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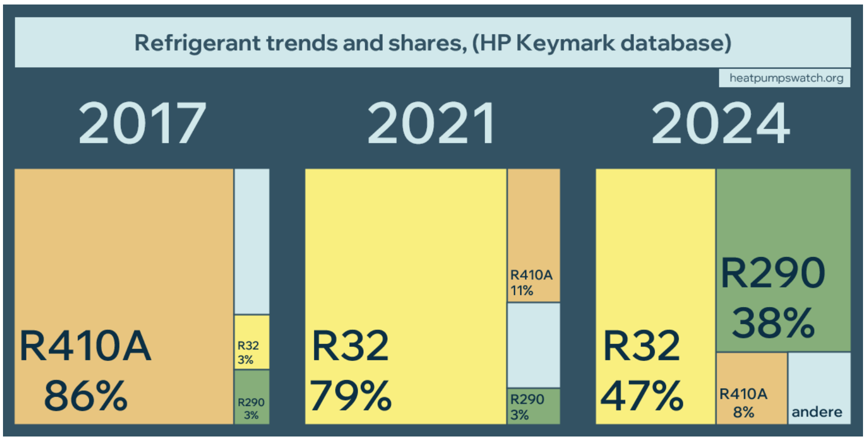
HEAT PUMPS: YOUR BURNING QUESTIONS, ANSWERED NOW

16/18
Refrigerants

Author: Dr.-Ing. Marek Miara, published: 10.03.2026



The refrigerant circulates inside every heat pump and performs the actual transfer of heat – a technically indispensable component that has changed fundamentally over recent decades: from ozone-depleting CFCs to climate-impacting HFCs and on to natural alternatives such as propane. Which refrigerant a system uses affects efficiency, environmental impact and safety – making it more relevant to the buying decision than it might initially appear.

A heat pump consists of four components: evaporator, compressor, condenser, and expansion valve. The substance that circulates through all four and actually transports the heat is the refrigerant.

Certain refrigerants have proven to be environmentally problematic in the past and have triggered global regulatory processes – but they have also shown that the industry is capable of adapting. The forced phase-out of ozone-depleting CFCs in the 1990s is one of the few examples where global regulatory intervention has had a measurable effect: the ozone layer is demonstrably recovering.[1] Today, another change is on the horizon.

What a Refrigerant Does

The refrigerant is the substance that circulates in a heat pump and enables heat transfer. Its boiling point is crucial: water evaporates at 100 degrees Celsius, while other substances evaporate at minus 40 degrees or below. This is precisely what makes them refrigerants.

The refrigerant is the substance that extracts heat from the heat source and transfers it to the heating water.

When a liquid evaporates, it absorbs heat from its surroundings. A refrigerant with a low boiling point can absorb heat even from cold outside air – outside air at minus ten degrees Celsius is warm enough for such a refrigerant to trigger the phase transition. In the evaporator, the liquid refrigerant absorbs this heat and evaporates. The compressor increases the pressure of the gas and thus its temperature. In the condenser, it releases the heat to the heating water and becomes liquid again. Finally, the expansion valve lowers the pressure, cools the refrigerant – and the cycle begins again.

A Short History of Refrigerants

Refrigerants usually have a chemically complex name and an abbreviation beginning with the letter R – for refrigerant. R410A, R32, R290: These designations follow a standardized system that provides information about the chemical composition. In everyday life, it is sufficient to know the abbreviation – it is printed on the type plate of every heat pump and forms the basis of all regulatory requirements.

Pioneering Days: Natural but Dangerous Substances

Early refrigeration technology in the 19th century used natural substances: ammonia, sulfur dioxide, carbon dioxide. These substances are thermodynamically efficient – ammonia is still used in industrial refrigeration systems today. The problem was that they were dangerous: ammonia is toxic, sulfur dioxide is highly corrosive, and carbon dioxide requires very high operating pressures.

The history of refrigerants is a back and forth between environmental friendliness and human safety.

The Supposed Breakthrough: CFCs

In 1930, an American chemist presented a new substance at a trade conference that was supposed to make everything better. He demonstrated its harmlessness by inhaling a lungful of it and extinguishing a candle with it. The newly developed synthetic refrigerants – known at the time under the brand name Freon – seemed to be the perfect solution: chemically stable, non-flammable, non-toxic, and technically easy to handle.

Their chemical stability became an ecological problem: these substances rise into the upper atmosphere, where they destroy the ozone layer. This mechanism was scientifically proven in the 1970s[2], and the growing ozone hole over Antarctica was documented in 1985[3]. The Montreal Protocol of 1987 mandated a global phase-out; today it is considered one of the most effective environmental agreements in history.

Ozone-friendly, but Harmful to the Climate

CFCs were replaced by substances that no longer contained chlorine and did not attack the ozone layer. This solved one problem – but the next one followed: their global warming potential is considerable. A widely used refrigerant of this generation, R410A, is over 2,000 times more potent than CO_2 per kilogram. This property was only fully understood after its widespread introduction.

Refrigerants Compared: Climate Impact and Regulation

The ozone problem of the CFC era is now considered solved. The decisive parameter today is global warming potential (GWP). It describes how much one kilogram of a substance warms the climate compared to one kilogram of CO_2 over 100 years. The EU has drawn conclusions from this: the F-Gas Regulation sets a GWP limit of 150 for new heat pumps up to 12 kW from 2027[4]. R410A and R32 – the previous standard refrigerants – significantly exceed this value. Existing systems may continue to be operated.

The latest generation of synthetic refrigerants, known as HFOs, have very low GWP values and would meet the limit. Their problem lies elsewhere: they decompose in the atmosphere into trifluoroacetic acid (TFA) – a substance that is extremely persistent and hardly biodegradable[5]. Scientific studies show that its concentrations in rain, soil, and drinking water are increasing irreversibly[6]. This debate could narrow the approval window for HFOs more than their low GWP values would suggest.[7]

Refrigerant	GWP	EU Status from 2027 on
R410A	2,088	No new admission in HPs up to 12 kW
R32	675	No new admission in HPs up to 12 kW
HFOs	1–10	Permitted ; TFA controversy
R290 (Propane)	< 0,1	Permitted; meets all requirements

Table 1: Refrigerants compared

Propane (R290): Characteristics, Advantages, Safety

Propane is a natural hydrocarbon that has been used in refrigeration technology for decades. As a refrigerant, it is used in a highly pure form – with a purity of over 99.5 percent, free of moisture and other hydrocarbons. Only in this quality does it deliver the thermodynamic properties that a heat pump needs for efficient and safe operation. As a refrigerant in heat pumps, it has a decisive advantage over synthetic alternatives: it has virtually no greenhouse gas effect and thus meets the EU requirements applicable from 2027 without restrictions.

Propane has virtually no greenhouse effect and meets all EU requirements.

Propane is well suited thermodynamically. It efficiently absorbs heat even at low outside temperatures and operates at moderate pressures. Studies show that R290 heat pumps achieve comparable or slightly better efficiency values in heating mode than systems with synthetic refrigerants[8,9,10]. A practical advantage: propane appliances achieve maximum flow temperatures of 70°C on average, with some models even reaching 80°C – significantly more than R32 or R410A systems, which typically reach 60°C. This makes propane heat pumps suitable for older buildings with higher heating system temperatures.[11]

The high temperatures that can be reached with propane are especially suitable for old buildings.

The Challenge: Flammability

According to European standard EN 378, propane belongs to safety class A3 – highest flammability, low toxicity. This influences the design and installation in several ways.[12]

Today, propane heat pumps are mainly built as so-called monoblock units: the entire refrigerant system – compressor, heat exchanger, and all pipes – is located in a single outdoor unit. Only water pipes lead into the building. This greatly simplifies the safety requirements because any leak in the outside air is immediately diluted and no concentration can build up indoors.

A monoblock unit's refrigeration cycle is placed outdoors, thus lowering risks

In so-called split systems, where the indoor and outdoor units are connected by refrigerant pipes, it is more difficult to ensure that these requirements are met. The amount of refrigerant that may be used in the building is limited by standards. For this reason, the monoblock has become the standard concept for propane heat pumps in residential buildings.

No Fear but Respect

The refrigeration cycle of a heat pump is a hermetically sealed, permanently installed system. The refrigerant circulates continuously within it without coming into contact with the environment. Residents never come into contact with it.

Refrigerant in a heat pump is not a consumable. It is not used up, does not need to be refilled, and remains in the system permanently under normal operating conditions. This applies to residential buildings – the technology is different for large industrial refrigeration systems.

To put the fill quantities into perspective: a standard propane cylinder for barbecues or camping stoves contains 5 to 11 kilograms of gas. The refrigerant filling quantity of a heat pump for a single-family home is typically between 0.5 and 2.5 kilograms. Current research projects – and the first series products – already manage with less than 150 grams.[13]

Propane is flammable, but only ignites in the air within a certain concentration range. However, this is only relevant if gas actually escapes. For this to happen, the hermetic system would first have to fail, allowing the gas to accumulate in sufficient concentration in a room, and then an ignition source would have to be present. Heat pumps are equipped with various active and passive safety mechanisms to prevent this from happening. If systems are installed and maintained correctly, dangerous situations are highly unlikely. There are no known increased accident rates for R290 systems compared to systems with non-flammable refrigerants.

When installed and maintained correctly, propane appliances are no more dangerous than heat pumps that use other refrigerants.

What combustibility requires is not special caution during operation, but care during installation and maintenance. Both must be carried out by certified specialists – this is required by law and is no different from other refrigerants.

To clarify: millions of European households have gas heating systems that burn natural gas on a daily basis during normal operation – a substance that is also flammable and would also be volatile and odorless if no warning agent were added. Propane in a heat pump, on the other hand, is never burned and never released. Technically, these two risks are not comparable.

The Market is Changing: What Certification Data Shows

Market data shows how quickly the industry is actually moving. An evaluation of 2,443 heat pump models from the European certification register paints a clear picture of the refrigerant transition: in 2016/17, over 80 percent of newly certified heat pumps still used R410A. From 2018, R32 began to replace R410A, reaching a peak share of 79 percent in 2021. Since then, a second wave has been taking place: propane has risen steadily since 2022 and already accounted for 38 percent of new certifications in 2024.

Another trend is linked to the thermodynamic properties of propane: The maximum flow temperatures of certified models have risen from an average of 57°C to 62°C since 2017 – the reason for this is the increasing use of propane. The refrigerant therefore has less of an impact on efficiency levels than on the range of applications: heat pumps are becoming accessible to more buildings thanks to the switch to R290.

5 What that Means for the Buyer

The refrigerant does not have to be a purchasing decision – but it can be. Every heat pump approved today will be able to run smoothly for the next 20 years. Choosing propane is generally a good and future-proof choice.

Propane systems will meet the EU requirements applicable from 2027 without any modifications. Systems using other approved refrigerants will remain legally permissible as long as they are in operation. European manufacturers have now largely established their product lines with natural refrigerants; many suppliers – especially those from Asian countries – are still in transition. Propane systems currently cost around 10 to 15 percent more than equivalent devices with synthetic refrigerants – due to more complex safety components.[14] However, these systems are rapidly becoming the standard, the safety technology is mature, and the price differences will no longer be significant in the coming years.

Summary

The history of refrigerants is a history of learning: new substances solved real problems—and brought with them new obstacles, to which science and regulatory authorities responded. Today, with 21st-century safety standards and manufacturing precision, the industry is returning to natural refrigerants, which were used at the dawn of refrigeration technology.

Propane combines thermodynamic suitability, minimal climate impact, and global availability. Its flammability can be constructively controlled thanks to decades of experience in refrigeration technology. The key factor here is that the refrigeration circuit is hermetically sealed – this is the most important feature of the system: no contact, no intervention, no maintenance required for residents. The F-Gas Regulation sets the regulatory framework: from 2027, only refrigerants with a GWP below 150 will be permitted in new systems. The market is already moving in this direction.

One thing deserves clarification in conclusion: every heat pump with a refrigerant approved today is far superior to a gas boiler in terms of its overall ecological balance. The refrigerant contributes to the climate balance to a small extent – the decisive factor is the electricity used to operate the heat pump. Its climate impact decreases with every percentage point of renewable energy in the grid.

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