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Mitsubishi Electric Guide to the Future of Air Conditioning

Information Guide **86**

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This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today.

This guide accompanies a series of seminars, all of which are CPD certified.

Contents

The low-carbon future for buildings - and air conditioning

One of the most significant impacts on the future of air conditioning is the drive for low-carbon buildings. As design and operation of buildings becomes more focused on reducing operational and embodied carbon, every element of a building is scrutinised for its carbon impact, including HVAC systems.

Building services have a significant impact on the whole life carbon of a building (see definitions on page 5). This is increasingly being recognised in legislation and local planning. For example, as noted in the CIBSE Journal[1], the Greater London Authority benchmarks allocate 21% of a building's whole life carbon to building services.

This reflects the fact that elements of building services are likely to be replaced throughout the building's life cycle while also using energy. If issues such as refrigerant leaks are also taken into consideration, then it's clear that to achieve low-carbon buildings we must address the carbon footprint of HVAC systems.

In addition, removing on-site fossil fuel heating systems is becoming a significant element of retrofitting existing buildings. This process of decarbonisation means gas boilers are being replaced by electric systems for heating and hot water that can make the most of the UK's increasingly renewable electricity supplies.

Air conditioning manufacturers have responded to these underlying trends, developing new products and introducing new approaches. Engineers and installers now have access to a wide range of options to consider, giving them more capability in delivering low-carbon buildings for the future.

This Guide will consider the main aspects of change in air conditioning systems and consider the best ways these can be applied to optimise energy performance, reduce carbon emissions and deliver high quality indoor environments for occupants now and in the future.

Understanding Carbon Emissions

Whole Life Carbon (WLC)

Whole Life Carbon (WLC) refers to the carbon emissions associated with a building across its whole life cycle, from construction to operation, maintenance, and demolition.

Embodied Carbon

Embodied Carbon is included in WLC and refers to emissions arising from the manufacture, transportation and installation of the materials and products in a building. This includes the carbon emissions from the use of materials such as steel, concrete, and glass, as well as the embodied carbon of equipment such as air handling units, electrical wiring, and ductwork.

Operational Carbon

Operational Carbon is also part of a building's whole life carbon footprint. It includes emissions produced in the building, for example, from the combustion of on-site gas boilers. These are known as direct emissions. Emissions from purchased electricity used to operate the building (indirect emissions) are also part of Operational Carbon emissions

The air conditioning specification challenge

A great deal of legislation introduced into the construction and property sector over the past few years has been focused on two key goals: reducing energy consumption in buildings; and shrinking the carbon footprint of the UK's built environment.

As significant energy users in a building, the specification of air conditioning systems for new-build and retrofit projects must reflect the requirements of these legal requirements, standards and local planning rules. Some of the most important are:

Part L of the Building Regulations 2022

The most recent update to Part L (Conservation of energy) came into force in June 2022. Under Part L, new non-dwellings must meet both a target primary energy rate (kWh/m^2/year) and a target carbon emission rate (kgCO_2/m^2). The targets are set against a notional building (set out in the National Calculation Methodology Guide).

One of Part L 2022's most significant requirements for non-dwellings is that the target carbon emission rate per year is 27% lower than the previous Part L (2016). The regulation also states that: 'Where a building is erected, it must be a nearly zero-energy building."

In existing buildings, Part L is triggered by consequential improvements in buildings with a floor area of 1000m^2 or more. This applies if any proposed extension is both greater than 100m^2 and more than 25% of the total useful floor area of the building. The regulation includes a list of acceptable 'energy efficiency measures' which must be installed during a refurbishment. These include upgrading heating, cooling or air handling systems which are more than fifteen years old.

Air conditioning systems are therefore impacted by Part L, since they contribute to energy use and operational carbon emissions, with older HVAC systems targeted for upgrades in buildings over 1000m^2.

Another aspect of Part L 2022 which impacts air conditioning specification is that it introduced minimum energy efficiency requirements for building services equipment in new and existing buildings. This includes heat pumps and comfort cooling (*Part L: Table 6.6 Minimum energy efficiency ratio for comfort cooling*).

Further reading: **Mitsubishi Electric CPD Guide to the Updated Building Regulations 2021**

The air conditioning specification challenge

Minimum Energy Efficiency Standards (MEES)

MEES were introduced in 2015 by the UK government as part of its drive to achieve Net Zero emissions. They apply to all buildings in the private rented sector (residential and non-dwellings). For non-dwellings, the current MEES regulations state that it is illegal to let any property with an EPC (Energy Performance Certificate) rating of less than band E.

This rule used to only apply when leases were agreed with new tenants. However, since April 2023 MEES has been in force for all ongoing tenancies, regardless of their start date.

MEES has had a significant impact on the UK commercial property sector. The number of F and G rated EPCs fell from a peak of 18% of allocated certificates in 2018 to less than 2% of EPCs in current government figures[2].

In 2021, the government concluded a consultation on a proposed change to MEES requirements for non-domestic properties. The proposal is to raise the minimum EPC to band C by 2027; and band B by 2030, although there has been no confirmation of this policy in 2024.

The commercial property sector is keenly aware of the potential impacts. There are still around 19,000 commercial buildings with EPCs of F or G, so they don't comply with current regulations. Research from Search Acumen[3] estimates that only 14% of commercial properties currently have an EPC band B, and that at the current rate of retrofit progress it would take until 2036 to achieve the proposed higher targets.

MEES is therefore one of the main driving factors in the current wave of retrofitting in the commercial property market. The impact of air conditioning systems on energy use in buildings means that optimised energy performance is key and should be a critical area of consideration.

Further reading: The Mitsubishi Electric CPD Guide to Minimum Energy Efficiency Standards for Non-dwellings

Decarbonisation Strategies in the Public Sector

The public sector is also focused on carbon reduction. The government's 2023 Net Zero Government Strategy[4] (*UK Roadmap to Net Zero Government Emissions*) sets out a target to reduce emissions from public sector buildings by 50% by 2032 and then 75% by 2037 (against a 2017 baseline).

Several schemes are in place to support this goal, and one of them is the Public Sector Decarbonisation Scheme[5] (PSDS, also referred to as the Salix Scheme). This provides funding to help the public sector make the transition away from fossil fuel systems in buildings that are reliant on gas or oil, for example. Funding between 2022 and 2026 is set at £1.425 billion.

The current Phase 4 of the scheme is more targeted, prioritising schemes which 'deliver the best value for money based on the most direct carbon emission reductions". While details of the scheme have yet to be released, the focus will be on showing operational carbon emissions reductions, putting an emphasis on a switch to electric systems that are also highly energy efficient.

Corporate Client Strategies

Although government is pushing forward the low-carbon building agenda through legislation, there are increasing signs that corporate clients are setting their own strategies. The result is a growing demand for buildings which have demonstrable low-carbon and energy efficiency credentials.

For example, property consultant JLL noted that 2024 to 2026 will be a 'critical time' for corporate occupiers searching for spaces that reflect their carbon commitments. JLL figures show that this 'low-carbon demand' is likely to exceed supply by 2030.

The value placed on buildings that meet these criteria is such that they can set higher rents - putting a strong commercial value on energy efficient and low-carbon buildings.

This is a strong commercial driver for retrofitting existing buildings, and there is no doubt that air conditioning will be a significant element of decisions around building upgrades for efficiency and decarbonisation.

The air conditioning specification challenge

F Gas Regulations

These regulations originated in the European Union in 2006 and have had a direct impact on the development of air conditioning systems since that time. Their purpose is to phase out the use of fluorinated (F) gases which trap heat in the earth's atmosphere, contributing to global warming and climate change.

The Regulations cover the most common type of F gas, HFCs (hydrofluorocarbons). Each HFC is allocated a global warming potential (GWP) number to reflect its impact on the environment. GWP indicates how much heat is trapped by a mass of the HFC compared to a similar amount of carbon dioxide. The higher the GWP, the greater its potentially damaging impact on the environment.

The UK is no longer a member of the EU, so the F Gas regulations have not applied here since 2017. However, the UK has adopted F Gas regulations and we are following a similar schedule of HFC phase downs.

Importantly, in February 2024 the EU recently updated the phase down programme, speeding up the process along a steeper curve. The UK has not yet officially adopted this new approach, but government has stated that it intends to do so.

Time period	Previous EU phase-down programme – currently applied in the UK in 2024	Updated EU phase down adopted in February 2024
2021 - 2023	**45%**	
2024 - 2026	**31%**	**23.6%**
2027 - 2029	**24%**	**10.1%**
2030	**21%**	**5%**
2048		**2.38%**

While the UK government has yet to make an official announcement regarding changes to the UK's phase down of HFCs, it is important to note that the EU's approach will impact air conditioning equipment sold here.

The EU's F Gas regulations will affect the availability of HVAC equipment and the price of refrigerants, since most are imported via the EU. This will impact the design of new HVAC systems as well as the maintenance of installed equipment.

In addition to regulations on refrigerants, the F Gas Regulations in the EU also prohibit several categories of products containing HFCs on the market. Product ranges affected include chillers, heat pumps and air conditioning split systems.

The tables below show timings for air-to-water and air-to-air split systems bans.

Split Air-to-Water

X <= 12 kW at 150 GWP	1st January 2027
X <= 12 kW full F Gas prohibition	1st January 2035
X > 12 kW at 750 GWP	1st January 2029
X > 12 kW at 150 GWP	1st January 2033

Split Air-to-Air

X <= 12 kW at 150 GWP	1st January 2029
X <= 12 kW full F Gas prohibition	1st January 2035
X > 12 kW at 750 GWP	1st January 2029
X > 12 kW at 150 GWP	1st January 2033

Further reading: **The Mitsubishi Electric CPD Guide to F Gas Regulations and the Future of Refrigerants**

The air conditioning specification challenge

These regulations and strategies not only impact new-build projects, but they have also set off a substantial wave of refurbishment and retrofit projects across all types of non-residential buildings. The recent BESA Top 30 Contractors 2024[6] report stated that the rate of refurbishment work is outstripping new-build for many contractors.

In the office market, for example, landlords must ensure that their properties do not become stranded assets - buildings that face falling rents due to lack of environmental credentials or because they don't achieve the minimum required EPC.

Inevitably in this wave of retrofit, air conditioning systems are also being updated. HVAC accounts for a significant proportion of energy use in buildings, contributing to operational carbon emissions. It is also included in calculations for a building's embodied carbon.

Retrofitting cooling and heating technologies therefore represents an important element of an overall building retrofit programme where energy efficiency and carbon reduction are important objectives.

However, beyond these aims, there is also the practicality that there are many ageing air conditioning systems still in operation. For example, if we consider VRF systems, BSRIA figures show that in 2022 there were 27,000 systems in place in UK buildings. Of those, 31% were over 10 years old at that time.

Updating these systems is critical not only to meet new standards on energy use, refrigerants and carbon but also to support healthy indoor environments for occupant comfort.

The evolution of air conditioning systems

Like any technology, air conditioning is continuously evolving. Manufacturers respond to market demands which in turn are directed by end-user requirements, standards and legislation. This has resulted in a range of system types that are now available to the market, resulting in a more complex specification process.

There are three major factors which have driven the evolution of air conditioning systems over the past decade: refrigerants; hydronics; and advanced controls.

The changing refrigerant landscape has been a major influence on air conditioning technology evolution. With high HFCs being phased out under F Gas regulations, air conditioning manufacturers have been switching to modern, low and lower GWP refrigerants.

The table below highlights a few of the common modern refrigerants and their characteristics.

Refrigerant	Characteristics
R32 (GWP 675)	■ Efficiency remains the same ■ Capacity increases ■ Technology only available for small inverter-driven compressors ■ Cost neutral ■ Specified due to availability of small DX compressors using inverters to manage higher discharge temperature
R290 - Propane (GWP 3)	■ Used in industrial refrigeration for many years; known domestically in use for outdoor heaters and cookers ■ Low GWP ■ Non-toxic ■ Good thermodynamic properties, making it highly energy efficient in systems ■ Flammable
R410A (GWP 2088)	■ Good energy efficiency ■ Higher cooling capacity ■ Superior heat transfer coefficient which allows for better heat exchange ■ Higher operating pressures which should be reflected in system design - correctly sized components are essential to optimise energy efficiency

The evolution of air conditioning systems

From the perspective of air conditioning product development, using the new low-GWP refrigerants is not simply a case of dropping in the new chemicals to existing ranges. The characteristics of refrigerants must be taken into account, and products designed that can optimise the benefits they offer while taking into account factors such as higher pressures or operating temperatures.

This new generation of refrigerants have been accompanied by updates to legislation around handling them, which has resulted in additional necessary changes to system design and installation.

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)[7] has developed terms to denote the relative flammability of refrigerants, and these are recognised globally. Several of the low-GWP refrigerants are designated as 'flammable' or 'mildly flammable'.

The table below indicates the ASHRAE flammability designations of common HVAC refrigerants:

Refrigerant	GWP	Safety class ISO 817; PED (EU)
R718 (Water)	**0**	**A1** (non-flammable)
R744 (CO_2)	**1**	**A1** (non-flammable)
R290 (Propane)	**3**	**A3** (higher flammability)
R1234yf	**4**	**A2L** (mildly flammable)
R1234ze	**7**	**A2L** (mildly flammable)
R454b	**466**	**A2L** (mildly flammable)
R513A	**631**	**A1** (non-flammable)
R32	**675**	**A2L** (mildly flammable)
R410A	**2088**	**A1** (non-flammable)

As a result, specifiers and installers must be aware of legislation around safe system design so they can demonstrate risk assessment compliance and hazard reduction. The HSE requires that all refrigeration, air conditioning and heat pump installations must undergo a DSEAR risk assessment.

There are two key standards to be aware of:

1. BS EN IEC 60335

This standard has several parts, but ultimately relates to the manufacturing of electrical products, including air conditioning. All products covered must meet the requirements of this Standard to achieve a CE mark (in the UK and Europe) to put their products on the market.

2. BS EN 378 2016 (*Refrigerating systems and heat pumps. Safety and environmental requirements - Design, construction, testing, marking and documentation*)

This is a safety standard that provides guidance and risk-assessment advice for businesses that design, construct, install, operate, maintain, and use vapour compression systems for refrigeration, air conditioning, heat pumps, chillers, and other similar systems.

As this Standard covers a range of product groups, it is known as a 'horizontal' standard. It provides detailed advice on the responsibilities of designers, installers and end users around safety and refrigerant-using equipment. Mitsubishi Electric recommends the use of this Standard when carrying out risk assessments required under DSEAR for air conditioning systems.

Further reading: **The Mitsubishi Electric CPD Guide to BS EN 378: Managing Risk in HVAC Systems with Modern Refrigerants**

The evolution of air conditioning systems

The second important development in the evolution of heating and cooling systems for buildings has been in hydronic systems. The rise of heat pump technology in the past decade as a low-carbon option (particularly in replacing fossil fuel heating systems) has been supported by many European governments, including the UK.

We have seen heat pump technology applied across a growing range of air conditioning products and systems, including heat pump chillers, ambient (low-temperature) heat networks and in high-temperature heat pumps that can replace the requirement for gas boilers, even in commercial environments such as hotels.

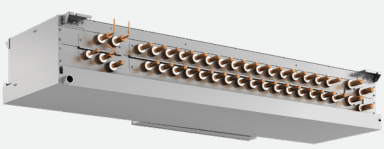
The energy efficiency of heat pumps is one favourable characteristic of this technology. However, switching to a heat pump only system may not be a practical option for some projects.

In this case, there are systems that combine benefits of heat pumps into 'traditional' air conditioning products. For example, harnessing the benefits of VRF and the efficiencies of R32 refrigerant (designated mildly flammable) alongside hydronic technology has allowed for the development of Hybrid VRF (HVRF).

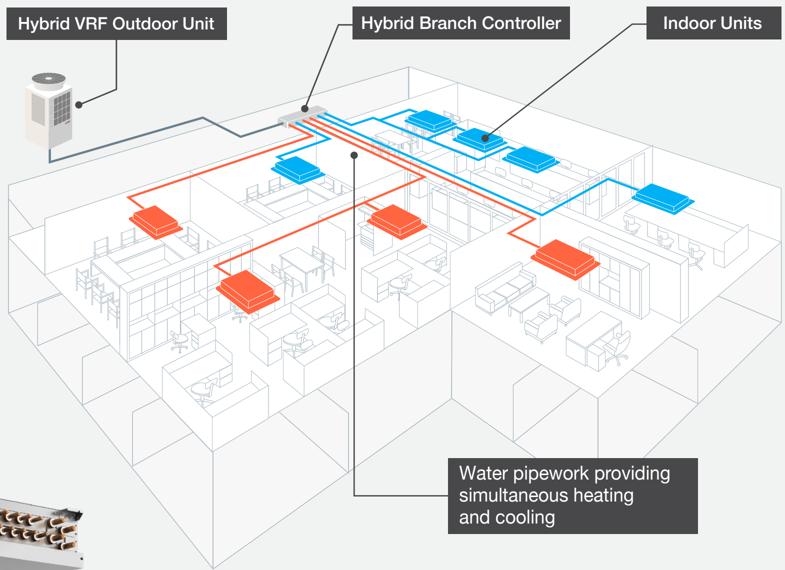
This system delivers simultaneous heating and cooling through a two-pipe design. HVRF uses water instead of refrigerant in occupied spaces, reducing risks to occupants, and removing the need for leak detection (saving installation time and costs).

Mitsubishi Electric City Multi Hybrid VRF

Hybrid VRF Outdoor Unit



Hybrid Branch Controller



R32 | HybridVRF

The evolution of air conditioning over the past decade has produced a range of technologies for specifiers and installers to consider.

The table below highlights a few of the options on the market.

Technology	Characteristics and benefits
Variable Refrigerant Flow (VRF)	■ An option that can be applied to a wide range of projects ■ The Mitsubishi Electric 2-pipe approach requires fewer joints and brazing points with reduced leak risks ■ It offers smaller pipe sizes (less material use) and tray space ■ VRF technology is now highly flexible, with options that provide a plug-and-play approach as well as low-noise modes ■ Straightforward maintenance regimes
Hybrid VRF (HVRF)	■ A good ‘bridging’ technology, providing a step towards using heat pump technology with many of the benefits of VRF ■ No refrigerant required in occupied spaces ■ Viable choice for a phased approach to upgrades (e.g., floor-by-floor) ■ Provides a flexible layout which is useful for buildings where there may be changes to future occupation
Room Air Conditioning (RAC)	■ Room air conditioning systems are ideal for small commercial spaces or residential ■ Quick to install and quiet to operate ■ Modern RAC systems use low-GWP R32 refrigerant and inverter technology for optimum energy performance
Packaged Air Conditioning (PAC)	■ Provides a range of solutions for a variety of end-user needs ■ Modern PAC systems operate on low-GWP R32 refrigerants ■ Extended pipe runs make installation straightforward ■ The latest models include controls for optimum energy performance

The evolution of air conditioning systems

The third factor driving change in air conditioning systems is in controls. With the focus on enhancing building energy efficiency and operational carbon emissions, monitoring and managing air conditioning systems is critical for building managers.

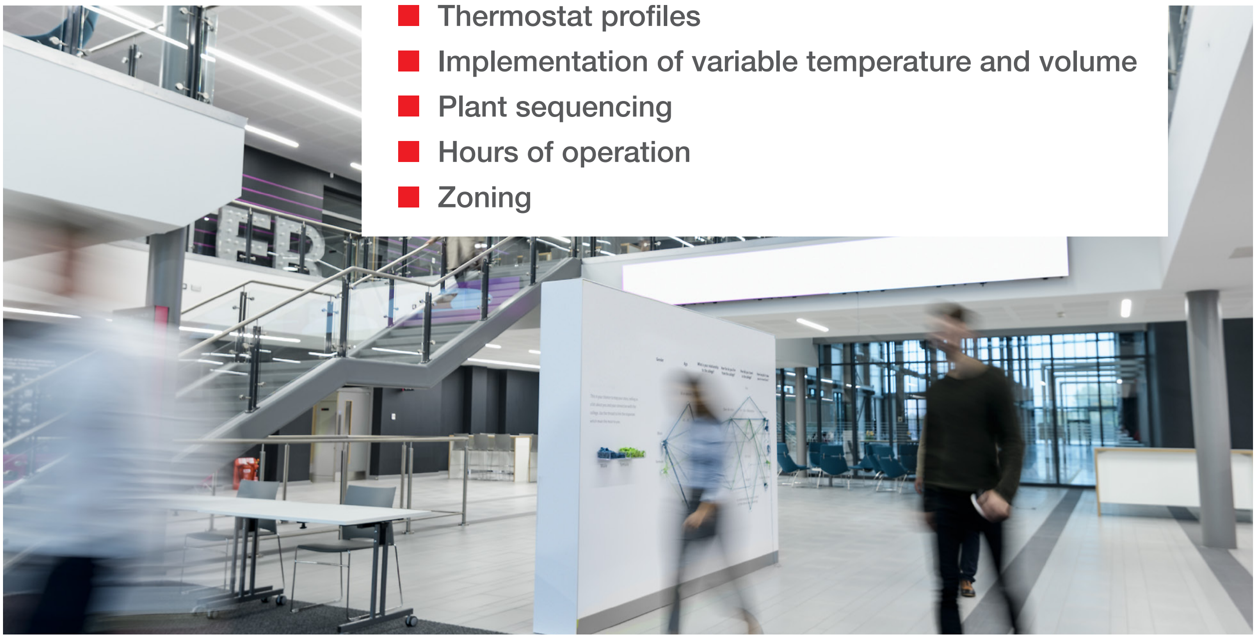
The most significant development in control technology in the recent decade has been the Internet of Things (IoT). This describes an ecosystem of devices that can connect to the Internet and communicate with each other directly. For example, Mitsubishi Electric has been at the forefront of this revolution, and all its air conditioning and ventilation products can connect to the Internet via its MELCloud Commercial platform.

The benefit for building managers is the ability to connect air conditioning systems (and other elements of a building such as access, meeting room booking systems and lighting, for example) to a single platform. Buildings can now be remotely monitored and controlled, while the control system can also capture real-time energy consumption data.

The evolution in building controls has also supported development of modern facilities management tools. For example, continuous monitoring of an air conditioning system allows maintenance teams to spot any changes in performance which may predict potential faults. These can be quickly addressed before they become failures. Without this level of insight, equipment may continue to operate less efficiently for some time, leading to energy waste.

CIBSE's TM54 (Evaluating operational energy use at the design stage)[8] underlines the importance of developing a control strategy early in the design process. This can help to deliver better outcomes for building energy efficiency and avoid overly-complex solutions. TM54 highlights five areas relating to HVAC to consider when setting out a controls strategy:

- **Thermostat profiles**
- **Implementation of variable temperature and volume**
- **Plant sequencing**
- **Hours of operation**
- **Zoning**



Air conditioning for today and the future

The future of air conditioning will be influenced by the same factors that have driven its evolution over the past decade: achieving low-carbon buildings; the growth of hydronic technologies and low-GWP refrigerants; and increasingly advanced control and monitoring systems.

There is no lack of equipment on the market to help designers and installers meet these changes with confidence. The challenge is finding a balance between what's possible, and what's practical.

For example, the focus on whole life carbon means analysing the embodied carbon of a product against its operational carbon (linked to its energy use). A component with low operational emissions may have higher embodied carbon or vice versa.

Further reading: **The Mitsubishi Electric CPD Guide to Whole Life Carbon in the Built Environment**

In addition, retrofitting older buildings, which is critical if the UK is to meet its Net Zero 2050 goal, adds another layer of complexity to air conditioning system design.

Finding a solution that works, that's flexible and that simply fits into the building is vital.

Here, it's important to be aware that long-established technologies such as VRF have an important role in the future of air conditioning. Modern VRF systems already offer low-GWP options, for example. The also provide a highly flexible approach to retrofits, allowing for a phased approach to HVAC refurbishments.

Using VRF can help to make the transition to the future more achievable and cost-effective for today's building owners. For instance, a system such as Hybrid VRF can introduce the principles of hydronics into a building without entirely switching to a heat pump approach in a single step. This can be a less intrusive approach to retrofitting that reduces a building's carbon footprint, while offering the benefits of modern VRF.

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Note: The fuse rating is for guidance only and please refer to the relevant databook for detailed specification. It is the responsibility of a qualified electrician/electrical engineer to select the correct cable size and fuse rating based on current regulation and site specific conditions. Mitsubishi Electric’s air conditioning equipment and heat pump systems contain a fluorinated greenhouse gas, R410A (GWP:2088), R290 (GWP:3), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R454C (GWP:148), R1234ze (GWP:7) or R1234yf (GWP:4). *These GWP values are based on Regulation (EU) No 517/2014 from IPCC 4th edition. In case of Regulation (EU) No.626/2011 from IPCC 3rd edition, these are as follows. R410A (GWP:1975), R32 (GWP:550), R407C (GWP:1650) or R134a (GWP:1300).

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