R290 as one of the Kigali keys for efficient room AC

Yosr Allouche | Director General of the International Institute of Refrigeration

Green Cooling Summit 2026

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Properties of low-GWP technologies

- Lower environmental impact
- Lower refrigerant costs despite moderate installation costs
- Good thermodynamic properties
- Comparable or higher energy-efficiency
- Opportunities for significant refrigerant charge reduction (*e.g. with natural refrigerants*)

Hydrocarbons: When **properly selected** for the appropriate application, integrated into **well-designed systems** and managed under strict **safety** protocols

Flammability should not be confused with unsafety!

→ Proper application, good engineering, appropriate standards, and qualified technicians

Lower costs: ex. Domestic HP based on HC R152a or R1234yf

Main characteristics of refrigerants

Refrigerant	GWP	PFAS	Flammable	Toxic	Comparative costs	
					Refrigerant	Installation
HFCs	High	Some are and a few form TFA	No GWP < 750 Moderate	Low, but toxic fumes when burning	Moderate	Low
HFOs	Low	Some are and several form TFA	Moderate	Not acute, but toxic fumes when burning	High	Moderate
Hydrocarbons	Low	No	Yes	Low	Low	Moderate
Carbon Dioxide	Low	No	No	Above 10%	Low	Moderate
Ammonia	None	No	Moderate	High	Low	Moderate
Water	None	No	No	No	Low	Moderate

Source: IIR (2025)

Natural refrigerants applications in air conditioning

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		Hydrocarbons		Ammonia	Water	CO_2
		HC-290	HC-1270	R717	R718	R744
Air-to-air air conditioners and heat pumps	Small self-contained ACs	↗	↗			
	Single-split ACs	↗				
	Multi-split ACs	↗(*)				
Applied building cooling systems	Ducted AC systems	↗ [1]	↗[1]			
	Air conditioning chillers	↗	↗	↗	↗	
	VRF Air Conditioning [2]	↗(*)	↗(*)			
Mobile air conditioning and heat pumps	Internal combustion engine	↗(*)				↗
	Electric vehicle	↗				↗

[1] Only in combination with heat transfer fluid, not in direct evaporation in public areas
[2] Direct expansion/evaporation in heat exchangers in the individual rooms/zones of a building
(*) Once obstructive charge limits in safety standards have been resolved

Source: IIR (2025)

- **R290 AC application is moving beyond pilots** and niche markets, it is entering **industrial deployment**.
- The most important technical discussions behind this transition is **refrigerant charge reduction**.

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Refrigerant charge in heat pumps

Wider adoption of heat pumps using hydrocarbons depends on safety issues,

which are strongly related to refrigerant charge reduction.

- Many of the safety discussions around hydrocarbons are directly linked to refrigerant quantity
- Compared with HFC models, R-290 air-to-air heat pumps show a **lower specific charge** (kg/kW)
- Many systems currently on the market were not originally optimised for charge reduction → future generations : **safer**, **more efficient** , **more competitive**.

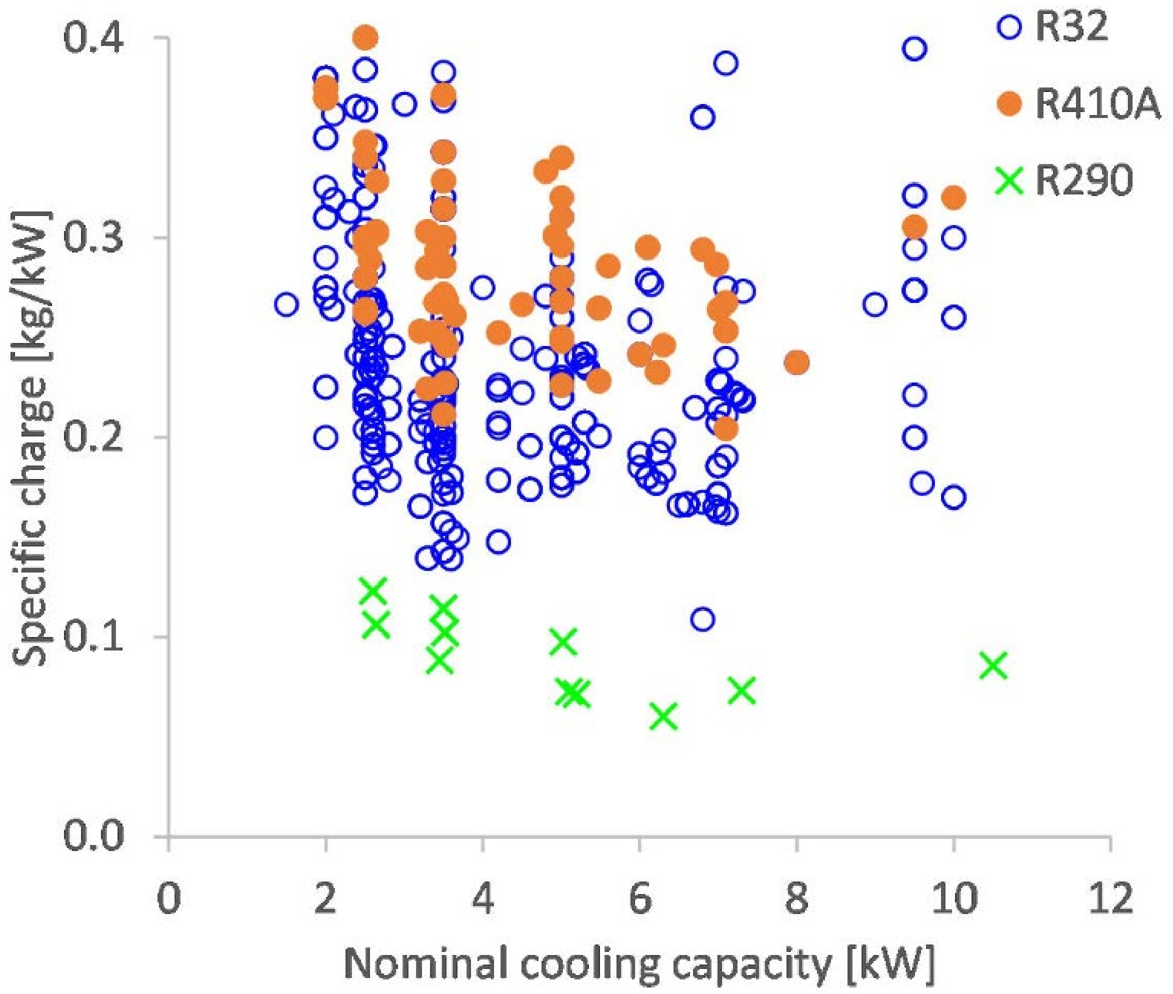

Fig. Comparison of specific charge vs nominal cooling capacity for air-to-air heat pumps with R410A, R32 and R290. IIR (2025)

Necessity of low-GWP transition

The RACHP sector accounts for 7.5% of global CO_2 emissions.

Cooling demand continues to grow everywhere: in cities, in emerging economies, in data infrastructure …

- Cut down emissions from the refrigeration sector
- Comply with Kigali Agreement and stricter regional legislations
- Encourage future-proof innovation under more stringent regulations
- Promote energy-efficient, safe and sustainable cooling.

We should look at the sector with a more holistic way

Europe is a clear example of this approach

Prohibitions under EU F-gas Regulation

MONOBLOCK HEAT PUMPS AND AIR-CONDITIONING:
ANNEX IV – Art. 8

- **2020** Plug-in room air-conditioning equipment moveable between rooms containing **F-gases with a GWP ≥150.**
- **2027** Plug-in room air-conditioning, monoblock air-conditioning, other self-contained air-conditioning equipment and heat pumps, **max. 12 kW containing F-gases with a GWP ≥150.***
- **2032** Plug-in room air-conditioning equipment, monoblock air-conditioning equipment, other self-contained air-conditioning equipment and heat pumps, **max. 12 kW containing F-gases.***
- **2027** Monoblock and other self-contained air-conditioning equipment and heat pumps, **between 12 kW and 50 kW, containing F-gases with a GWP ≥150.***
- **2030** **Other** self-contained air-conditioning equipment and heat pumps **containing F-gases with a GWP ≥150.**

SPLIT HEAT PUMPS AND AIR CONDITIONING:
ANNEX IV – Art. 9

- **2025** Single split systems containing less than 3 kg of F-gases **containing F-gases with a GWP ≥750.**
- **2027** Split air-to-water systems max. 12 kW containing **F-gases with GWP ≥150.***
- **2029** Split air-to-air systems max. 12 kW containing **F-gases with GWP ≥150.***
- **2035** Split systems **max. 12 kW containing F-gases.***
- **2029** Split systems **≥12 kW containing F-gases with GWP ≥750.***
- **2033** Split systems **≥12 kW containing F-gases with GWP ≥150. ***

NOTE

*The ban of certain applications receives an exemption if "required to meet safety requirements" and are in that case allowed to use refrigerants with a higher Global Warming Potential (GWP).

Source: EHPA (2024)

- R290 is receiving so much attention
- Environmental profile + long-term viable option for certain applications
- Globally: the transition has started

Current progress of the transition

Sustainable cooling is now embedded in national policy frameworks worldwide

- **172 countries**
  have prioritized sustainable cooling in national policy
- **167 Parties**
  have ratified the Kigali Amendment
- **134 countries**
  include cooling-related targets in national strategies
- **59 countries**
  are developing or implementing national cooling action plans (NCAPs)
- **70+ countries**
  have joined the Global Cooling Pledge

Climate Policies on the right path, but the question is how fast this will be implemented ?

Refrigerant transition **is not enough**

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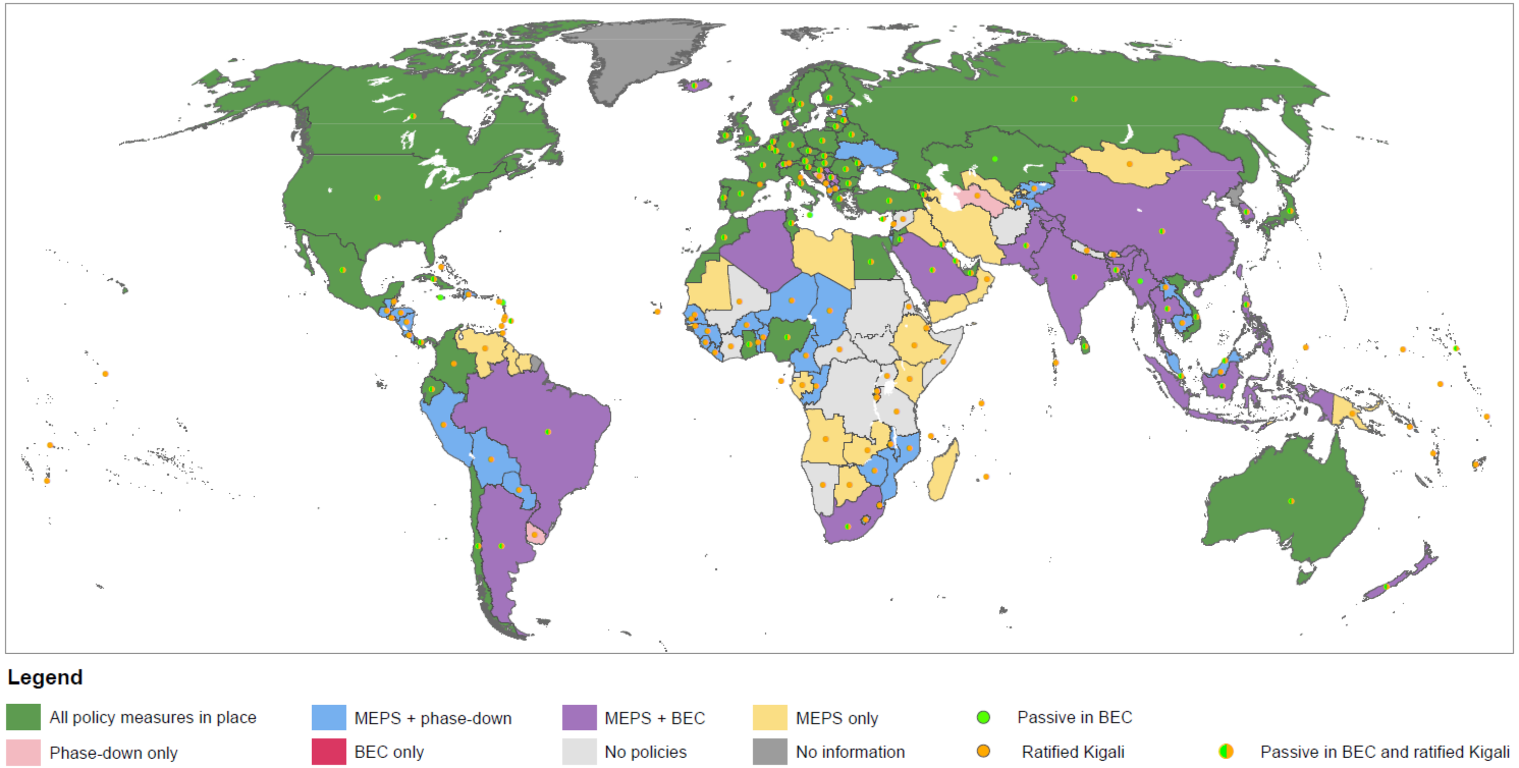
Policy frameworks address three main pillars to achieve near-zero GHG emissions from cooling:

- Integrating passive cooling measures through building energy codes (BEC)
- Improving energy efficiency through minimum energy performance standards (MEPS)
- Phasing down high-GWP refrigerants



Source: Global Cooling Watch 2025

The entire ecosystem needs to evolve together!

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Hydrocarbons under the perspective of the revised EU F-gas regulation

Year	Annex IV item[1]	Equipment category	Limitation[2]	R290 permitted[3] [kg]	
				IEC 60355-2-40	EN 378-1
2025	9(a)	Single split AC&HPs with > 3kg	No GWP > 750	1	1.5, 2.5
2027	8(b)	Plug-in room, monoblock AC and self-contained HPs ≤ 12 kW	No GWP > 150 (or GWP > 750)	1.0, 5.0	1.5, 5.0
2027	8(d)	Monoblock and self-contained AC&HPs, > 12 kW and ≤ 50 kW	No GWP > 150 (or GWP > 750)	1.0, 5.0	1.5, 5.0
2029	9(b)	AC&HP split ATW systems ≤ 12 kW	No GWP > 150	1	1.5, 2.5, 5.0
2029	9(c)	AC&HP split ATA systems ≤ 12 kW	No GWP > 150	1	1.5, 2.5
2029	9(e)	AC&HP split ATA systems ≥ 12 kW	No GWP > 750	1	1.5, 2.5
2030	8(e)	Other self-contained AC&HPs	No GWP > 150 (or GWP > 750)	1.0, 5.0	1.5, 5.0
2032	8(c)	Plug-in room, monoblock AC and self-contained HPs ≤ 12 kW	No F-gases (or GWP > 750)	1.0, 5.0	1.5, 5.0
2033	9(f)	AC&HP split systems > 12 kW	No GWP > 150	1	1.5, 2.5
2035	9(d)	AC&HP split systems ≤ 12 kW	No F-gases	1	1.5, 2.5

1 The letter in parentheses refers to successive POM bans for each Annex IV item listed within Regulation 2024/573.
2 Text in parentheses ("or GWP > 750") refers to the condition "...except when required to meet safety requirements."
3 Actual value depends upon system architecture (IEC 60355-2-40) or access class/system location classification (EN 378-1).

Source: IIR (2024)

- Within 2024 EU F-gas regulation, progressive POM (Placing on the Market) bans are accelerating refrigerant transition.
- Most residential and small commercial AC/HP categories are expected to be satisfied with hydrocarbons.
- Green: R-290 charge limits broadly achievable; Orange: larger-capacity systems still face charge-limit challenges.
- Regulatory feasibility is established. The bottleneck is now deployment at scale.
- Scaling: manufacturing, standards, continuous technician training, supply chains, servicing, safety procedures and protocols…

Global hydrocarbon AC manufacturing situation

- **Asia:** This region is seeing the fastest growth in manufacturing, with major conversion of production lines to R-290 occurring in China and South-East Asia. A 5.3 million R-290 split AC annual production capacity is already established in China and India.

- **Europe:** Europe is rapidly adopting hydrocarbon-based systems, especially for reversible heat pumps, as it seeks to reduce its dependence on synthetic refrigerants, with the market expected to grow significantly.

- **North America:** Manufacturers are slowly adopting R-290, with a focus on portable units and commercial chillers, but are hampered by slower revisions to safety standards regarding high-charge flammable refrigerants.

- Once manufacturing scales up, costs decrease, familiarity increases, market confidence grows.

Why the transition is still lagging behind?

Barriers to the transformation towards hydrocarbons use for green cooling in buildings

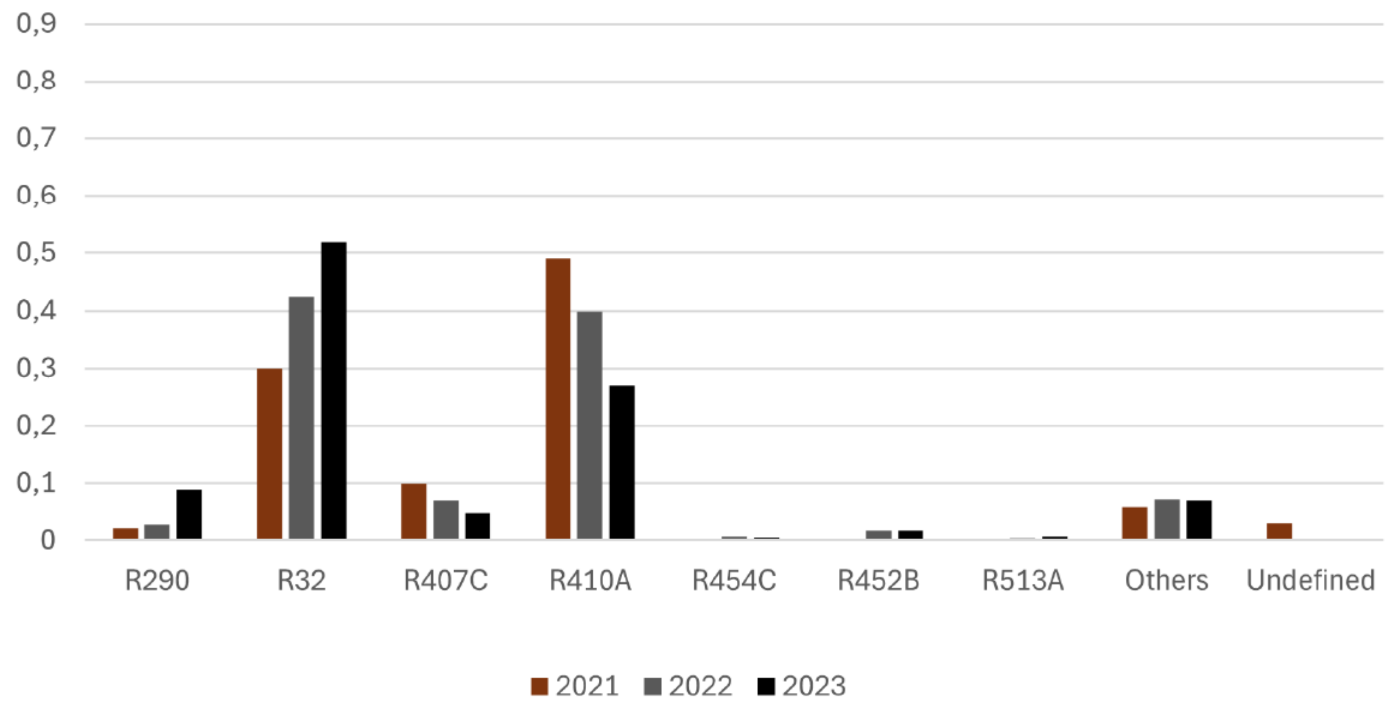
- **Risk perception still exceeds actual risk**:
  Persistent concerns about flammability, overly cautious internal policies, insurance and liability concerns
- **Regulatory implementation remains uneven**:
  Policies exist, but enforcement is inconsistent, national codes lag behind standards, approval pathways are slow
- **Economic incentives still favor predominant technologies:**
  Existing HFC production ecosystems, installed servicing infrastructure, procurement based on upfront cost only

Offer by manufacturers and demand by consumers

- Offer by manufacturers: increase of both R290 systems and R-32 systems, decrease of other HFC-based systems

- Demand by consumers: according to German market survey data, approximately 20% of house owners would install a R290 system

- However, also R-32 system demand has increased from 2020, due to funding schemes



Evolution of the “offered” domestic HPs as listed in the HP Keymark database according to their refrigerant. Source: IIR (2024).

Hydrocarbon AC remains a small share of global market

- R-22 dominated global AC manufacturing until 2000 and has now been fully phased out in new systems across non-Article 5 countries.

- Despite this progress, legacy equipment remains significant: as of 2022, around one-third of the global AC installed base (400–600 million units) still operated with R-22, while 90% of new units had transitioned to non-ODP refrigerants.

- Current market reality
  - ~110M AC units produced globally each year
  - ~80M/year are non-ducted split systems (largest segment)

- Refrigerant transition trend
  - Market transition has largely favored R-410A and R-32, which are still the most widely adopted refrigerants
  - R-290 adoption remains limited to selected regions and product categories

What must happen next

Five actions to accelerate transformation

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Align policy with technology readiness

- **Faster updates**
- Harmonized standards adoption
- Clear national **implementation roadmaps**
- **Stronger enforcement**

Shift market incentives

- Climate-based procurement
- **Incentives for natural refrigerant systems**
- Efficiency-linked subsidies

Scale workforce readiness

- **Mainstream hydrocarbon training**
- Mandatory certification
- Manufacturer-service partnerships

Build confidence through visibility

- More case studies and **demonstration projects,**
- **Transparent performance data**
- **Sharing** of operational **experience**

Industry leadership

- **Increase production capacity**
- Invest in supply chains
- Standardize designs
- **Communicate performance clearly**

- The more confidence is built in these systems, the more end user will request them, demand will expand and the market will need to respond.

The end-user is the real decision maker!

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The technologies for sustainable cooling already exist, the challenge now is to accelerate their large-scale adoption in a safe, efficient, and practical way.

- Train technicians for safe and efficient operation.
- Build confidence in these systems.
- Probably not the answer to all application, but becoming one of the major options for the future of efficient room air conditioning and heat pumps
- Collaboration is essential: the choices we make over the next years will shape our future

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Thank you!

- **Dr. Ing. Yosr Allouche**
- Director General – International Institute of Refrigeration (IIR)
- y.allouche@iifiir.org