



OEWG46 Danfoss Side Event

Flammable  
refrigerants is what  
keeps us awake



#### Agenda

- Welcome & Introduction
- Overview: Flammable Refrigerants and how to address them
- A Policy Perspective
- An OEM Perspective
- An Installer Perspective
- Conclusions

# Disclaimer



Danfoss does not assume liability for any statements made in and during this presentation or any actions taken by its readers or users, which may cause unintended damage or injury as a result of any recommendations or inferences made within this presentation.

Please always refer to manufacturers' manuals and instructions.

Although all statements and information contained herein are believed to be accurate and reliable, they are presented without guarantee or warranty of any kind, expressed or implied.

This presentation makes only general recommendations on the use of Low GWP refrigerants which do not compensate for individual guidance and instructions.

National laws and guidelines must be consulted and adhered to under all circumstances.

# Welcome & Introduction



Andrea Voigt  
VP Public Affairs, Sustainability & Communication Danfoss

# Danfoss in brief



We engineer solutions that increase machine productivity, reduce emissions, lower energy consumption, and enable electrification.

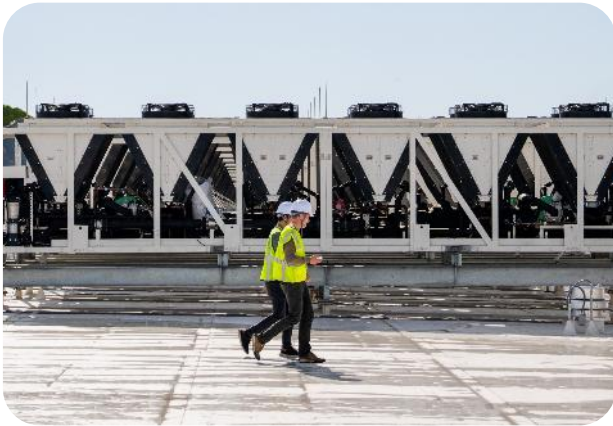
## Business segments



### Danfoss Power Solutions

Share of sales: 44%

Full solutions across mobile and industrial hydraulics, fluid conveyance and data centers applications, electrification, and software.



### Danfoss Climate Solutions

Share of sales: 34%

Energy-efficient heating and cooling solutions for industrial applications, buildings, infrastructure, data centers and the cold chain.



### Danfoss Power Electronics and Drives

Share of sales: 22%

Power semiconductor modules, variable speed drives, and power conversion solutions engineered to enable electrification, and enhance energy efficiency and productivity across industries.

## Worldwide sales

Americas  
36%

Europe  
40%

Asia Pacific  
24%

## Global sales

EUR 9.4b

## Employees worldwide

39,353

As per annual report 2025

# Danfoss sustainability targets:

## Sustainability drives competitiveness – for us & our customers!

### Decarbonization

Pioneer solutions for customers to enable decarbonization in an intelligent, cost-optimal manner and decarbonize own operations.

#### Targets

**$\geq 90\%$**  reduction in scope 1 and 2 emissions by 2030<sup>1</sup>.

**66%** reduction of scope 3 emissions per EUR gross profit<sup>2</sup> by 2035

**Net-zero** by 2050

### Circularity

Innovate best-in-class and environmentally safe products as the default when developing and marketing new value propositions.

#### Targets

**80%** of new products covered by circularity approach<sup>3</sup> by 2030.

**25%** increase of circular business revenues by 2030<sup>4</sup>.

### Inclusion

Commit to create an inclusive work environment, enabling us to attract and retain talents.

#### Targets

**$\geq 80$**  inclusion score by 2030.  
The scoring is based on our employee engagement survey, Voice

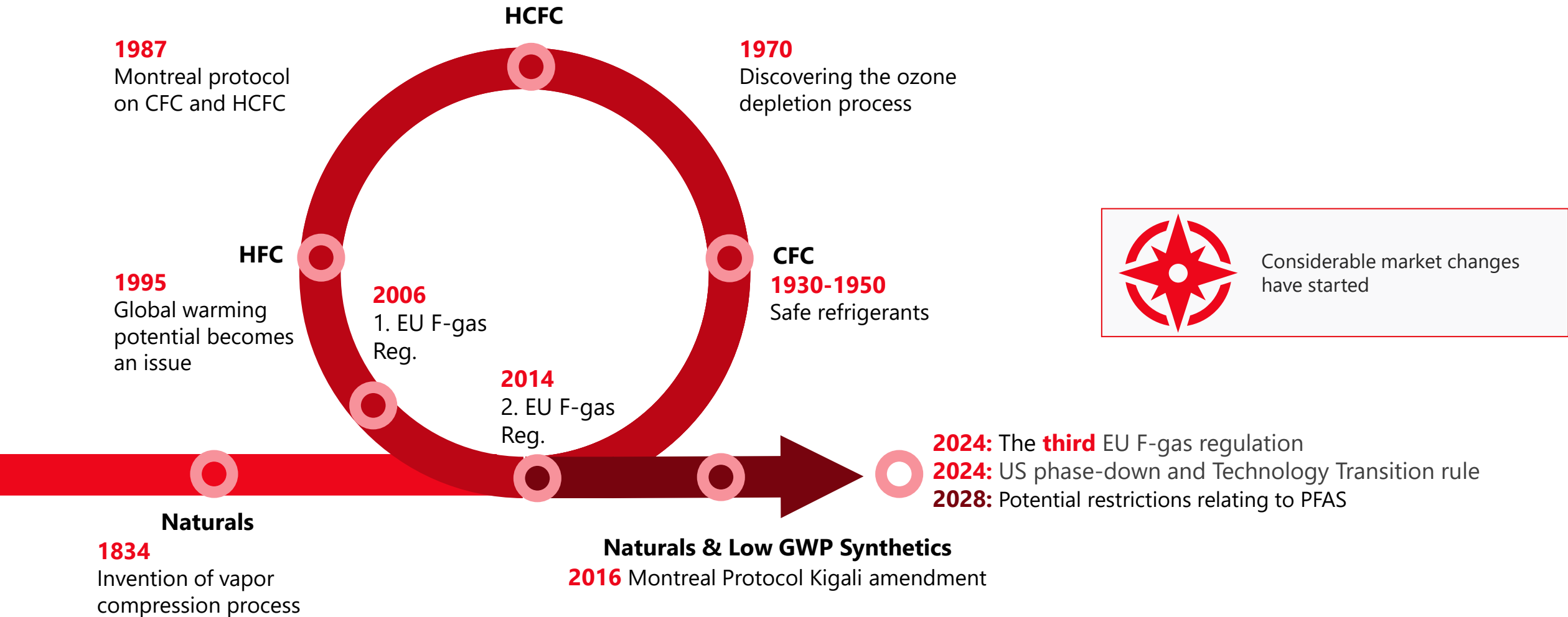
**$\leq 5\%$**  Gender pay gap in 2030

**$\leq 1.0$**  LTIF: Number of incidents per million hours worked

1. Our SBTi-validated target is to reduce 90% by 2035 from a 2024 base year. 2. Additionally, achieve a 66% reduction in the intensity of our scope 3 emissions from the use of sold products per ton of refrigeration from our commercial compressors business. 3. Following the principles of Rethink-Reduce-Recirculate. 4. Compared to our 2023 base year.

# Almost 200 years of refrigerants

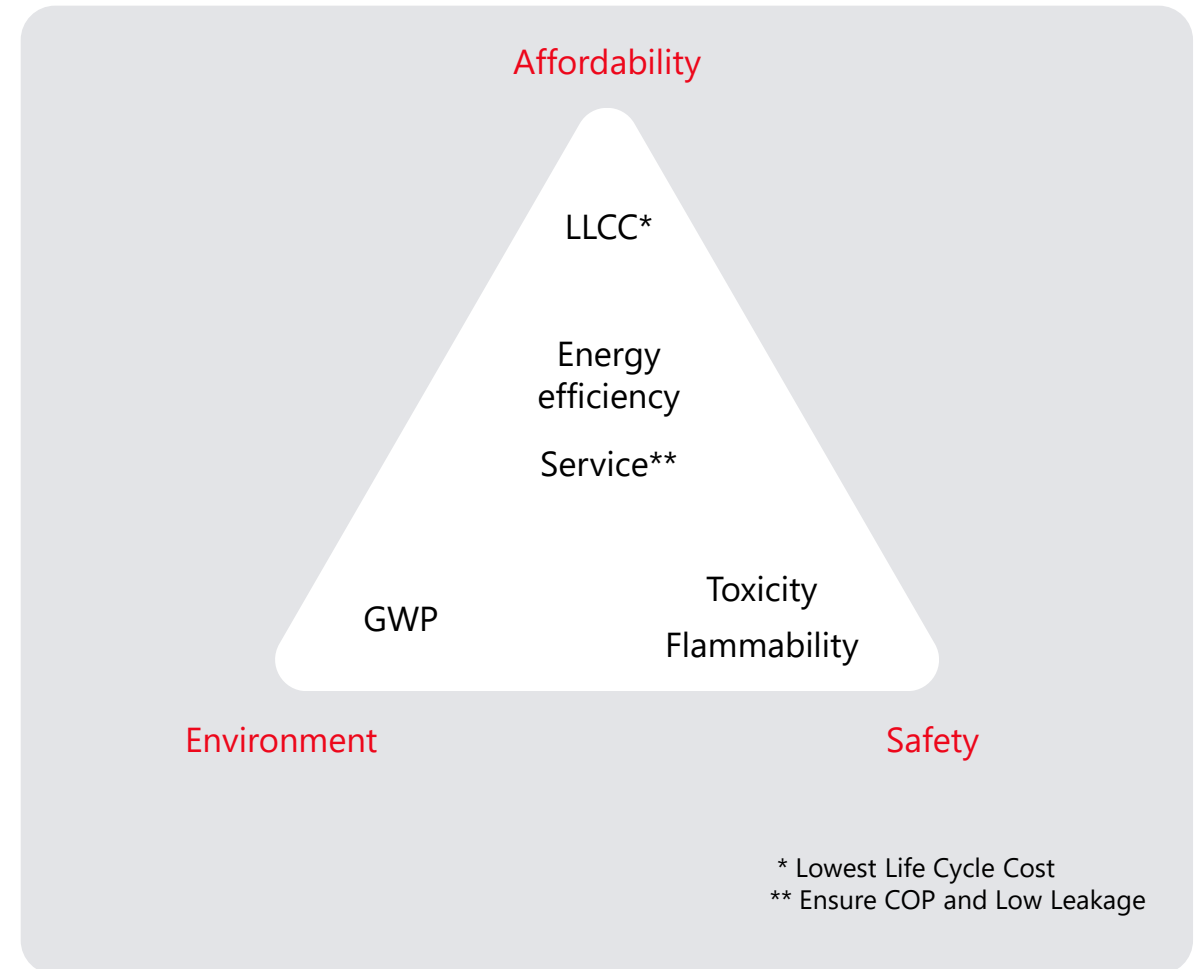
## Back to square one?



# There is no silver bullet:

## Choosing the right refrigerant is a delicate balance

- Choosing the right refrigerant is a delicate balance between many factors
- Regional differences play a significant role. The ideal refrigerant choice for an application in one region, may be very different from the choice in another region.
- Installment and service are pivotal for safety and efficiency. Education of next generation technicians is a premise for using low GWP refrigerants



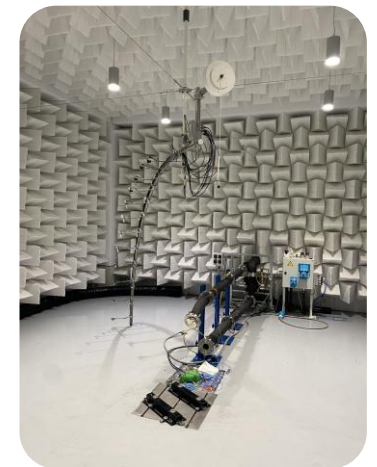
# Getting ready for flammable refrigerants with state-of-the art **ATEX laboratory**, Wuqing Campus

- Inaugurated in May 2023, the Danfoss Global Green Refrigerants Compressors laboratory in Tianjin is Danfoss' most advanced and largest compressor innovation facility globally
- Building area 7,300 sqm, CAPEX €20m
- Testing facilities with A1, A2, A2L, A3 refrigerants
- Commercial compressor prototyping (machining, CMM, assembly...) and testing (performance, reliability, certification etc.)
- Technologies and solutions tested and proven in the laboratory will be widely used in air conditioning, heat pumps, data centers, cold chains, and energy storage industries.



# Accelerating the use of sustainable refrigerants with our state-of-the-art **ATEX laboratory**, Reyrieux, France

- Dedicated ATEX laboratory for testing compressors with flammable and low-GWP refrigerants
- Building area 4,500m<sup>2</sup> ATEX Lab
- 200,000 testing hours annually
- Testing facilities for refrigerants up to A3 classification, supporting the transition to A2L and A3 alternatives
- Commercial compressor testing capabilities covering performance, reliability, endurance, acoustics, oil management and certification
- Technologies and solutions developed and validated in the laboratory support the transition to low-GWP refrigerants across air conditioning and refrigeration applications



# Key takeaways of today's event



- The industry needs to work with flammable refrigerants
- Specific training and relevant certification is necessary
- Regulations and standards are in place and are constantly developed
- Flammable refrigerants do not require ATEX by default (but ATEX approved components might be convenient)
- Components are available in full serial production
- Additional information is available (e.g. Danfoss White Paper)



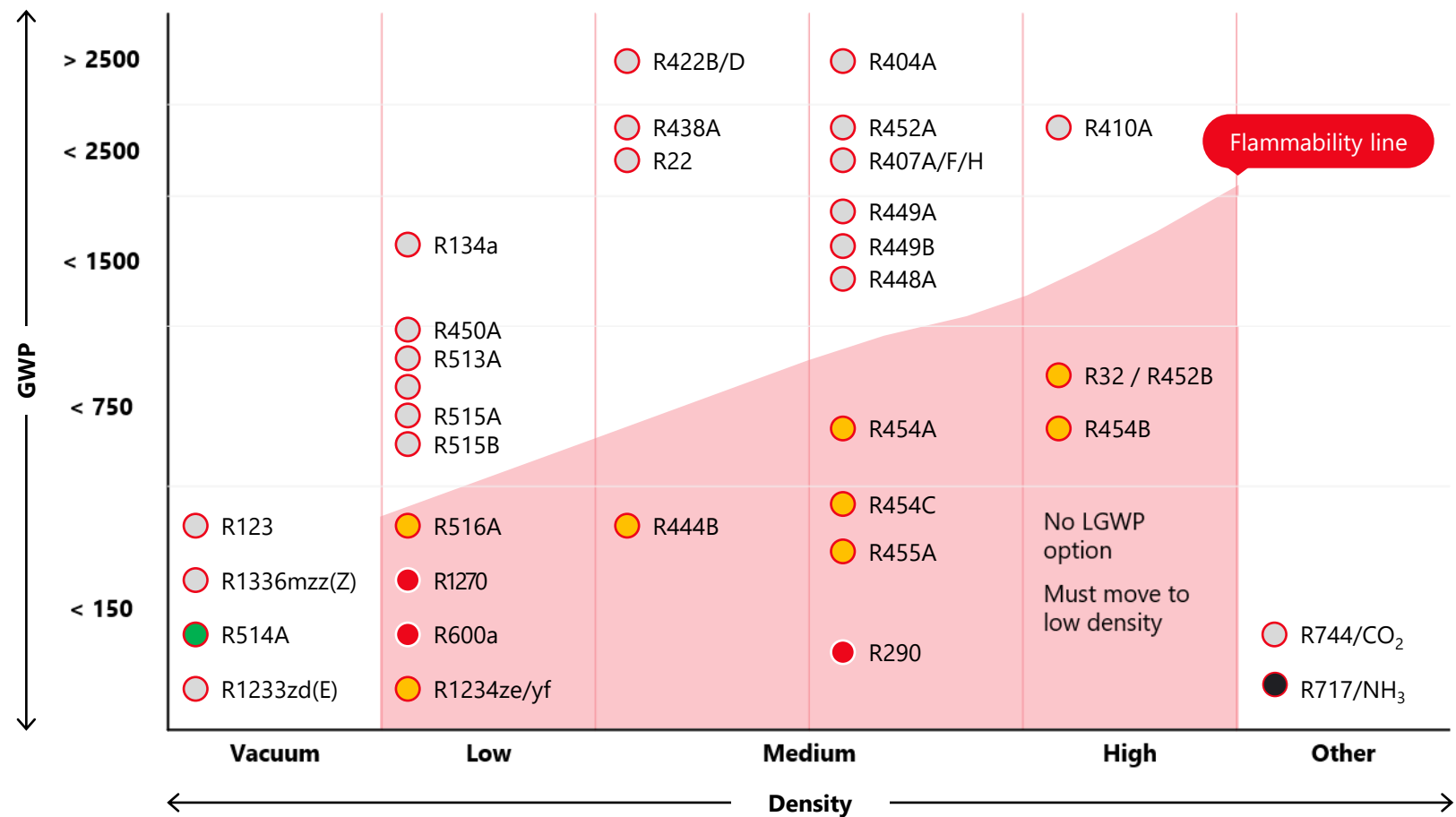
# Flammable refrigerants & how to address them: An overview



Torben Funder-Kristensen - Online  
Head of Compliance & Standardization, Danfoss

# Main refrigerants at play

## The future with A2L and A3 options



### Legend

- A1 - Non flammable
- A2L - Mildly flammable
- A3 - Highly flammable
- B1 - Toxic Non flammable
- B2L - Toxic less flammable

- On the market
- Not yet on the market

GWP versus Density (pressure) of the main refrigerant groups

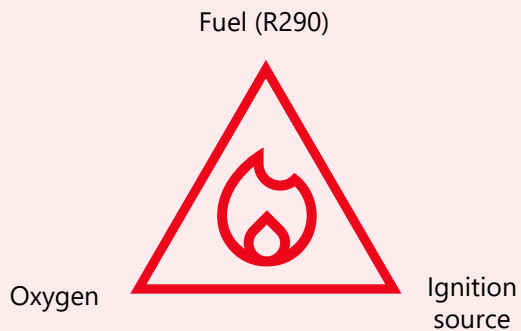
# Flammability



To create an ignition, fuel and oxygen need to be present at sufficient concentrations at the same time as an ignition source.

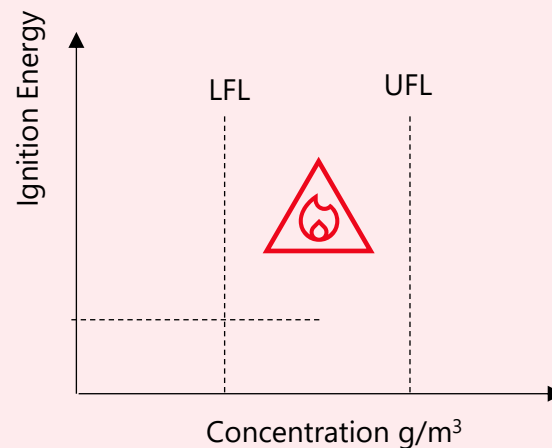
Two important parameters to observe:

- LFL means 'Lower Flammability Level' (2,5% for R290)
- UFL means 'Upper Flammability Level' (9,5% for R290)



In between LFL and UFL the atmosphere can be ignited and a flammable front will propagate.

The intention in **safety standards** is always to keep the concentration far below LFL. (LFL=38 g/m<sup>3</sup> for R290 at room temperature)



The nature of flammability for refrigerants can depend on temperature and humidity.

- Hydrocarbons show no or very little dependence on humidity
- Fluorinated refrigerants with more F than H need humidity for the burning process.
- R1234yf depends on Humidity
- R32 does not depend on Humidity

# Flammability



- To create an ignition there is a need of ignition energy
- The ignition energy of R290 is commonly listed as 0,25 mJ.
- Implication: Static electricity is enough to ignite R290.
- The speed of the ignition front is called the 'burning velocity' and is used to characterize flammable refrigerants into classes.

- Registered burning velocity values are valid for a laminar and controlled propagation that can be verified in a laboratory.
- In practice flame propagation and ignition is very complex and relies on many parameters. That is why LFL values are selected where no ignition is possible to happen.

\*Example: In practice the flame propagation will likely change from laminar to turbulent burning, and travel much faster than the laminar burning velocity.

|               | LFL [%] | Laminar Burning Velocity [cm/s] | Ignition Energy [mJ] |
|---------------|---------|---------------------------------|----------------------|
| R290 (A3)     | 2,5     | 40                              | 0,25                 |
| R600a (A3)    | 2,0     | 46                              | 0,7                  |
| R1234yf (A2L) | 7,1     | 1,5                             | 5000                 |

| Class | LFL ASHRAE 34 [g/m³] | LFL; ISO 817 [vol %] | Burning Velocity [cm/s] | Heat of Combustion [MJ/kg] |
|-------|----------------------|----------------------|-------------------------|----------------------------|
| A1    | No LFL               | No LFL               | 0                       | 0                          |
| A2    | > 100                | > 3.5                | > 10                    | N.A.                       |
| A2L   | > 100                | > 3.5                | ≤ 10                    | N.A.                       |
| A3    | ≤ 100                | ≤ 3.5                | N.A.                    | ≥ 19                       |



# Basic requirements for safe operation with A3 refrigerants

## Eliminate ignition sources



Welding & Cutting  
Only after emptying  
the system



Smoking



Open flame



Mechanical sparks  
e.g from metal tools

### Approved components



Electric arc



Static charge  
ensure ground  
connection



Hot surface

100K below auto ignition temperature

# Safety standards



## Introduction

- There are international, regional and national safety standards
- Majority of standards are linked
- Standards are updated regularly within Standard Committees. Be aware of different editions of the standards



International and regional standards:

- ISO
- IEC
- EN

## Safety standards requirements

- Practices for minimizing the probability and size of leaks
- A potential flammable volume from a leak not to pool up at floor level, even under worst case conditions. This is ensured by limiting the amount of refrigerant allowed in a system and potentially by adding air circulation in the room
- No ignition sources to be allowed where leaked refrigerant can flow or stagnate
- A risk assessment to be carried out for each product to ensure compliance with the standard



Important national standards:

- UL
- ASHRAE
- GB (China)

# Charge limitations for A3 refrigerants (EN 378: 2016)

For applications other than human comfort e.g. Commercial Refrigeration like Cold Rooms

|                   | Compr & vessel indoors                                                                                                    | Refrig equipment indoors<br>Compr & vessel outdoors | Machinery room<br>or open air | Ventilated enclosure                                                 |
|-------------------|---------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-------------------------------|----------------------------------------------------------------------|
| General access    | Only sealed systems.<br>20% x LFL x room volume<br>Below ground: not more than 1 kg<br>Above ground: not more than 1,5 kg |                                                     | 5 kg                          | Max<br>130m <sup>3</sup> x LFL<br><br>Max<br>5 kg R290<br>5 kg R1270 |
| Supervised access | 20% x LFL x room volume<br>Below ground: not more than 1 kg<br>Above ground: not more than 2,5 kg                         |                                                     | 10 kg                         |                                                                      |
| Authorised acces  | 20% x LFL x room volume<br><br>Below ground: not more than 1 kg<br><br>Above ground not more than 10 kg                   |                                                     | No limit                      |                                                                      |
|                   | Above ground not more than 25 kg                                                                                          |                                                     |                               |                                                                      |

# Charge limitations for A3 refrigerants (EN 378: 2016)

For human comfort applications e.g. Air Con and Heat Pumps

|                   | Compr & vessel indoors                                                                                                                                                                                                  | Refrig equipment indoors<br>Compr & vessel outdoors | Machinery room<br>or open air | Ventilated enclosure                                                          |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-------------------------------|-------------------------------------------------------------------------------|
| General access    | <p>Depends on room size and location of indoor units (floor, wall, ceiling)</p> <p>but not more than<br/>1,5 x 26m<sup>3</sup> x LFL or 1,5 kg</p> <p>It means</p> <p>1,5 kg R290<br/>1,5 kg R1270<br/>1,5 kg R600a</p> |                                                     | 5 kg                          | <p>Max<br/>130m<sup>3</sup> x LFL</p> <p>Max<br/>5 kg R290<br/>5 kg R1270</p> |
| Supervised access |                                                                                                                                                                                                                         |                                                     | 10 kg                         |                                                                               |
| Authorised access |                                                                                                                                                                                                                         |                                                     | No limit                      |                                                                               |

# Are ATEX approved components needed?



## ATEX zones during normal operation

### Zone 0

Permanent explosive atmosphere e.g. inside a fuel tank

### Zone 1

Sometimes explosive atmosphere e.g. around a filling valve of a petrol station

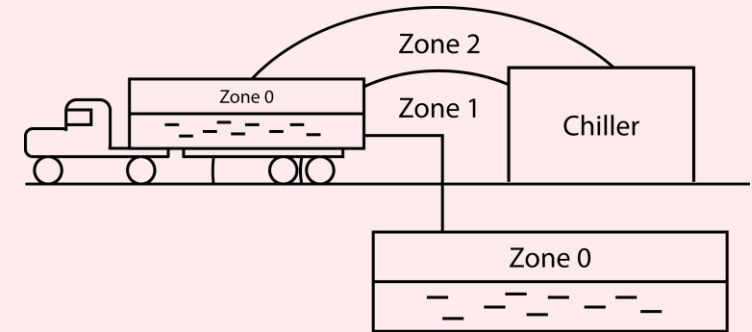
### Zone 2

Rarely and only short time explosive atmosphere e.g. rest of the petrol station

A refrigeration system does not create an ATEX zone itself, no matter which refrigerant is used.



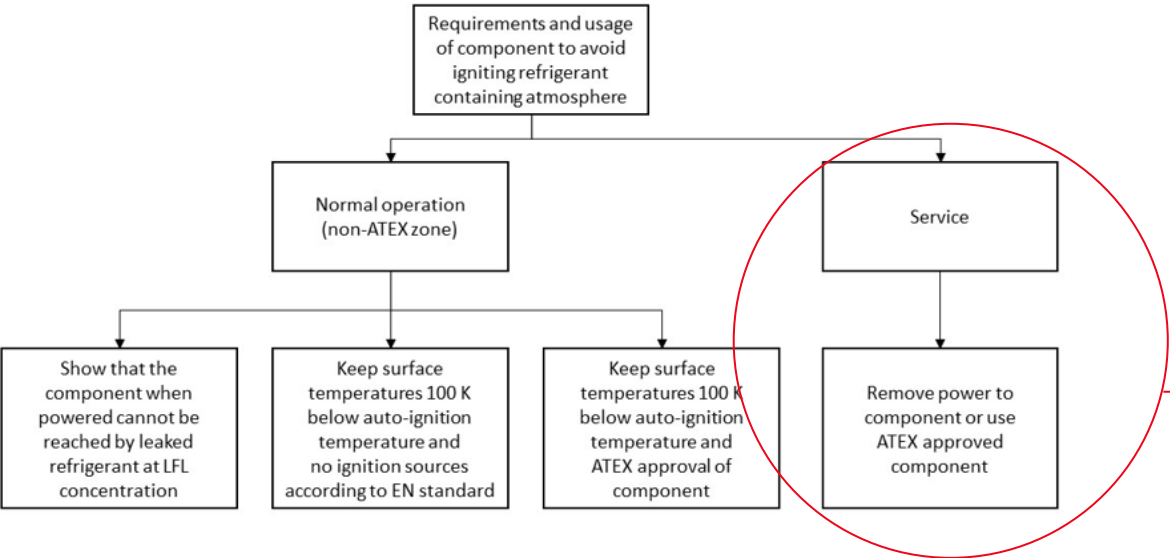
EN 1127-1-2011, Annex B:  
'a refrigeration system is technically tight'



**IF** a refrigeration system is placed within one of these zones it must comply to ATEX – *also if the refrigerant is A1*

# How to apply components for flammable refrigerants

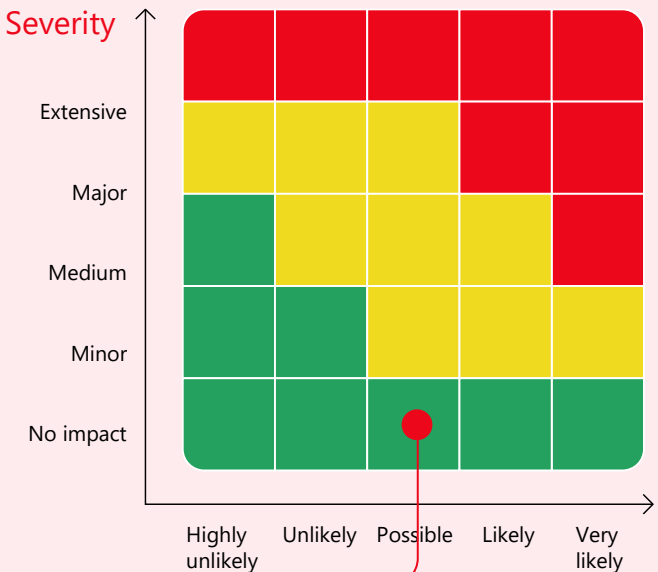
- Designing a system always requires a risk assessment. The risk assessment normally make use of the safety standards
- The shown diagram shows two operational modes when applying components in a system
- Normal operation: three criterias for evaluation of a component usage
- Service situation: As the system may be opened – all ignition sources wherever placed to be without power



Example of a risk assessment matrix

Categories

- Non acceptable
- ALARP
- Acceptable



ALARP:  
As Low As Reasonably Practicable

# Component availability @Danfoss

## All components available in serial production



Compressors and  
Condensing units



Electronic  
controllers



Expansion devices  
(electric and mechanical)



Regulating  
valves



Other  
valves



Heat  
Exchangers



Sensors and  
switches



Systems  
protectors

# Danfoss Refrigerants Whitepaper



[Learn more](#)



# A policy perspective

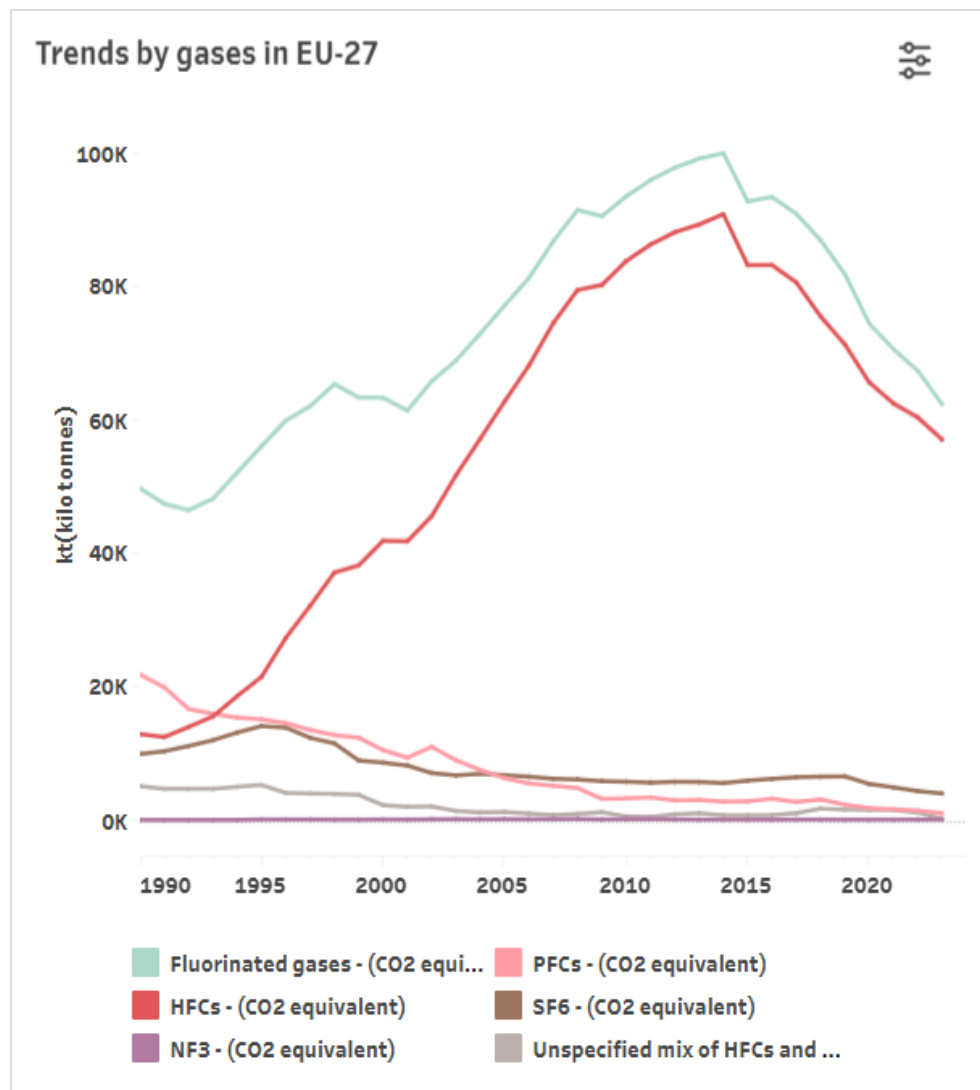


Arno Kaschl  
Policy Officer, DG CLIMA

# Implementing the EU F-Gas Regulation: Flammable Alternatives

*Danfoss side event, OEWG48 of MP, 16 July 2026*

# EU Fgas Regulation - Reversing Course on Fgas Emissions



During the period 2015-2023, total F-gas emissions fell by 32.8% and HFCs by 31.4%

Total F-gas emissions in 2023 fell by 7.4% compared to 2022 (HFCs by 5.5%)

Source: [EEA greenhouse gas data viewer](#)  
based on data reported by EU Member States  
under the EU Governance Regulation

# Effects on innovation

- Strong trigger for green growth
  - 71,800 CO<sub>2</sub> transcritical systems installed in Europe
  - 3.2 million hydrocarbon-based retail cabinets (2023)
  - 3360 small charge ammonia systems (industrial sites)

*All data from ATMO market report 2023*

- Technology adjustment costs only €6/tCO<sub>2</sub>eq (2015-19)

lower than estimated beforehand (€17/tCO<sub>2</sub>eq)

- For many sectors we expect negative abatement costs going forward -  
as a result of energy efficiency gains

Figure 10: Transcritical CO<sub>2</sub> Historical Installation Growth in Europe

(stores and industrial sites)

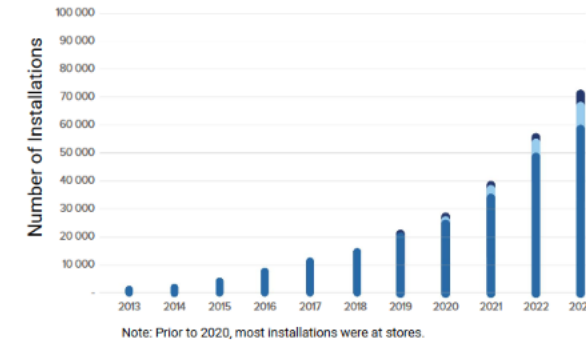
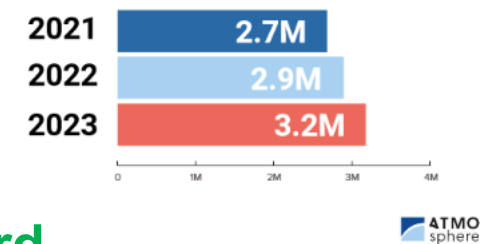


Figure 12: Self-Contained Hydrocarbon Cabinets, Historical Installation Growth in Europe



# Main pillars of EU F-gas Policies

## Reducing HFC use

- Phase-down of HFCs (Quota system)
- Specific prohibitions on use of old / marketing new products & equipment

## Reducing HFC losses („life-cycle refrigerant management“)

- Emission prevention rules, **Leak checks, Certification/Training of Technicians, Recovery Obligation, End-of-Life Treatment, ...**

## Controlling & enforcement

- Trade licensing, Custom rules, Market surveillance, Labelling, Penalties, Reporting

# EU policies on F-gases – short history

- 2006 **First F-gas Regulation**
  - Focus on **containing F-gases (“refrigerant management”)**: leak checks, training and certification of technicians, emission prevention, gas recovery and destruction,..
- 2007 **MAC Directive** (use refrigerant with GWP<150 in AC of passenger cars, from 2011+ for new types, 2017+ for all new cars)
- 2014 **Second F-gas Regulation** (HFC quota system and some accompanying prohibitions)
  - 2016 **Kigali Amendment** to the Montreal Protocol
- 2024 **Third F-gas Regulation** (Many sectoral prohibitions including in AC)

*To come:*

**PFAS Restrictions & Next Review** of F-gas Regulation (2030)

# Quota system for HFCs

(New) placing on the EU market of HFCs

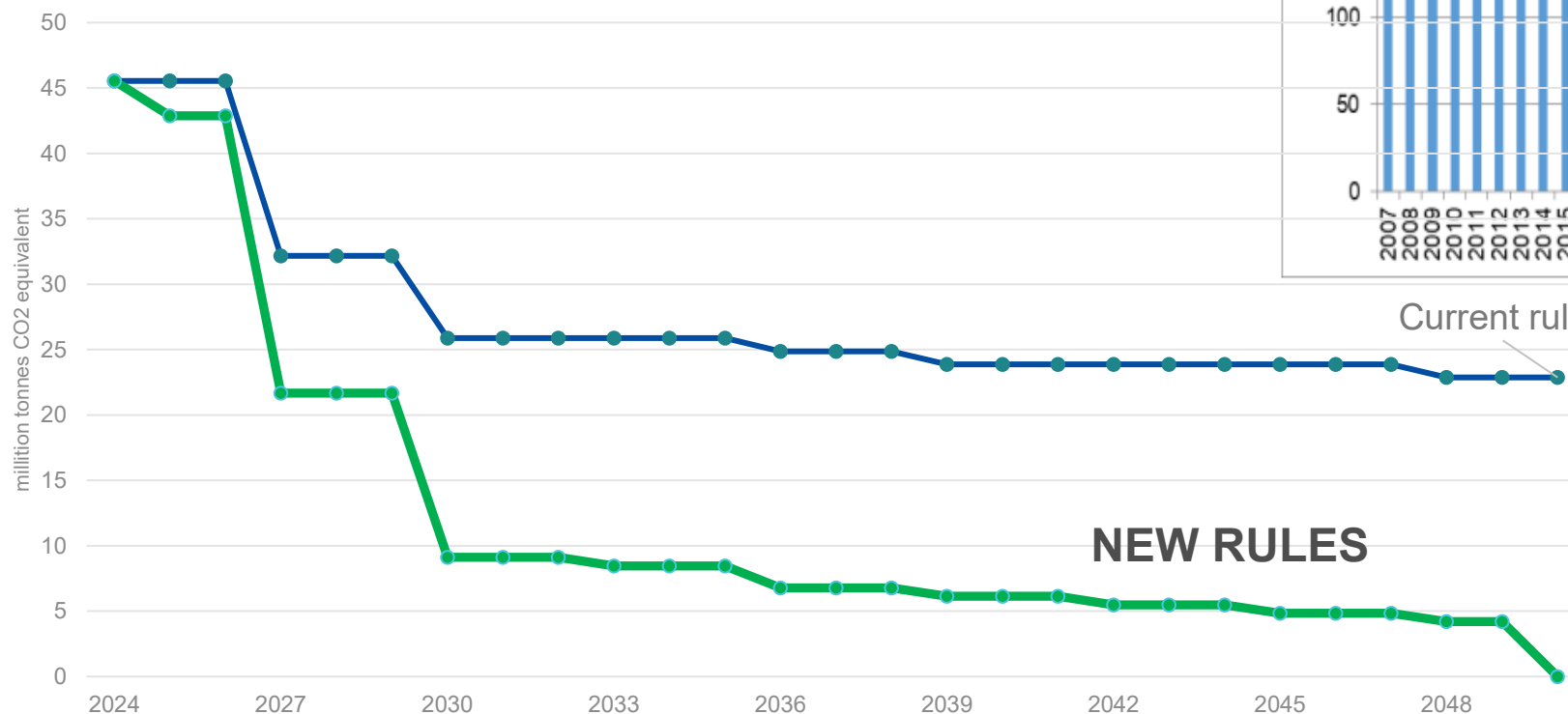
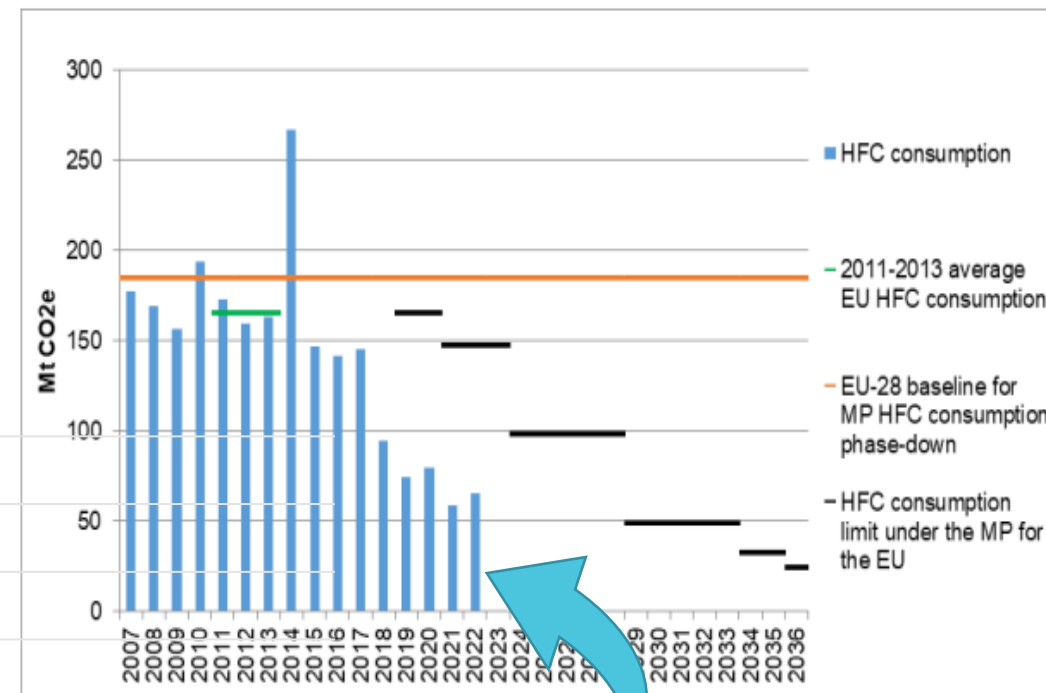


Figure 6-1 EU progress under the Montreal Protocol HFC phase-down



# New restrictions for refrigeration equipment

|                                           | Existing                              | Near term         | Medium term (2030+) |
|-------------------------------------------|---------------------------------------|-------------------|---------------------|
| <b>Domestic</b>                           | <GWP150 (2015)                        | No F-gases (2026) |                     |
| <b>Commercial<br/>Fridges/Freezers</b>    | <GWP150 (2022)                        |                   |                     |
| <b>Other self-contained</b>               | <GWP2500 (2020)<br>Except for T<-50 C | <GWP150 (2025)    |                     |
| <b>Multi-pack<br/>supermarket systems</b> | <GWP150 (2022)                        |                   |                     |
| <b>Small chillers</b> ≤12kW               | <GWP2500 (2020)<br>Except for T<-50 C | <GWP150 (2027)    | No F-gases (2032)   |
| <b>Large chillers</b> >12kW               |                                       | <GWP750 (2027)    |                     |
| <b>All other refrigeration</b>            | <GWP2500 (2020)<br>Except for T<-50 C |                   | <GWP150 (2030)      |

# New restrictions for AC equipment

|                                                 | Existing                                                 | Near term               | Medium term (2030+)     |
|-------------------------------------------------|----------------------------------------------------------|-------------------------|-------------------------|
| <b>Small self-contained AC/Heat Pumps</b> ≤12kW | <GWP150 (2020)<br>Movable plug-ins only                  | <GWP150 (2027)          | No F-gases (2032)       |
| <b>Large self-contained AC/Heat Pumps</b> >12kW |                                                          | <GWP150 (2027)<br>≤50kW | <GWP150 (2030)<br>>50kW |
| <b>Small split AC/Heat Pumps</b> ≤12kW          | <GWP750 (2025)<br>Single splits with max 3kg charge only | <GWP150 (2027)<br>A/W   | No F-gases (2035)       |
|                                                 |                                                          | <GWP150 (2029)<br>A/A   |                         |
| <b>Large split AC/Heat Pumps</b> >12kW          |                                                          | <GWP750 (2029)          | <GWP150 (2033)          |

- No F-gases means the use of hydrocarbons (e.g. propane), CO<sub>2</sub>, ammonia, water,...

# Important pursuits relevant to flammables

- **Safety codes to allow safe use of flammable refrigerants (propane):**  
Important new developments with IEC 60335-2-89 (commercial refrigeration) and IEC 60335-2-40 (air conditioning)
- **Restrictions come with safety exemptions**
  - Use of non-flammable alternatives with GWP higher than threshold allowed, if laws or relevant standards would not permit a flammable solution, e.g. because room size is too small
- **Increase number of service personnel** qualified to install equipment with climate-friendly, in particular flammable, alternatives
  - Obligatory training & certification (skills, safety, awareness, environment, energy efficiency.)

- Strong transition towards R-290 (propane) in air/water monobloc heat pumps  
→ Multiple manufacturers have readily available solutions
- Current trade fairs
  - Single-split propane heat pumps up to 6 kW (up to around 700 g propane) presented by multiple manufacturers
  - Large propane chillers presented by multiple manufacturers
  - Combination of central propane air/water heat pumps for building complexes with individual small <150 g propane heat pumps inside (Panasonic)
  - VRV system with CO<sub>2</sub> (R-744) from Daikin
  - Other multi-split heat pumps still relying on HFC-32
- Heat pump market is shifting swiftly towards natural refrigerants
- No quota shortage is foreseen for the near future



# A few final thoughts



The F-gas Regulation has been a driver for green technologies

- *Phase-out of HFCs by 2050 is set*
- *Restrictions in many sub-sectors take effect in the next few years*
- *New restrictions will also need to consider the PFAS angle*
- *Natural refrigerants continue to grow; propane an excellent solution especially for smaller equipment where charges are low*
- *Continue updating standards with technological development is crucial for ensuring safe use of flammable refrigerants*
- *Outlook: PFAS policies, technical review for mobile equipment and general review around the corner*

# Thank you

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[https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases\\_en](https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases_en)



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# An OEM perspective



Hilde Dhont  
Department Manager, Daikin Europe Environment Research Center

# Flammable refrigerants

## A manufacturer's perspective



Hilde Dhont  
Bangkok OEWG 2026

# Intro Daikin

Founded in **1924**  
100 Years of History

39

**¥5 trillion**  
Overall Sales

**84%**  
of Daikin Sales are from  
outside Japan

## Cooling & Heating + cold chain



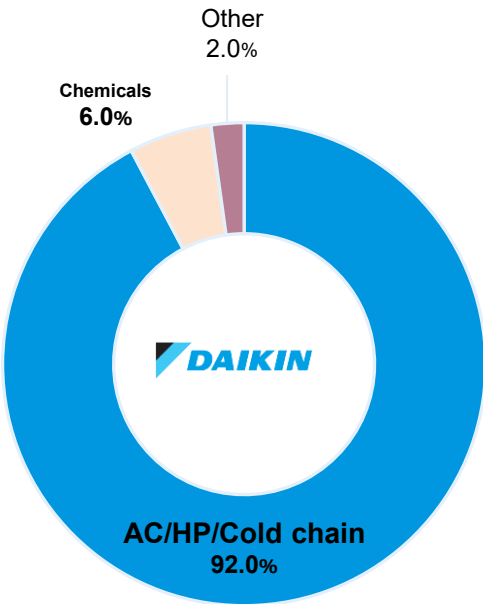
Residential



Commercial & industrial



After Sales Service



## Other Businesses



Oil Hydraulic  
Equipment



Oxygen  
Concentrators

## Chemicals



Refrigerant



Semiconductor Applications



Automotive Applications

**130+**  
Production Bases  
In the World

Business Development in  
**170+**  
Countries and Regions

**100,000+**  
Employees

# Contents

How to ensure safety in case of flammable refrigerants ?

- Risk analysis
- Risk Mitigation options (examples)
- Standards & Legislations
- Guideline example

# Criteria for refrigerant choice

Selecting the right refrigerant for each application is **not a one-size-fits-all solution**



## Environmental impact

- Lower refrigerant global warming potential (GWP)
- Potential to be recycled and reused
- Lower lifecycle climate performance (LCCP) of equipment

## Energy efficiency

- Reducing energy consumption to lower the indirect CO<sub>2</sub> impact
- Reduced running costs for end-users

## Safety

- Considering the whole life cycle, including transport, storage, installation, use, servicing, recovery and recycling
- Evaluating for each type of use, taking into account toxicity, flammability, pressure etc

## Affordability

- Affordable solutions
- Regarding equipment, installation, operation, maintenance and end-of-life treatment

# Examples of products using flammable refrigerants



R32 split type  
comfort cooling &  
heating



R290 plug in  
display case



R290 monobloc  
heat pump  
(air to water)



R290 cold room



R290 chiller

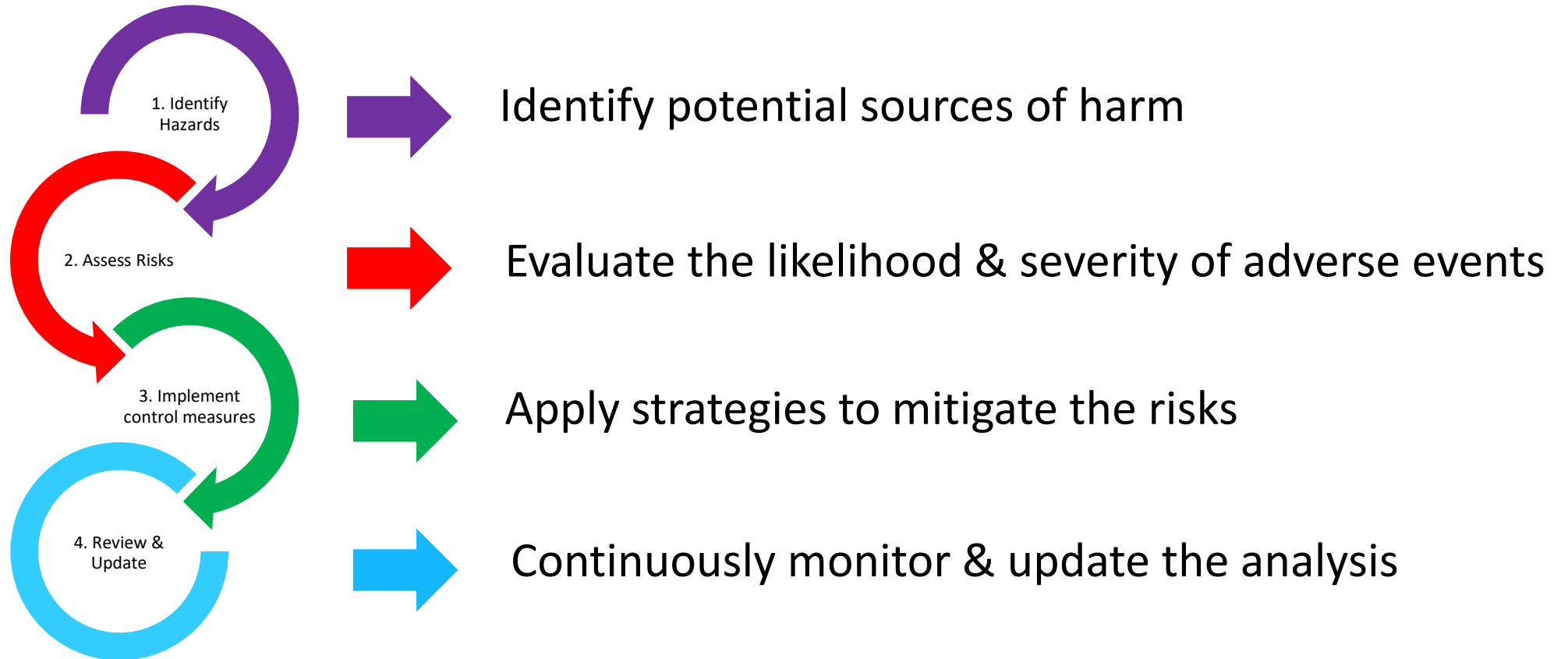


R1234ze chiller

# How to ensure “safety” ?

- Hazard handling analysis is a critical process that involves systematically identifying and evaluating potential dangers to ensure safety.

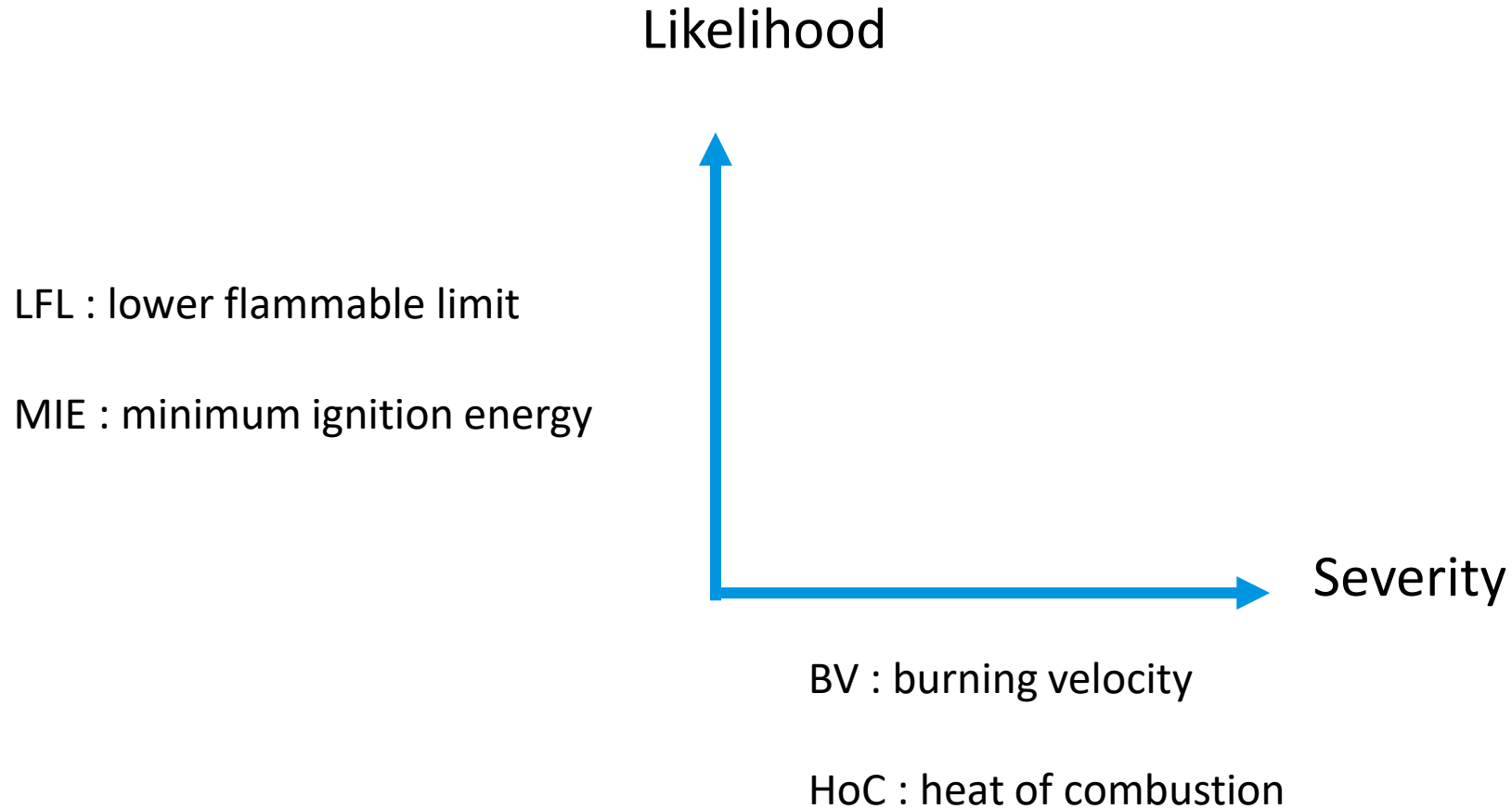
Key steps :



# Evaluating the risk of flammable refrigerants : a case-by-case approach

- Refrigerant characteristics
- Locations
- Handling processes
- Market circumstances

# Refrigerant characteristics - flammability



- Refrigerant Examples

## LIKELIHOOD

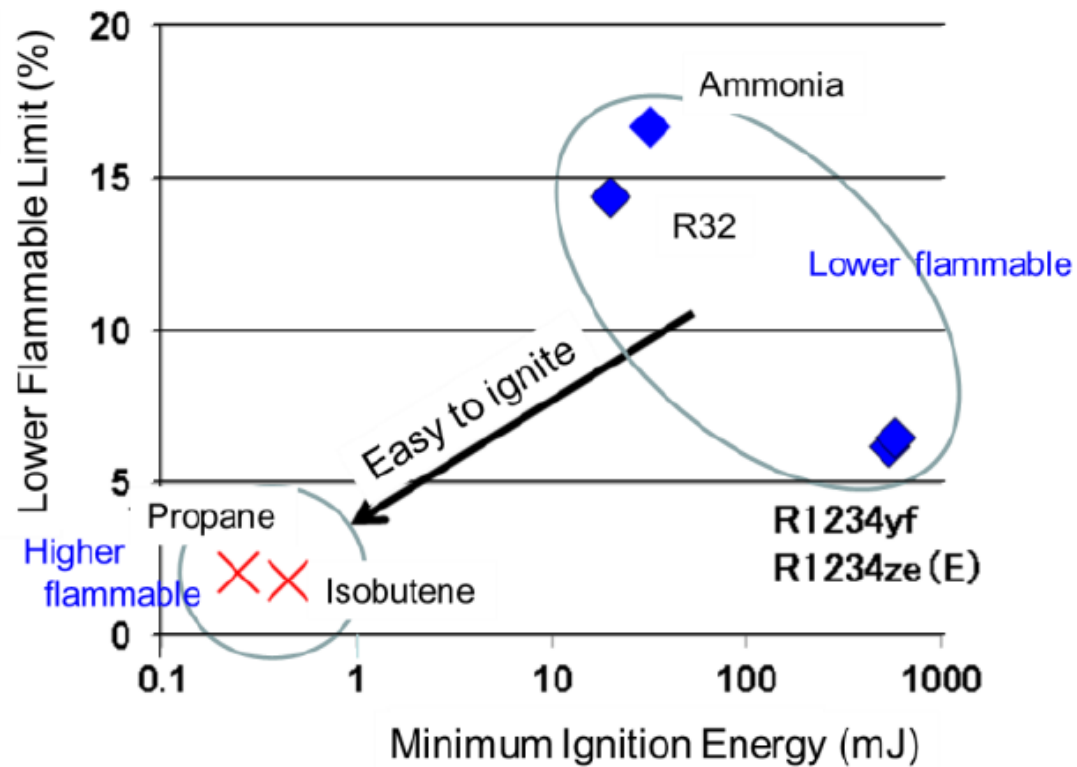


Figure 1-6 Comparison for easy ignition

## SEVERITY

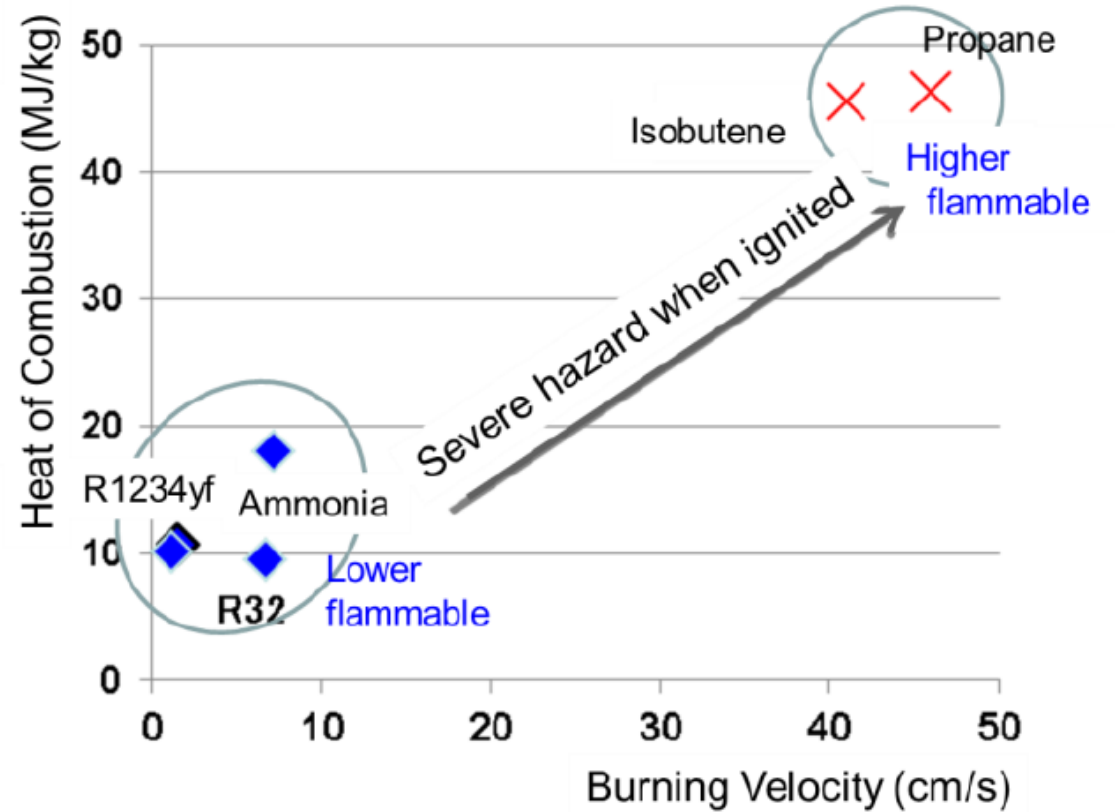
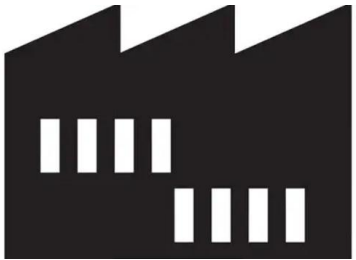


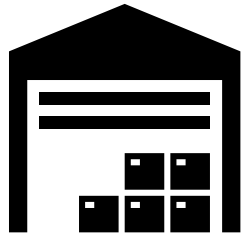
Figure 1-7 Comparison for hazard severity

# Locations

→ not only the site of use needs to be safe



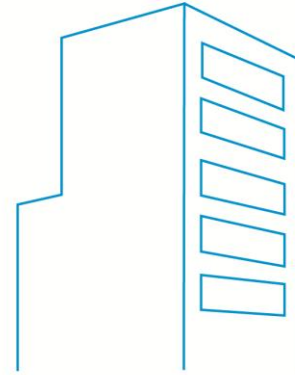
Factory  
& test rooms



warehouse



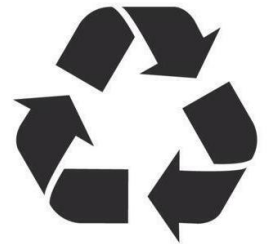
transport  
spaces



site of use



waste  
collection  
site



waste  
treatment  
site

# Handling processes

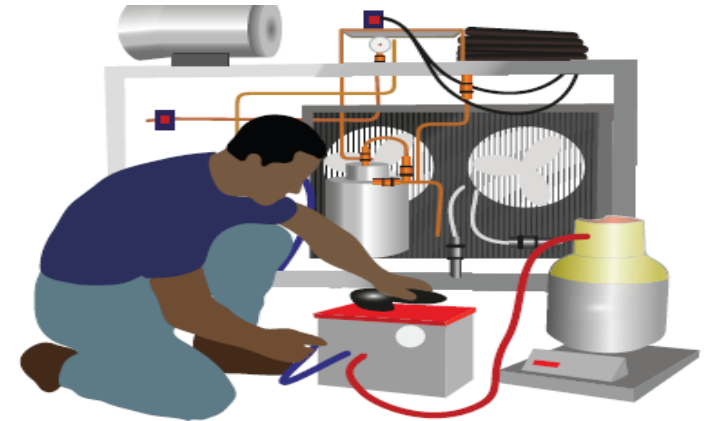
- Directly interfering with refrigerant circuit
- may include handling of refrigerant cylinders



installation, requiring  
refrigerant piping connections  
on site



repair



recovery

# Handling processes

→ NOT directly interfering with refrigerant circuit, risks still to be assessed



transporting



installing without need for  
on site refrigerant  
connection

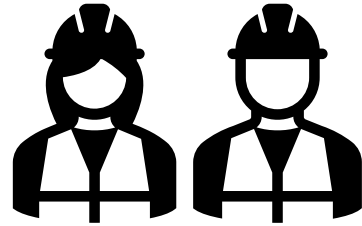


using  
the equipment

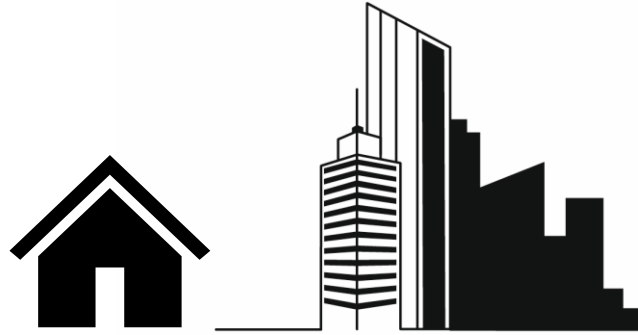
# Market circumstances



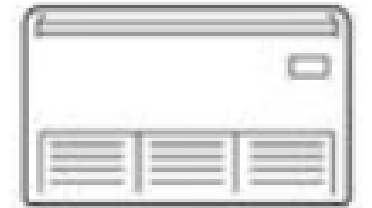
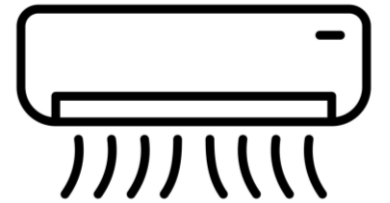
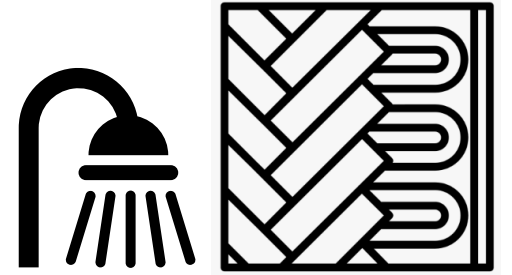
Logistic conditions



Availability of Skilled workforce



Building types



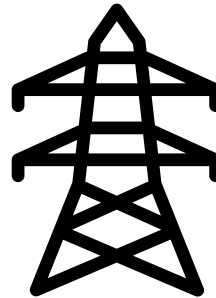
User preferences



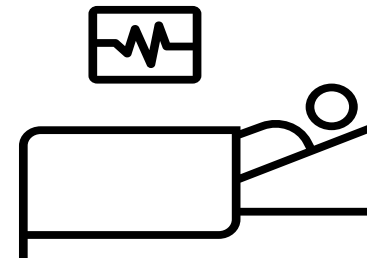
Natural disasters



Enforceability



Grid stability



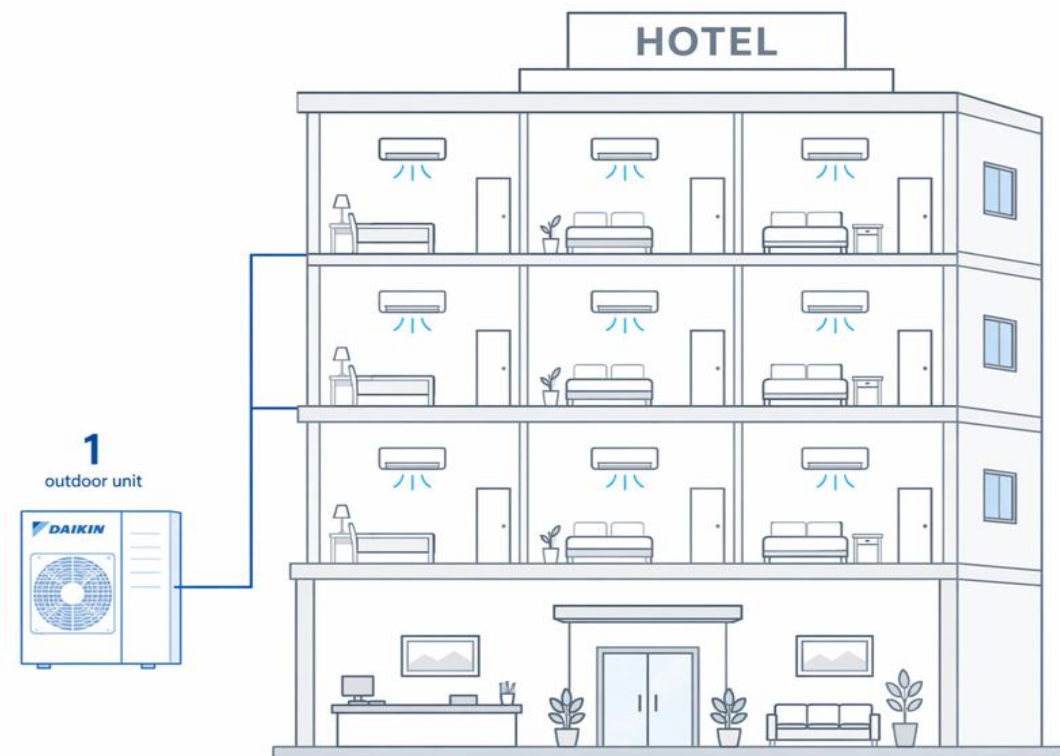
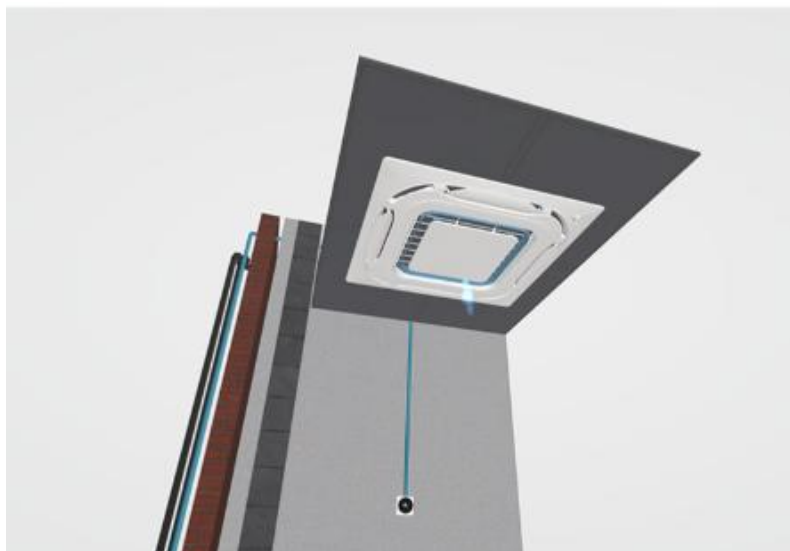
User vulnerability

# Risk mitigation measures - examples

- Next slides give a few examples, it is not a comprehensive list
- Different measures apply case-by-case / product by product / site by site

# Risk mitigation – equipment design

## Example R32 VRV design measures



## What is included in Shîrudo Technology?

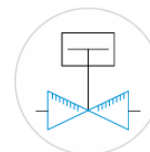
- Factory-integrated refrigerant control measures, designed to comply with IEC 60335-2-40 and third-party certified by a Notified Body, providing complete peace of mind



Leak detection sensor in every indoor unit



Audible & visual alarm in Madoka controller or via iTM



Shut-off valves in the outdoor unit or SV box



Specially developed algorithms

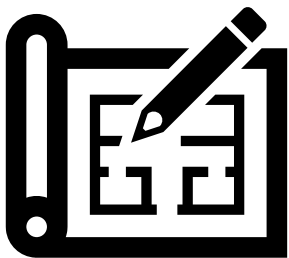
# Risk mitigation – equipment design

## Example R290 chiller



- Requires **an independent 230V power supply for all safety devices**, provided by the customer. If the power supply to the safety devices is not active, is interrupted, or is not correctly connected, the unit will not start and will remain in a safe standby condition.
- The **electrical switchbox** is designed as a controlled environment. It is continuously **pressurized and equipped with refrigerant leak detection systems, supported by ATEX-certified ventilation, visual and acoustic alarms** that provide immediate indication in the event of any abnormal condition.
- The R-290 refrigerant is **factory-charged into dedicated storage tanks**, increasing safety during transport and handling prior to installation. The refrigerant circuit also includes mechanical **safety valves** to manage potential overpressure conditions, with controlled discharge to the outside if required.
- **Additional safety measures** allow any potential refrigerant dispersion to be detected and managed in a controlled manner, enabling the unit to shut down safely. The **hydronic circuit is also protected**: if a leak is detected, a shut-off valve isolates the water circuit, preventing refrigerant from spreading beyond the unit.

# Risk mitigation - installation instructions



Examples of installation instructions (indoors) → minimum floor area

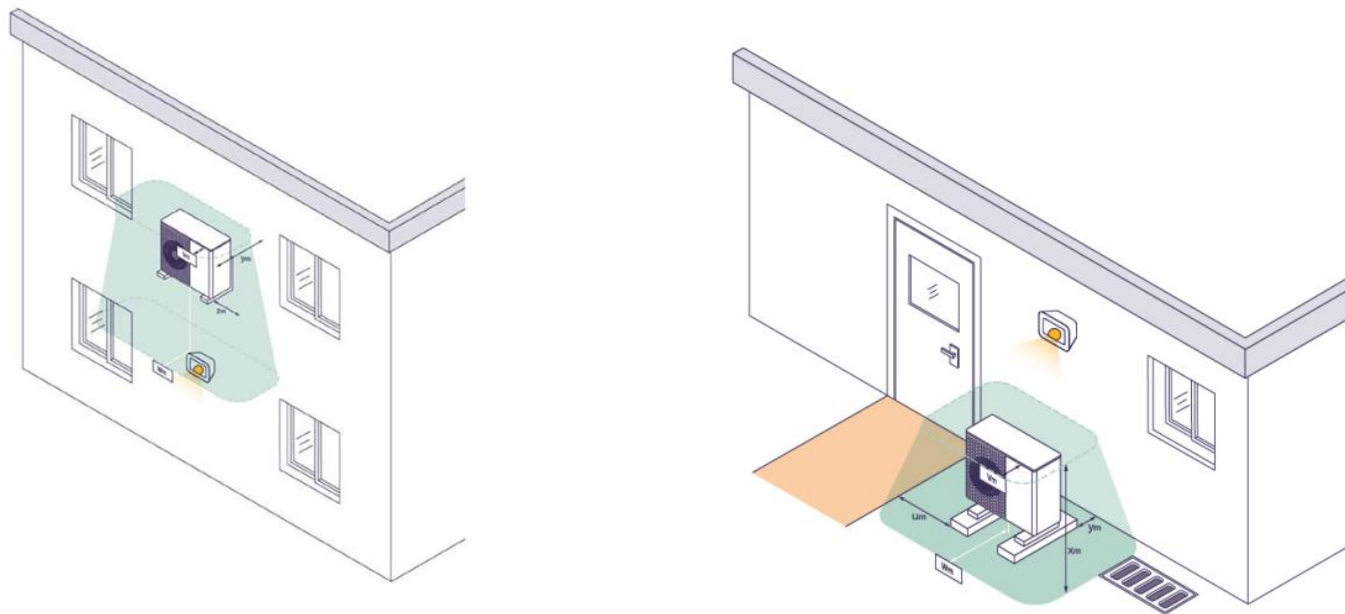
Example of Split indoor unit using R32

| SPECIAL PRECAUTIONS WHEN DEALING WITH R32 UNIT     |                                   |                                                      |                                                     |                                                                     |
|----------------------------------------------------|-----------------------------------|------------------------------------------------------|-----------------------------------------------------|---------------------------------------------------------------------|
| Model                                              | R32 charge, kg<br>for 7.5m piping | Minimum floor area,<br>Xm² (based on 7.5m<br>piping) | R32 charge, kg for<br>max allowable<br>pipe length* | Minimum floor area, Xm²<br>(based on max allowable<br>pipe length*) |
| FTXC20B - RXC20B                                   | 0.55                              | 0.29                                                 | 0.76                                                | 0.55                                                                |
| FTXC25B - RXC25B                                   | 0.55                              | 0.29                                                 | 0.76                                                | 0.55                                                                |
| FTXC35B - RXC35B                                   | 0.75                              | 0.54                                                 | 0.96                                                | 0.88                                                                |
| FTXC50B - RXC50B                                   | 1.00                              | 0.95                                                 | 1.38                                                | 1.82                                                                |
| FTXC60B - RXC60B                                   | 1.10                              | 1.15                                                 | 1.48                                                | 2.10                                                                |
| FTXC71B - RXC71B                                   | 1.15                              | 1.26                                                 | 1.53                                                | 2.24                                                                |
| * Calculation based on Installation Height of 1.8m |                                   |                                                      |                                                     |                                                                     |
| * Max. Allowable Length (L),m for:-                |                                   |                                                      |                                                     |                                                                     |
| FTXC20/25/35B-RXC20/25/35B:20                      |                                   |                                                      |                                                     |                                                                     |
| FTXC50/60/71B-RXC50/60/71B:30                      |                                   |                                                      |                                                     |                                                                     |

English

# Risk mitigation – installation instructions

## Examples of installation instructions (outdoors)



Example R290 monobloc heat pump  
(self contained air to water)

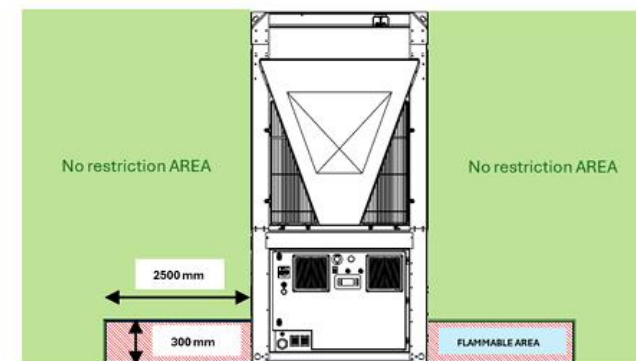
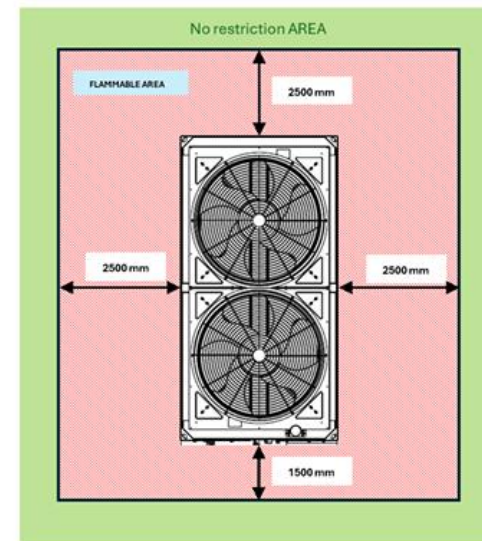


Figure 13 – Flammable area

Example R290 chiller

# Risk mitigation –installation skills



## Example R290 chiller



Installation of the units is limited to **qualified and authorised personnel**. Commissioning activities must be registered via Daikin's proprietary e-Care application. This will ensure traceability of start-up operations and guarantee that the system is installed and operated in line with the original design intent from trained technicians

# Standards & legislations

- Lifecycle safety is a shared responsibility
- Safety standards do not cover the entire lifecycle
- Various local & international rules also apply



Building safety codes

# Guideline example



SKILLSAFE EU

## Skills Enhancement for Safe Handling of Highly Flammable Refrigerants in the EU

Europe is on the brink of a heat pump revolution. Driven by the RePowerEU plan and stringent F-gas regulations, millions of heat pumps will be installed across the EU in the coming years. While this transition is essential for a greener future, it also presents significant safety challenges.



SKILLSAFE EU



Co-funded by  
the European Union



Guideline for self contained heat pumps using highly flammable refrigerants installed outdoors is completed : [Skillsafe guideline self contained heat pumps outdoors](#)

Guideline on safe handling of self-contained air-to-water residential heat pumps with refrigerants with higher flammability installed outdoors in Europe



Grant agreement No: LIFE27 101167753



Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

# Conclusion

GWP is not the only criteria for refrigerant choice

Safety requires life cycle analysis & tailored mitigation measures to manage the risks



**Environmental impact**



**Energy efficiency**



**Safety**



**Cost-effectiveness**

# An installer perspective



Marco Buoni  
Centro Studi Galileo



# From the Student to the Installer: Why We Should Start Building the Skills of Future Technicians Today

**Marco Buoni**

Centro Studi Galileo *Director*

AREA *Former President*

*w/ international affairs mandate*

16<sup>th</sup> July 2025

OEWG Bangkok



# About AREA

***Established in 1989***

***26 national associations***

***22 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.



Helping building the new certification scheme A1 and A2 for flammable refrigerants, many courses now available in EU



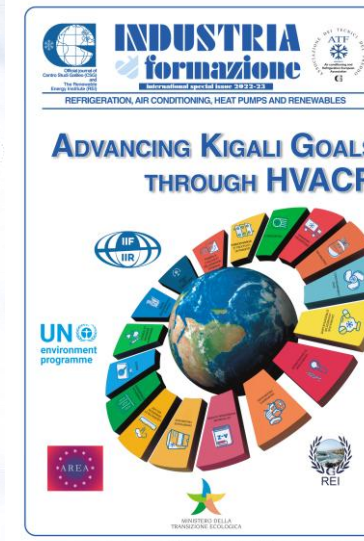
# About Centro Studi Galileo

International presence and Events:

- **Conferences & Training courses** in Italy and globally (300 trainings every year to 3000 technicians)
- **International Projects: Impact F, Real Alt.**
- **International Special Issue I&F**

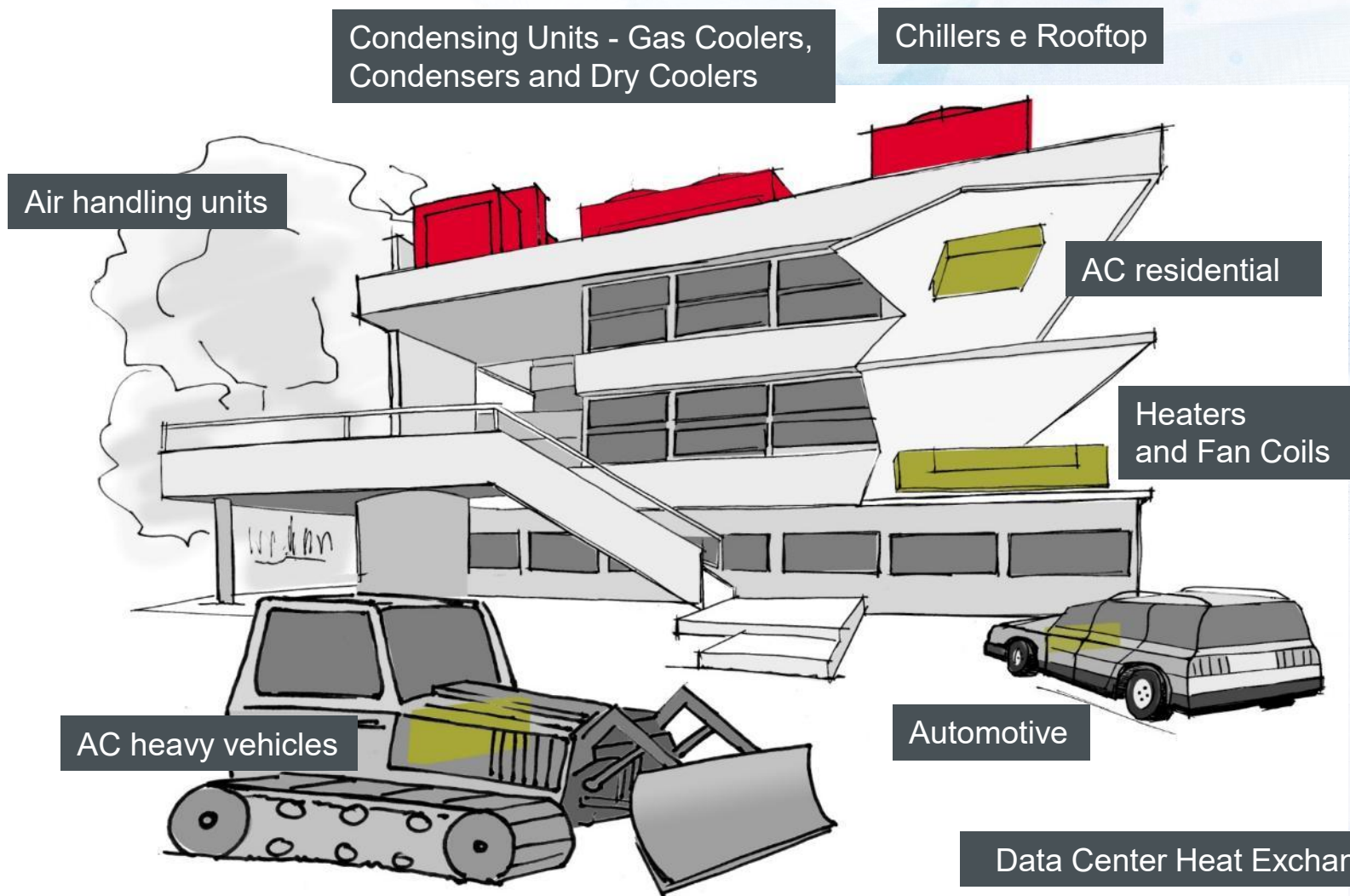
Communication:

- **I&F Blog** for spreading RAC news and facts
- Monthly **newsletter** to 60.000 technicians
- **Websites** for training courses
- **Social medias**
- **AREA app**



Presented in  
**MOP** and **COP**

## AROUND US – RACHP IS GROWING





# The Skills Gap Is Becoming the Biggest Bottleneck

| Region         | Current Workforce                               | Workforce Needed                                             | Estimated Gap                 | Source                                                                 |                                                                                                                                   |
|----------------|-------------------------------------------------|--------------------------------------------------------------|-------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| United Kingdom | 4,000–10,000 active heat pump installers (2024) | ~70,000 installers by 2035                                   | ~60,000 additional installers | UK Government – Clean Energy Skills Assessment                         |                                                |
| European Union | around 117,000 (2024)                           | 450,000–500,000 full-time equivalent (FTE) employees by 2030 | Hundreds of thousands         | European Heat Pump Association (EHPA), European Labour Authority (ELA) |                                                                                                                                   |
|                |                                                 |                                                              |                               |                                                                        | School<br>↓<br>Vocational Education<br>↓<br>Training Centre<br>↓<br>Certification<br>↓<br>Installer<br>↓<br>Continuous Upskilling |

# Today's student is tomorrow's installer



- Every heat pump,
- every supermarket,
- every hospital,
- every data centre depends on a skilled technician.

**HP Vocational Academy for Technical High Schools in Italy**

Schools cannot solve this alone. Industry cannot solve it alone.  
The solution is partnership.



# A Successful Industry–Education Collaboration:

## Danfoss & CSG Supporting the Next Generation of Heat Pump Experts

- **Direct exposure to innovation** through a technical visit to **MCE – Mostra Convegno Expocomfort 2026**.
- **Strong partnership with the Sobrero Technical School:** a practical learning pathway that bridges **education, industry and future employment**. We work to equip students with competencies for the future sustainable HVACR technologies.



*Technical Visit at Danfoss Stand at MCE 2026*

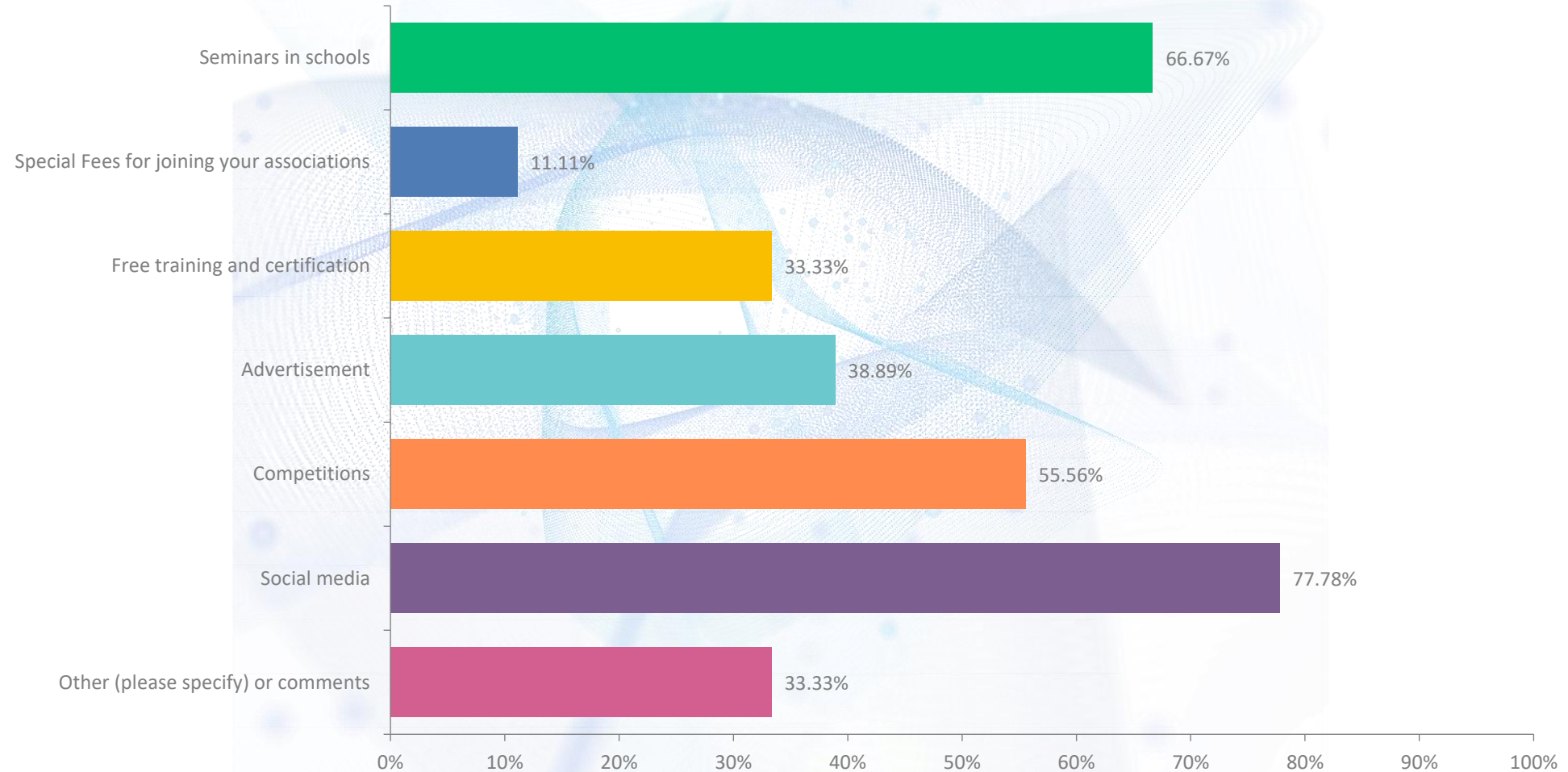


*Awarding of Certificates of Participation*

# Q10: How do you attract young technicians to join our sector?



- Answered: 18 EU associations Skipped: 0





# Building Regional Centres of Excellence in Bangkok following EU standards for Fgas & Alternatives certification

- Manufacturers – Centro Studi Galileo partnership Academy
- Qualified training centre
- EU Fgas certification session, trainer and assessor

Other qualified training centers in Dubai, Tunisia, Burkina Faso, USA (Miami), Italy, UK, etc... and all RALT project OTP





# WORK in art.5 countries

- Assessing TVET centres
- Assessing curricula

Recently in Bhutan, Bangladesh, Benin, etc....



# European Rising Stars – Women & Youth in Cooling Competition

## Shortage of skilled workforce



- **Competition Themes**

The subjects of the video are one or both of the following:

**Design and application of RACHP systems Handling of a refrigeration, air conditioning or heat pump system**

- **Evaluation criteria The evaluation criteria are:**

- The use of the necessary devices and tools
- The use of security means
- The correct explanation of the task to be performed

- The winner obtain a **Prize and an amount of 1000 euros** which will be awarded to the winner in UNEP-IIR-AREA-ATF conference by World Refrigeration Day secretariat and the AREA President. AREA, through ATF, will sponsor flight, accommodation, dinner and participation to the AREA general assembly.

**The name of the winner will be officially announced in May'25 during the AREA general assembly in Istanbul.**



# IN EU BEST PRACTICES BASED ON REAL Alternatives LIFE PROJECT



## 18 languages..

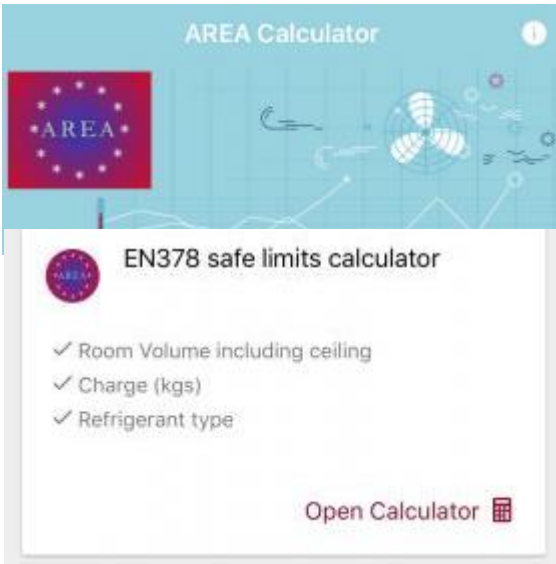
|          |            |
|----------|------------|
| Croatian | Italian    |
| Czech    | Polish     |
| Dutch    | Portuguese |
| English  | Romanian   |
| Estonian | Russian    |
| Finnish  | Slovakian  |
| French   | Spanish    |
| Greek    | Swedish    |
| German   | Turkish    |

All the logos of the  
partners, associations  
or universities

Download on android  
«AREA Fgas»



National Leads  
& Training Providers



Training component for:



# IMPACT-F

INTEGRATED MITIGATION PLATFORM  
FOR ASSESSING CLIMATE TARGETS FOR  
F-GASES

JULY 2026



Funded by  
the European Union



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Thank you to all partners

EST 1892  
**LSBU**





## Conclusions - The refrigerant transition will not succeed without skilled people

- **A Growing Sector**
- **Change of mindset:** more students, technicians & design engineers
- **New equipment:** hydrocarbons in A/C, CO<sub>2</sub> in commercial refrigeration
- **New behaviour:** improved attention to flammability & refrigerant recovery
- **Collaboration is essential:**
  - Institutions (UN agencies, NOUs, etc.)
  - Schools
  - Associations
  - Industry
  - SMEs & technicians
-  **No one left behind**
- Let's invest not only in equipment, but also in people



**Stronger together**

***Thank you  
Marco Buoni***

***Email: [buoni@centrogalileo.it](mailto:buoni@centrogalileo.it)***



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

**AREAVISION2030**



Thank you

