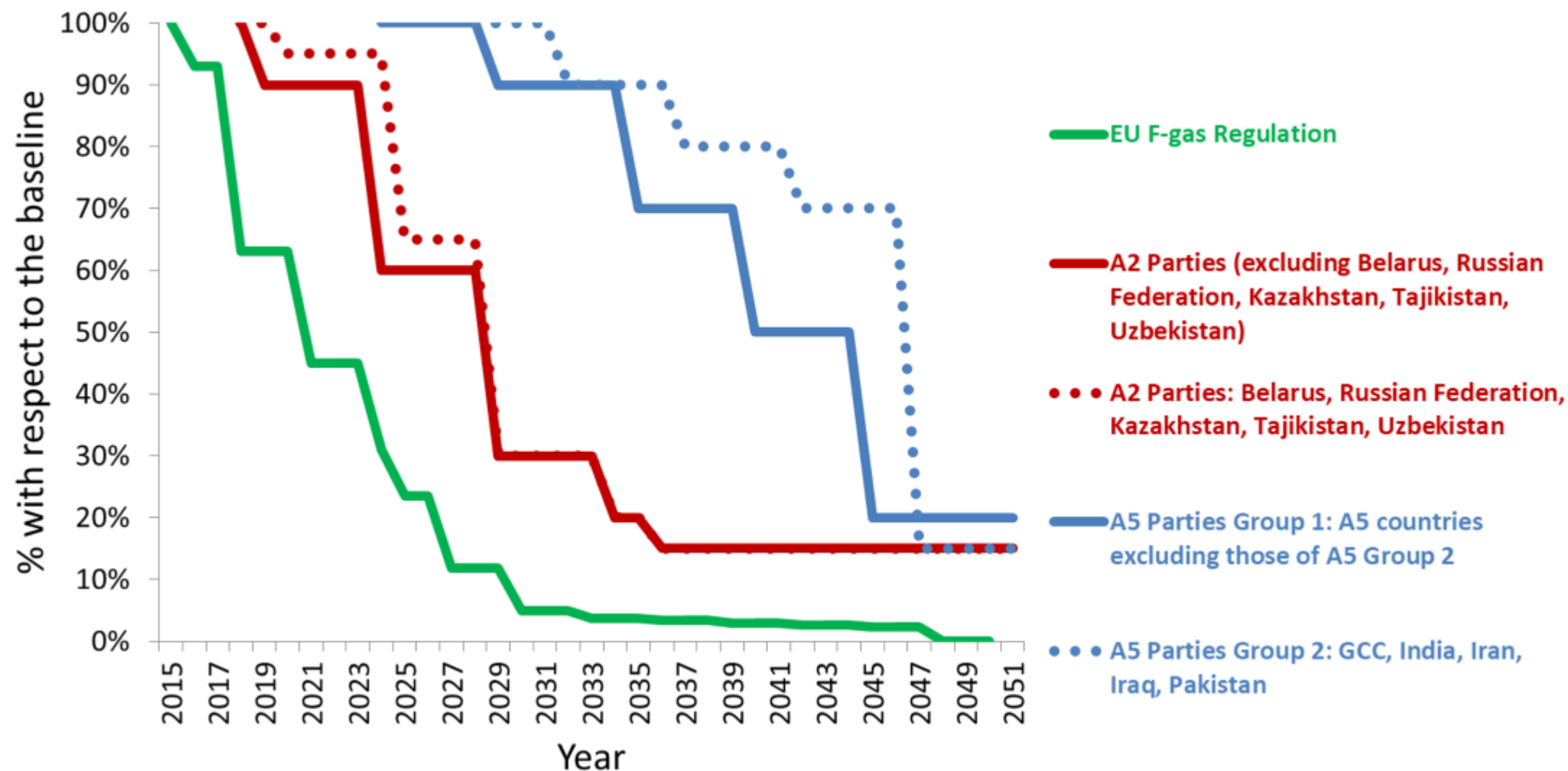


With contribution of the LIFE programme
of the European Union



EU HFC phase-down becoming a phase-out

Allowed placing on the market of HFCs

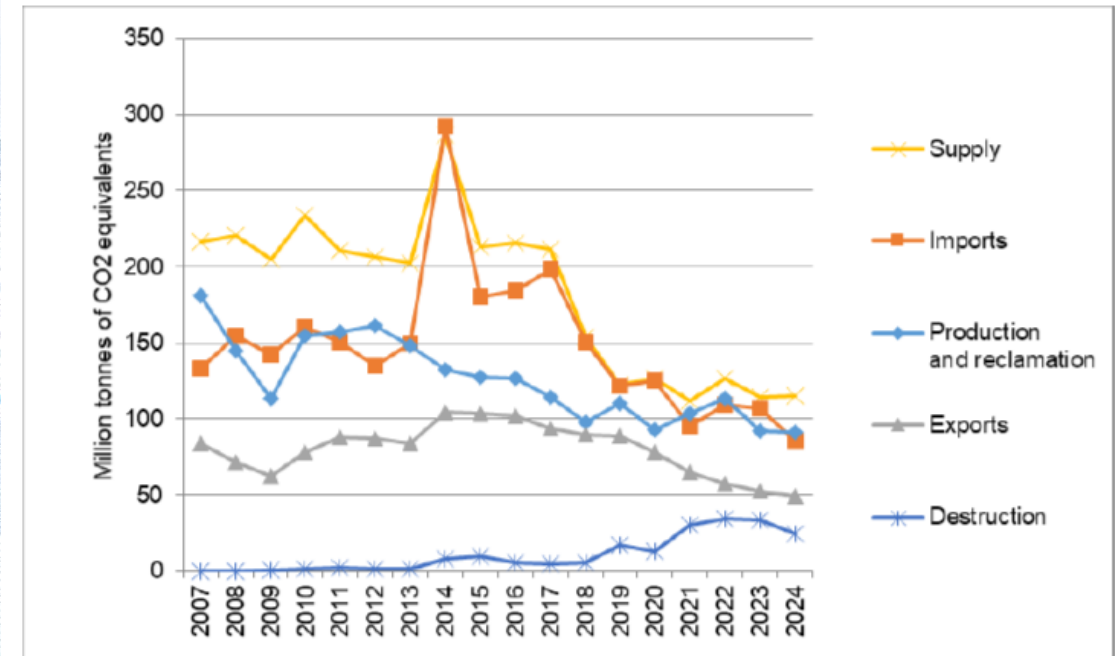


Training for “Kigali”

Fgas Regulation and the Certification is working (400.000 certified technicians in EU):

- less leaks, more controls on the system, periodical inspections
- more competence, skilled personnel and companies
- better equipped, calibration, recovery, reuse, reclaimed refrigerant
- lower quantities of high GWP refrigerants in the market
- higher quantities of alternative refrigerants (mainly flammables)

Figure B-3 Supply, production, import, export and destruction of F-gases (CO₂e)



EEA Fluorinated greenhouse gases report 2025



With contribution of
the LIFE programme
of the European Union

Official Training Provider

**We need a certification on top of
what we have, which is working
Real Alternatives**

F-gas certified personnel and companies by country (2023)

Austria	1,321
Belgium	2,563
Croatia	1,906
Czech Republic	550
Denmark	2,767
Estonia	N/A
Finland	4,995
France	20,000
Germany (1)	3,500
Greece	120
Ireland	817
Italy	43,786
Netherlands	2,000
Poland	13,557
Portugal	2,200
Slovakia	1,979
Spain	19,100
Sweden	1,745
Total EU	122,906
Norway	1,359
Turkey	26
Total non-EU	1,385
Grand total	124,291

Companies

Austria	3,970
Belgium	9,742
Croatia	2,434
Czech Republic	7,126
Denmark	5,944
Estonia	430
Finland	11,220
France	50,000
Germany	63,900
Greece	10,600
Ireland	4,800
Italy	79,281
Netherlands	3,200
Poland	43,245
Portugal	6,536
Slovakia	1,728
Spain	56,000
Sweden	8,716
Total EU	368,872
Norway	4,037
Turkey	5,000
Total non-EU	9,037
Grand total	377,909

Personnel



UK 52.300 (in 2021)

Certification and training

- **Certificate A1** attesting that holders may carry out all the activities provided for in Article 2(1) in relation to **fluorinated greenhouse gases and hydrocarbons**;
- **Certificate A2** limited to equipment with a charge size of less than 3 kg (6 kg hermetically sealed)
- **Certificate B** attesting that holders may carry out all the activities provided for in Article 2(1) in relation to carbon dioxide (**CO₂**)
- **Certificate C** attesting that holders may carry out all the activities provided for in Article 2(1) in relation to ammonia (**NH₃**);
- **Certificate D** attesting that holders may carry out the activity of recovery for the equipment containing less than 3 kg HFC/HFO (6 kg hermetically sealed); (**Recovery**)
- **Certificate E** attesting that holders may carry out leak check HFC/HFO (**Leak check**)

F-Gas Certification curriculum

		Certificate					
SKILLS AND KNOWLEDGE		A1	A2	B	C	D	E
1	Legislation and basic thermodynamics						
1.00	Basic understanding of the applicable EU and national legislation, in particular F-gas, WEEE and Ecodesign	T	T	T	T	T	T
1.01	Knowledge of the basic ISO standard units for temperature, pressure, mass, density and energy	T	T	T	T	T	T
1.02	Understanding of basic theory of refrigeration systems: basic thermodynamics (key terms, parameters and processes such as Superheat, High Side, Heat of Compression, Enthalpy, Refrigeration Effect, Low Side, Sub-cooling), properties and thermodynamic transformations of refrigerants, including identification of zeotropic blends and fluid states	T	T	T	T	T	T

- **set of minimum competence requirements (2215/24, Implementing Regulation Annex I)**
- Certificate A1&A2,B,C,D,E: HFCs and flammable large, HFCs & flammable small, CO2, Ammonia.....
- based on state-of-the-art standards EN 13313 and ISO/DIS22712

Contains: (a) applicable regulations and technical standards;

(b) emission prevention;

(c) recovery of fluorinated greenhouse gases listed in Annex I and in Section 1 of Annex II;

(d) safe handling of equipment of the type and size covered by the certificate;

(e) safe handling of equipment containing flammable or toxic gases or operating under high-pressure or involving other relevant risks;

(f) the measures for improving or maintaining the energy efficiency of equipment during installation, or maintenance or servicing.

EU MAC Certification



- **Attestations and Training Types:**

- **M1:** Full range of activities including servicing, leak checks, repair and recovery of F-gases and Hydrocarbons.
- **M2:** activities including servicing, leak checks, repair and recovery of F-gases and Hydrocarbons only when an automatic recovery station is used (pics below).
- **M3:** activities with units using CO2.
- **M4:** Recovery of F-gases and limited-service activities.

- The EU association of contractors and technicians dealing with larger stationary and mobile AC and refrigeration units
- There are no specific requirements to possess particular tools, but since recovery and leak checks are mandatory, it is pr machine and a leak detector would be necessari



The new
**F-gas Reg.
(EU)
2024/573**
sets new
minimum
attestations
requirements
which expand to
more vehicle
types.

International Project: Real Alternatives Blended learning for low GWP refrigerants



real alternatives
eurpe

National Leads
& Training Providers



18
languages..

Croatian
Czech
Dutch
English
Estonian
Finnish
French
Greek
German
Italian
Polish
Portuguese
Romanian
Russian
Slovakian
Spanish
Swedish
Turkish

• (also in Chinese!)

All the logos of the
partners, associations or
universities

SVENSKA
KYL & VÄRMEPUMP
FÖRENINGEN

ec
ac



Armenia: Fund Shirakatsy Lyceum



Cyprus: University of Nicosia



Estonia: EKUK – Estonian
Environmental Research Centre



Croatian Refrigeration Air conditioning
and Heat Pumps Association



Czech Association for Cooling
and Air conditioning Technology



Portuguese Association
for Cooling and Air conditioning



Romanian General Association
of Refrigeration



Slovak Association for Cooling
and Air conditioning



Spanish National Confederation
of Installers and Maintenance



Turkish Association of Refrigeration Industry
and Businessmen



Greece: HUGAS
Hellas Air Conditioning Association



Netherlands: AERES TECH
Refrigeration Expertise Centre



New Zealand: Refrigerant License
New Zealand

REAL Alternatives

consistent learning among EU countries for low GWP refrigerants



- **Flammables** (HCs - HFOs - low GWP blends), **CO₂**, **Ammonia**
- **9 Modules Free learning material** available for download
- **Multi-lingual** programme (17 languages – 21 EU or 25 tot countries)
- **Licensed training providers (around 30) in each country:**
 - **Best Practices** in fully equipped laboratories, focusing on the safety issues
 - **Theory** in classroom or remote
- **Certification (theory and practice)** consistent and recognized among project members (more than 3000 certificates so far)



www.realalternatives.eu

Instructions on how to organise a course & certification

→ New partners, Training providers or just learners in our training centres are welcome!

Longstanding Cooperation with Turkey



- Real Alternatives EU Project 2012
- EU Fgas certification (SOSIAD-ISKAV) 2015
- COOL UP Project 2019



You can't see it, but you can hear it

How many times do you "use the cold" without knowing it?

We don't see the cold in our daily lives, but it's everywhere:
«One Health approach»:

- ❄️ air conditioning environments (home, car, HERE ...)
- 💻 IT equipment cooling and data centers
- 🎨 conservation of works of art (yes!)
- 🏭 Industrial processes
- 💊 storage of medicines (formerly: vaccines)
- 🥗 Food storage from producer to consumer

Refrigeration is not just about comfort: it is food safety.
Without the cold chain, many products would not be consumable.



Credit: Epta

Food waste

A global problem [1]



Every year, 20% of the food produced is not consumed. The numbers speak for themselves:
1.05 billion tons of food
~ 132 kg / capita / year



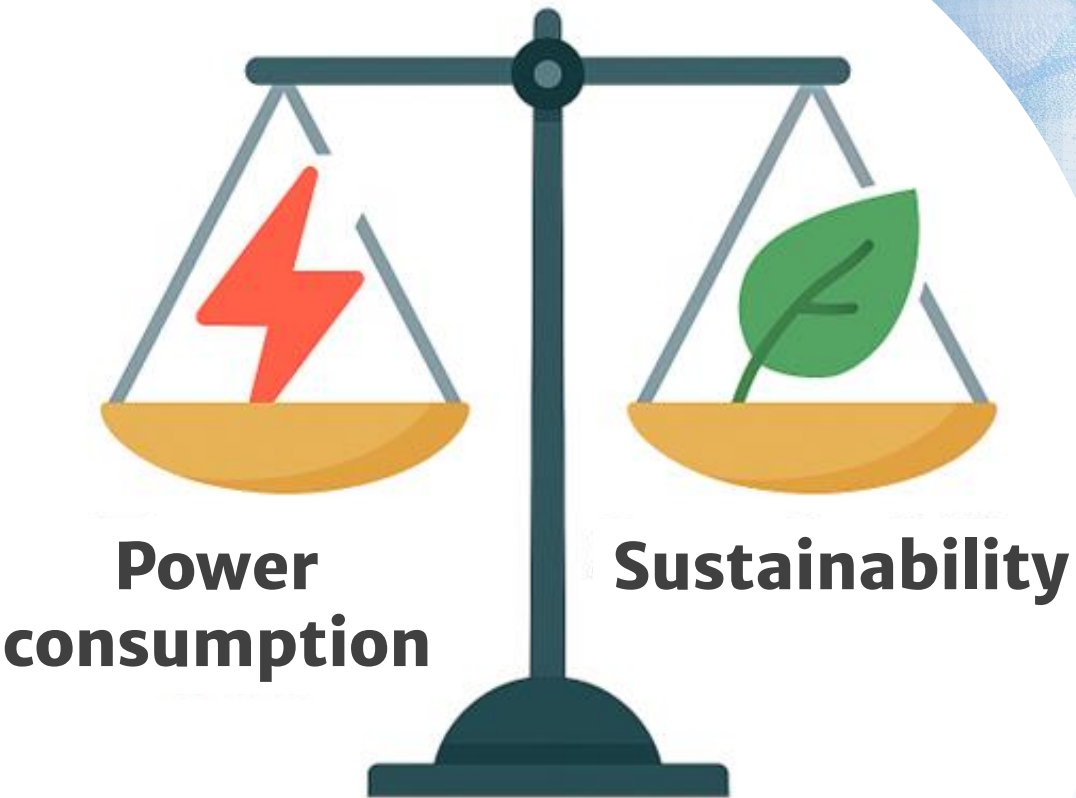
The economic loss is estimated at about
\$940 billion each year



Where does waste occur?
27.5% in the production chain
12.5% in retail and catering
60% in the domestic sphere



Environmental impact



Food waste is responsible for 8–10% of all greenhouse gas emissions (direct and indirect) [1]



Appliances for the storage of food products (transport, cold rooms and refrigerated counters for supermarkets, domestic refrigerators) have a global annual consumption of about 300 TWh, a country like Italy as a whole [2]

A paradox: we need refrigeration to reduce waste, but refrigeration consumes energy and generates emissions.

[1] UNEP – Food Waste Index Report 2024

[2] IIR – 7th Informatory Note on Refrigeration and Food 2021



AROUND US



MODINE



Condensing Units - Gas Coolers,
Condensers and Dry Coolers

Chillers e Rooftop

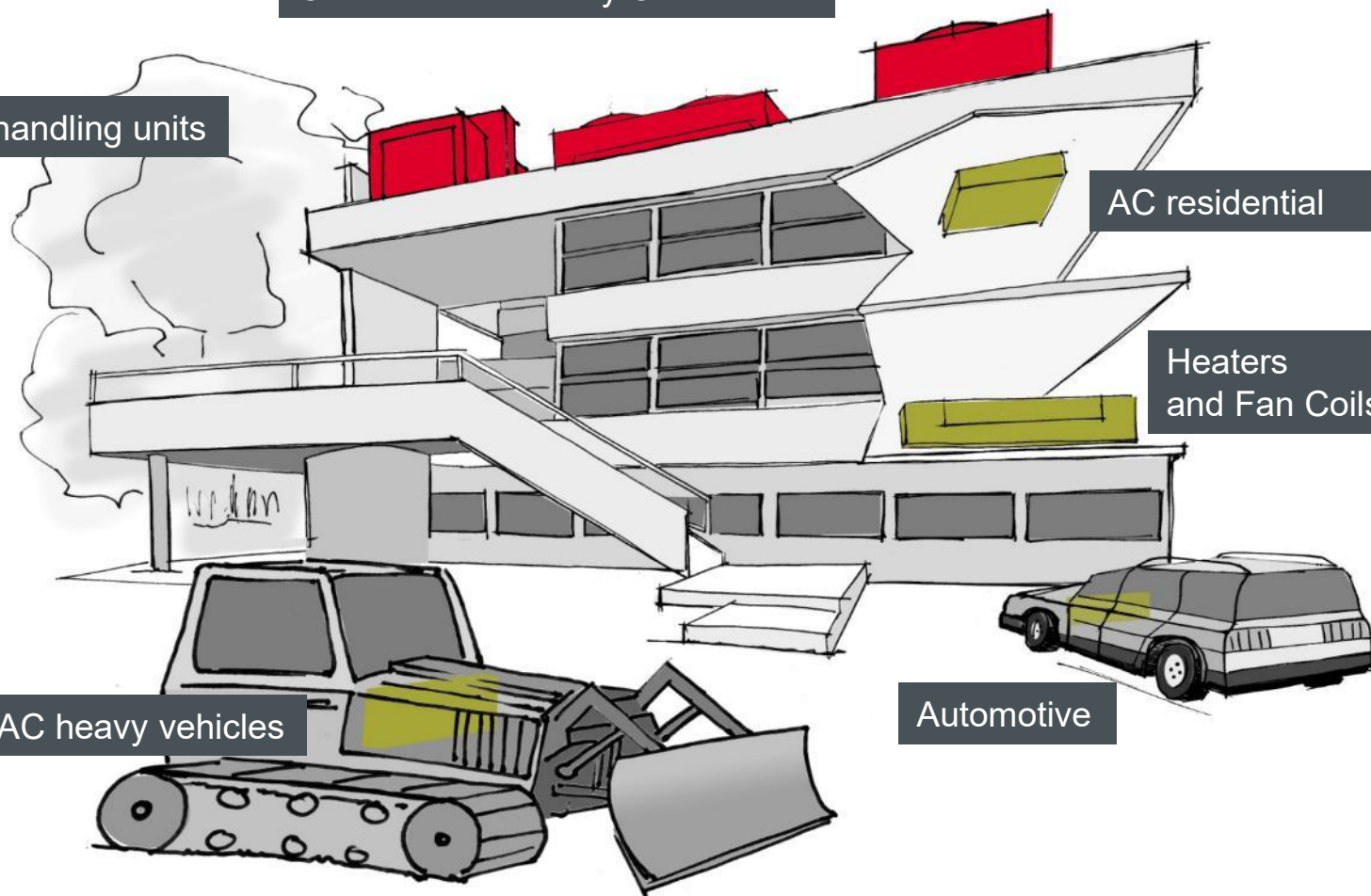
Air handling units

AC residential

Heaters
and Fan Coils

AC heavy vehicles

Automotive



AROUND US

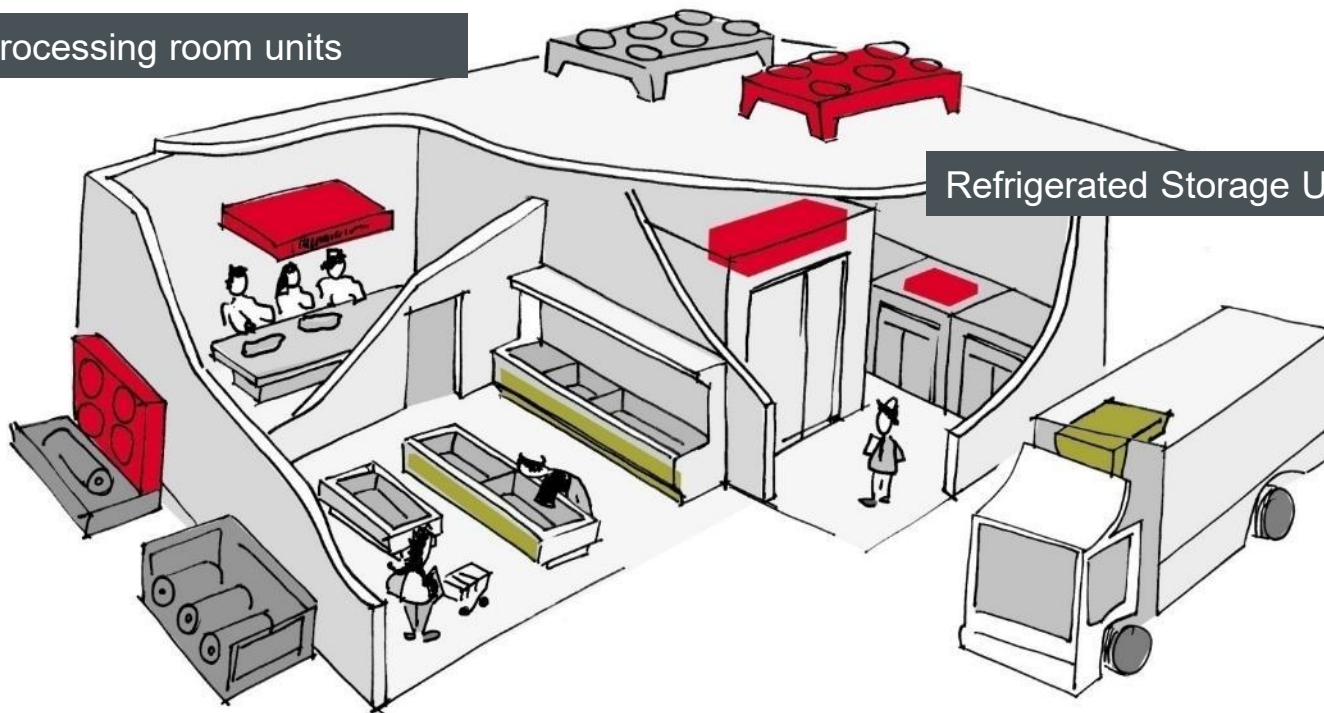


MODINE

Condensatori, dry coolers and gas coolers

Processing room units

Refrigerated Storage Units



no frost, evaporators for refrigerated display cases CO2 exchangers

Heat exchangers for trucks, vans and containers



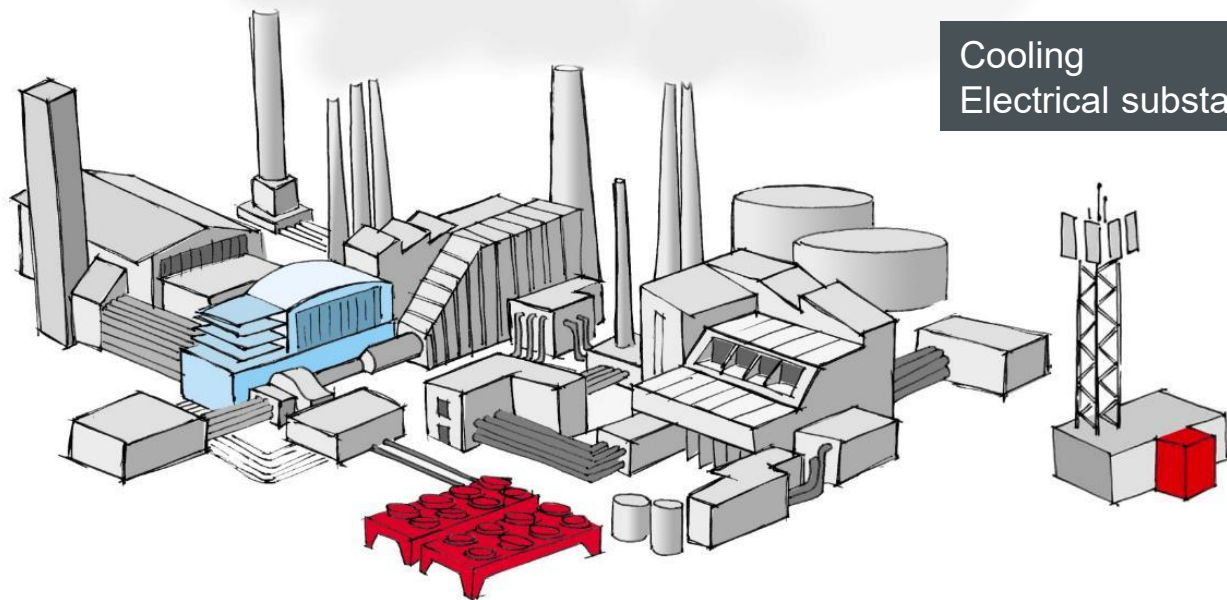
AROUND US



Condizionamento
veicoli pesanti



AROUND US

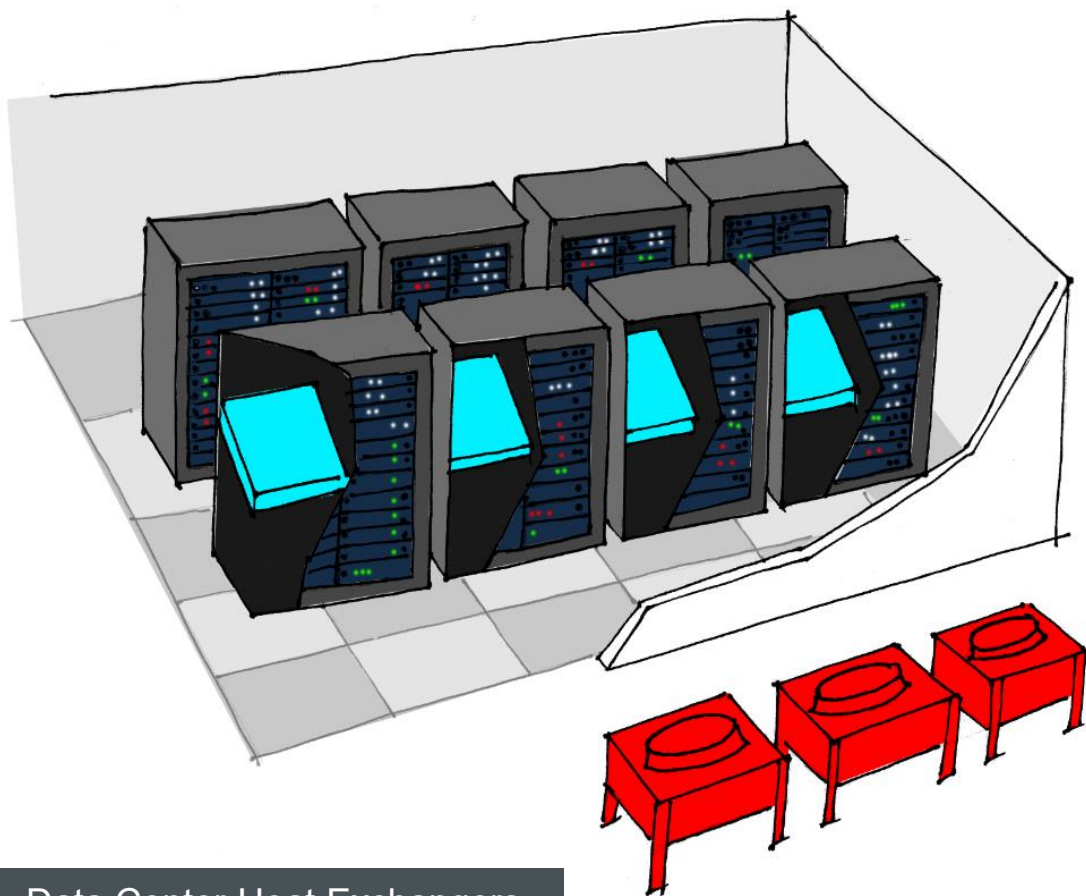


Cooling
Electrical substations

Dry coolers for cooling diesel engines, radiators
for power plants



AROUND US



Data Center Heat Exchangers





The cold is not visible, but it is essential for our lives.

There is no food safety without a cold chain.

There is no sustainability without energy efficiency.

There is nothing without our personal and best contribution.



Predictive vs Preventive vs Reactive Maintenance

Predictive Maintenance

- The use of real-time operational data, equipment performance trends, and material characteristics to predict the future condition of components, estimate their remaining useful life, and identify potential failures before they occur.

Preventive Maintenance

Based on a timescale

- **Preventive maintenance is essential under the following conditions:**
- Risk of failure increasing with operating hours;
- Impossibility/unprofitability of monitoring health status;
- Predictability of the average useful life.

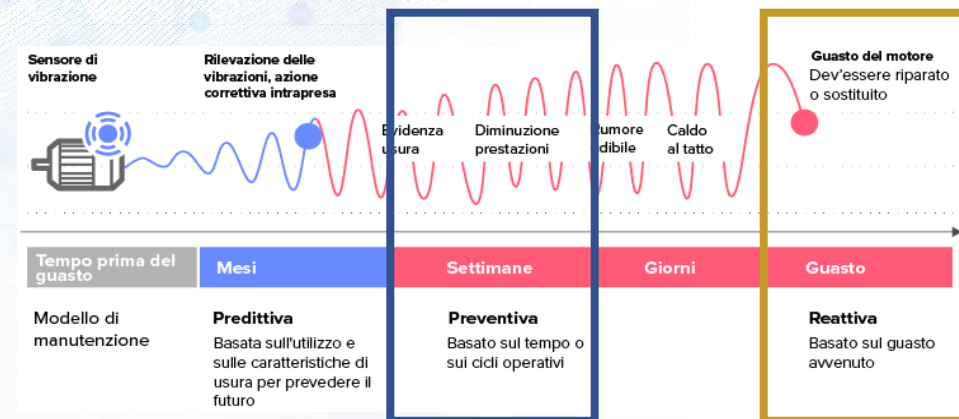


- Maintenance scheduling;
- Serious damage avoided.

Reactive maintenance

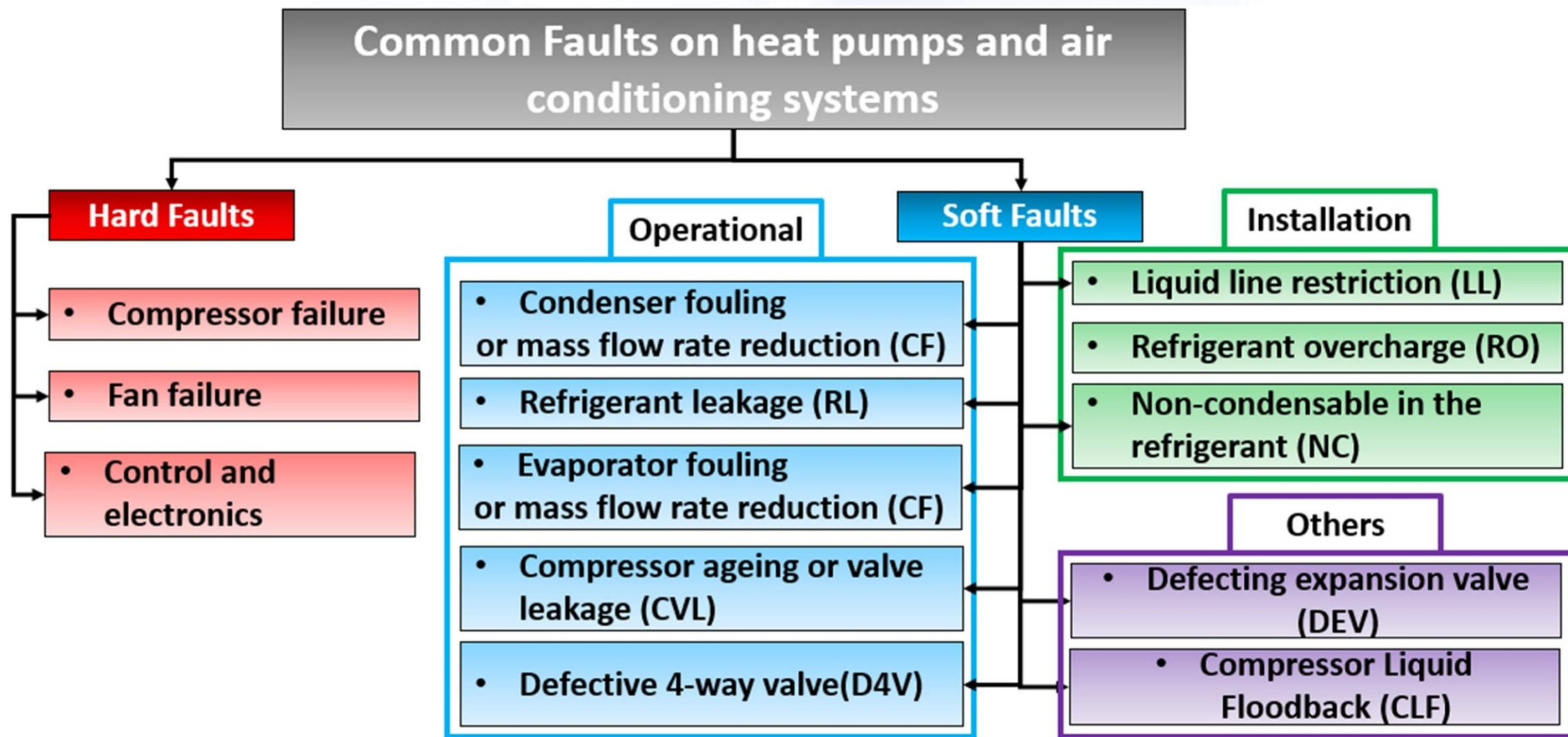
Breakdown repair:

- **When does it apply?**
 - Low value component;
 - Redundancy of components;
 - Impossibility/unprofitability of monitoring the operating condition;
 - Risk of random failure, not dependent on time;
- ↓
- Emergency maintenance with increased costs;
 - Exploitation of the maximum useful life (with some associated risks).





R & D about AI in RAC technologies for
predictive maintenance, resilience and
energy efficiency improvement



Soft Faults

Refrigerant Leakage

- Through pipe, joint or welding failures, leaking in the compressor
- Fault intensity slowly increases



Heat Exchanger Fouling

- Accumulation of dirt and dust on the HEX plates or fins
- Severity level accumulates along time with COP degradations
- Concentrated or uniformly distributed



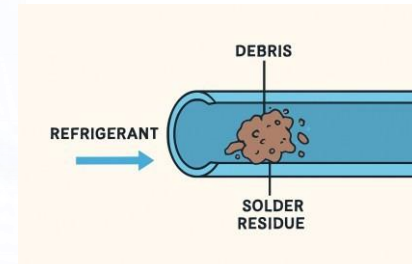
Refrigerant Overcharge

- Non-proper refrigerant recharge



Liquid line Restriction

- Clogged filter-drier due to impurities



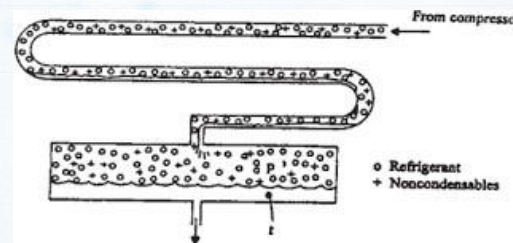
Compressor Ageing/ Valve Leakage

- Ageing of seals, bypass of refrigerant between suction and discharge
- Higher recirculated mass flow rate
- Same effect by a defective 4-way valve



Non-condensable in the refrigerant

- Caused by improper vacuum operations
- Penalization of heat transfer in HEXs

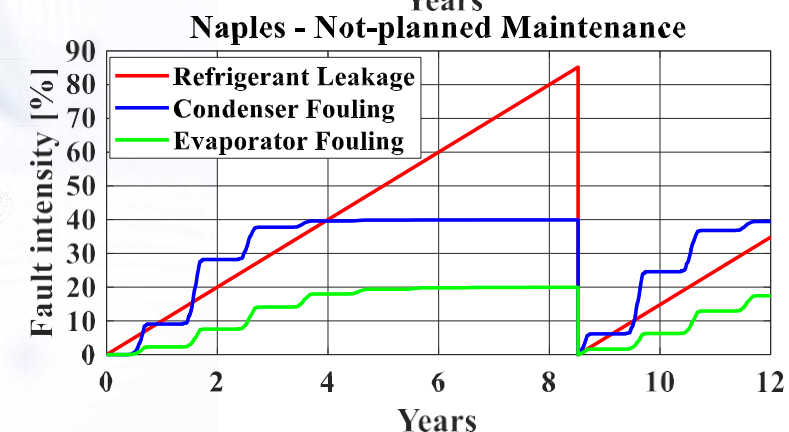
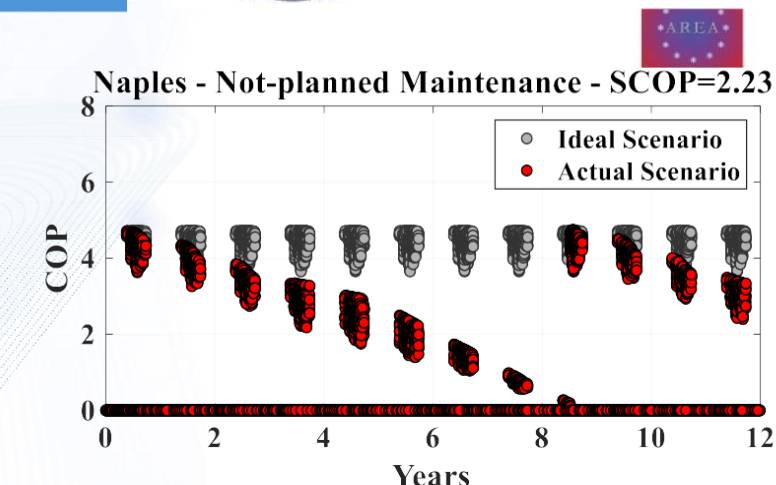
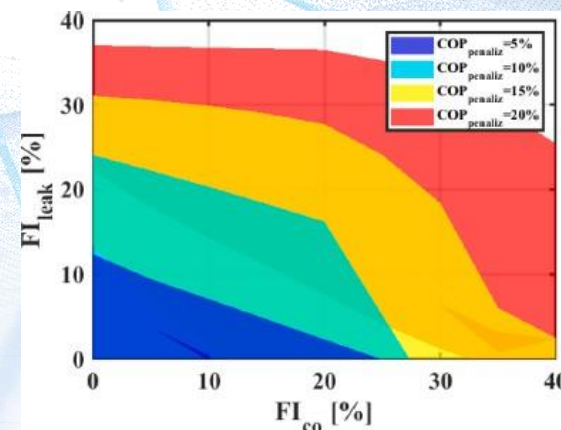
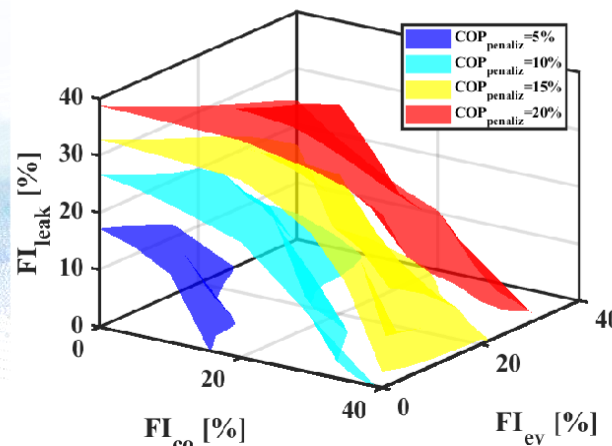


Defective Expansion Valve

- Accumulation error of steps or impulse counting
- For large system operating for long periods



- **Refrigerant leakage:** performance degradation up to 20-25%
- **Condenser Fouling:** performance degradation up to 10-15%
- **Evaporator Fouling:** performance degradation up to 10-15%
- Enhanced degradations due to **simultaneous occurring** soft faults
- **Seasonal performance degradation:** up to 50% SCOP decrease, up to 300-400% TEWI increase (worst case)

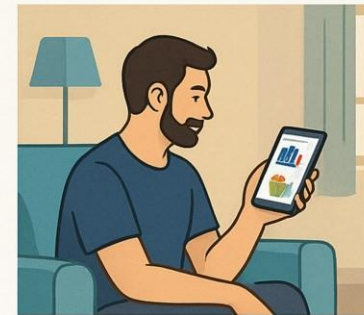
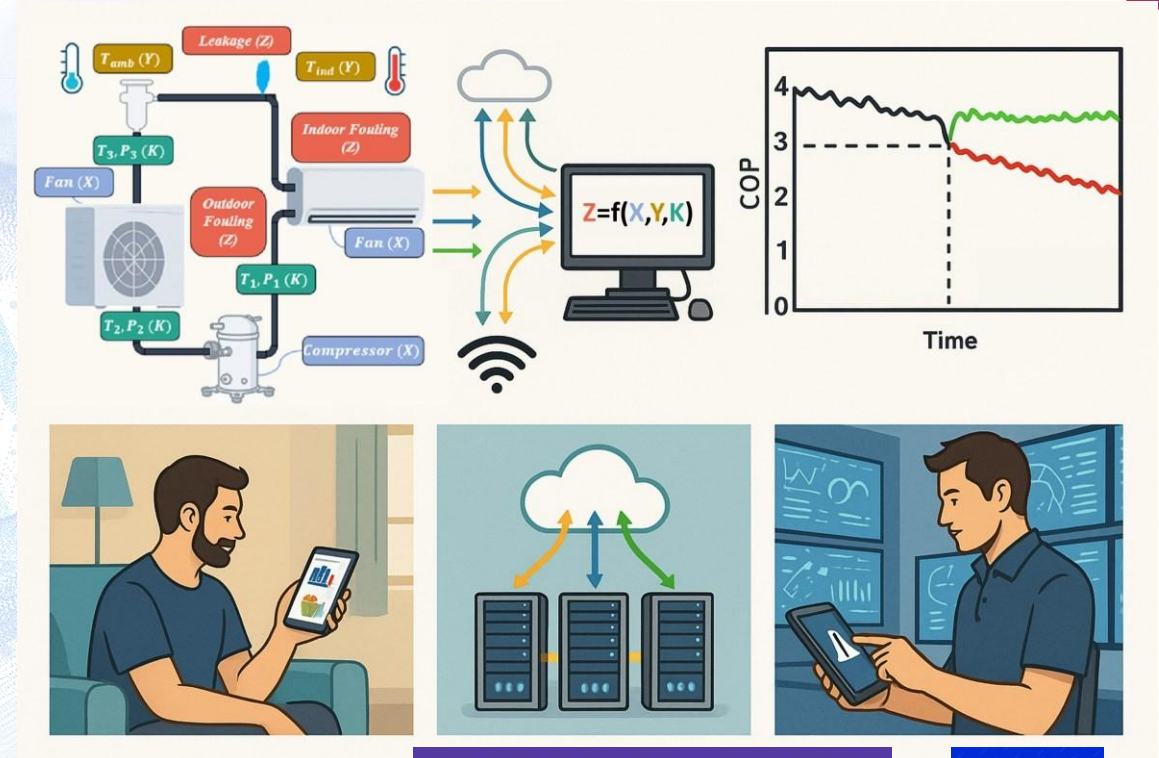


Research about

Fault Detection (FD) → Fault Diagnosis (FDD) → Fault Evaluation (FDDE)



- Measure actual **performance degradation and environmental impact**
- Evaluate **future scenarios** by maintenance intervention and **potential energy savings**
- Increased awareness of final users in case of **Cooling as a Service**



method for smart and affordable Evaluation of simultaneous faults in heating and cooling systems based ON compressed vapor technology” (BEYOND). Project ID: 101162436—Funded by the European Union under Horizon Europe.
<https://www.beyondproject.eu/>

Conclusions

- **A lot of work still to do – A Growing Sector**
- **Change of mindset:** technicians & design engineers
- **New equipment:** AI, IOT, hydrocarbons in A/C, CO₂ in commercial refrigeration
- **New behaviour:** improved attention to Energy, refrigerant management
- **The transition requires all elements to work together:** Phase-down of HFCs, Training and certification, Equipment bans Energy and Refrigerants obsolescence, Responsible sale and handling of refrigerants, Recovery and reuse, Energy efficiency, Maintenance
- **Collaboration is essential:**
 - Institutions (UN agencies, NOUs, etc.)
 - Associations
 - Industry
 - SMEs & technicians
-  **No one left behind**





Stronger together

***Thank you
Marco Buoni***

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*"For a clean,
decarbonised
and sustainable
heating and
cooling sector"*

AREAVISION2030

