

# FACT SHEET 9

## Large Air-Conditioning (air-to-air)

### 1. Description of market sector

This market sector includes various types of building air-conditioning system that utilise a direct expansion (DX) evaporator to cool air supplied to a room or to a whole building. This sector excludes small self-contained air-conditioning (see Fact Sheet 7) and small single split air-conditioning (see Fact Sheet 8). It also excludes air-conditioning using water chillers (see Fact Sheet 10).

#### Market sub-sectors

The sector has been split into three sub-sectors

- a) Large single split and multi-split air-conditioning
- b) Variable refrigerant flow (VRF) systems
- c) Ducted systems and packaged rooftop systems

#### Typical system design

All systems use a DX vapour compression cycle.

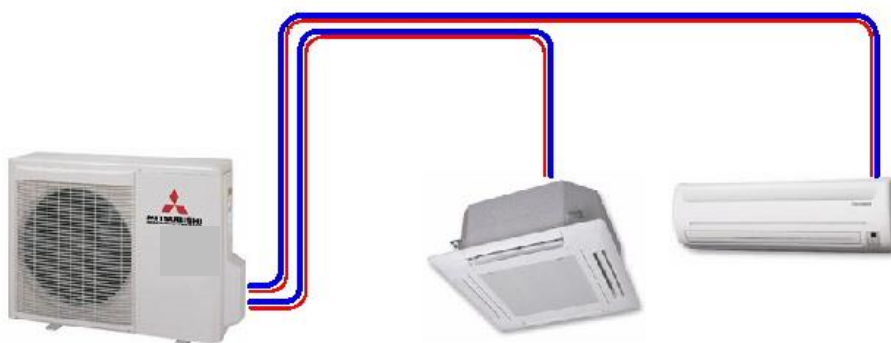
- **Large single splits and multi-splits** are very similar in concept to small single splits (see Fact Sheet 8). Large single splits are simply a larger version of a small split, consisting of a single indoor unit and outdoor unit. Multi-splits may have several indoor units (up to around 8) connected to a single outdoor unit. Most recent models are designed to be reversible (i.e. providing cooling in warm weather and heating in cold weather).
- **VRF systems** are sophisticated multi-split systems where several outdoor units can support many indoor units (up to 64). Some of these systems are designed to be able to provide simultaneous heating and cooling to different parts of the same building (each indoor unit can be individually selected to provide either heating or cooling).
- **Ducted systems and packaged rooftop systems** provide cooling to buildings via a ducted air ventilation system. A DX evaporator is located in an air handling unit to cool air that is ducted around the building being cooled.

#### Alternative technologies

There is currently no use of alternative technologies.

#### Changes driven by ODS phase out

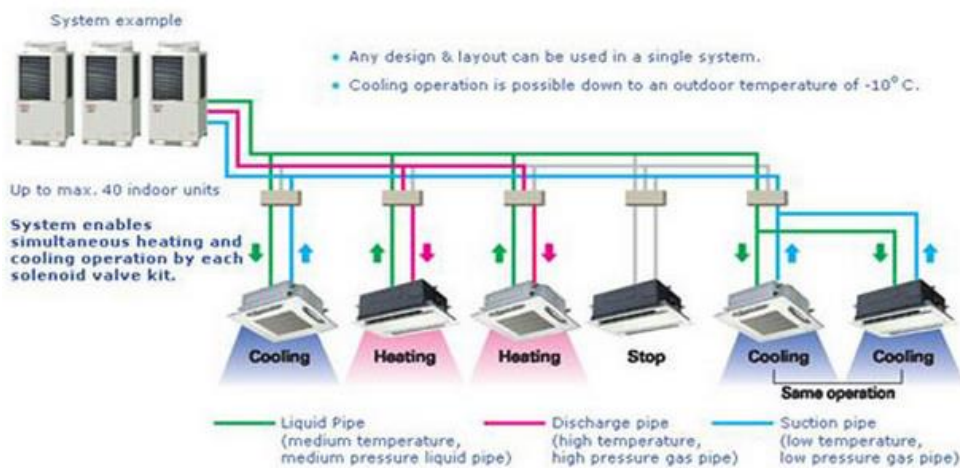
Prior to 1990 this sector used CFC-12 and HCFC-22. From mid-1990s some non-Article 5 countries started using R-407C and most quickly moved to R-410A. There is still significant use of HCFC-22 in Article 5 countries.



*Multi-split system with a ceiling mounted and a wall mounted indoor unit attached to a single outdoor units*

**Table 1: Large air-conditioning (air-to-air): characteristics for HFC equipment**

Market sub-sector:		Large single splits and multi-splits	VRF systems	Ducted and packaged rooftop
Typical refrigerant charge		3 to 10 kg	5 to 100 kg	5 to 100 kg
Typical cooling duty		10 to 40 kW	12 to 150 kW	12 to 200 kW
HFC refrigerants widely used		R-407C (GWP 1774 <sup>1</sup> ) R-410A (GWP 2088)		
Typical refrigeration circuit design		Direct expansion		
Manufacture / installation		Factory built indoor and outdoor units; site installed refrigerant pipework	Factory built or site assembled	
Typical location of equipment		Class A (access by persons not acquainted with safety precautions)		
Typical annual leakage rate		1% to 4%	1% to 5%	2% to 6%
Main source of HFC emissions		Losses at end-of-life	Losses at end-of-life	Operating leakage
Approx. split of annual refrigerant demand	New systems	75%	65%	50%
	Maintenance	25%	35%	50%



*VRF installation, illustrating simultaneous cooling and heating via 6 indoor units connected to 3 outdoor units*

*Packaged roof-top air-conditioning, with air handling unit and DX cooling circuit*



<sup>1</sup> All GWP values are based on the IPCC 4<sup>th</sup> Assessment Report

## 2. Alternatives to currently used HFC refrigerants

Table 2: Lower GWP alternatives for large air-conditioning (air-to-air)

Refrigerant	GWP	Flammability <sup>2</sup>	Comments
HFC-32	675	2L	HFC-32 has been used for small split systems in Japan since 2012 and in Europe since 2013. It is also suitable for multi-splits, VRF and ducted systems subject to compliance with refrigerant charge restrictions in safety regulations.
R-446A	460	2L	Newly developed blends with properties similar to R-410A. These are a possible alternative for multi-splits, VRF and ducted systems subject to compliance with refrigerant charge restrictions in safety regulations.
R-447A	582	2L	
R-450A	601	1	Newly developed blends with properties similar to HFC-134a. The non-flammable options are possible alternatives for ducted and packaged roof top units. The lower flammability options may also be suitable for these applications subject to compliance with refrigerant charge restrictions in safety regulations.  These options are not considered suitable for multi-split and VRF systems, due to a negative impact on capital cost and efficiency.
R-513A	631	1	
R-451A	140	2L	
R-451B	150	2L	
HFO-1234yf	4	2L	These HFOs also have properties similar to HFC-134a and could be considered for ducted and roof top units subject to compliance with refrigerant charge restrictions in safety regulations.
HFO-1234ze	7	2L	
R-744	1	1	R-744 can be used for larger air conditioning typically in ducted type systems. Efficiency is only acceptable in cool weather conditions.

These market sub-sectors create significant challenges for finding suitable low GWP alternatives.

R-410A is the dominant HFC refrigerant in new split systems. It allows use of compact compressors and provides good efficiency. Alternatives need to be able to match these characteristics.

The refrigerant charge for HCs is beyond the recommended quantities in safety standards for most large air-to-air air-conditioning systems.

R-744 is not a good option in warmer climates as efficiency would be low and cost is high. It may be applicable when air-conditioning is required in cool weather conditions e.g. in buildings with large internal heat gains from computers and other equipment.

<sup>2</sup> Flammability classes based on ISO 817 and ISO 5149

3 = higher flammability; 2 = flammable; 2L = lower flammability; 1 = no flame propagation

For many applications in these sub-sectors the use of a lower flammability refrigerant will be possible. This will depend on the refrigerant charge, the indoor unit locations and the room sizes. HFC-32 is beginning to be used in some of these applications and R-446A and R-447A may also be used.

For **split systems and VRF systems**, R-410A is currently the only non-flammable option. The use of a non-flammable alternative to HFC-134a is not an option for these sub-sectors as it would lead to increased capital cost and reduced efficiency.

For **ducted and rooftop packaged units** HFC-134a is sometimes used, so one of the non-flammable HFC-134a alternatives with a GWP around 600 may be considered. In some circumstances (depending on system design and compliance with safety regulations) a lower flammability blend with a GWP around 150 or an HFO with a GWP of 1 could also be considered.

### 3. Discussion of key issues

#### Safety and practicality

**HCs:** Cannot be used as the refrigerant charges are too high, except in a few circumstances where special design measures are applied.

**HFC-32, R-446A and R447A:** These have lower flammability and may be safe to use in multi-splits, VRF and ducted systems. The level of refrigerant charge allowed depends on room sizes, indoor unit location and system safety features. Refrigerant charges in the 15 to 60 kg region may be acceptable – which could include the majority of single, multi-split, VRF and ducted installations. Safety regulations<sup>3</sup> may need to be updated in some regions to allow these applications.

For ducted systems it may be possible to use non-flammable alternatives to HFC-134a (such as R-450A and R-513A).

#### Commercial availability

Some larger splits using HFC-32 have already been sold in Japan (only where the refrigerant charge meets safety standards) and the sales of these systems are growing. The use in VRF systems awaits more work on safety issues.

R-446A and R-447A units are being considered by some manufacturers. The timing of commercial availability is not clear.

#### Cost

HFC-32 systems are cost competitive with R-410A equivalents for smaller systems. The higher cost of the HFO / HFC blends may have some impact due to the larger charges of multi-split, VRF and ducted systems. In order to satisfy the safety requirements of these much larger systems, there could be incremental costs for additional safety features, such as gas detectors, ventilation and shut off valves.

#### Energy efficiency

HFC-32 systems can achieve better energy efficiency than R-410A equivalents.

Efficiency is not yet known for R-446A and R-447A but these are expected to have equal or better efficiency than R-410A.

<sup>3</sup> e.g. ISO 5149 or EN 378

## Applicability in high ambient

HFC-32, R-446A, R-447A, R-450A, R-513A, R-451A, R-451B have a higher critical temperature than R-410A which makes them better suited to operation in high ambient temperature than R-410A.

The main challenge for high ambient conditions is the balance between energy efficiency and maximum refrigerant charge limits for safety. The heat load per m<sup>2</sup> is higher than in cooler climates which leads to higher refrigerant charges per m<sup>2</sup> of occupied space. Several countries in the high ambient region increase the minimum energy efficiency requirements, leading to even higher refrigerant charges. This makes it more challenging to use flammable refrigerants for larger air-to-air air-conditioning in hot climates.

## Opportunities to retrofit existing equipment

It is not appropriate to retrofit existing HFC equipment in this market sector.

## Technician training

**HFC-32, R-446A, R447A, R-451A and R-451B:** Training will be essential for maintenance of systems with lower flammability refrigerants. The manufacturers that have introduced HFC-32 have established training programmes for their installation and maintenance technicians.

## Minimising HFC emissions from existing equipment

For some systems with relatively high leakage rates (e.g. some ducted systems), the majority of HFC emissions occur during the operating life. It is essential to ensure good installation and maintenance procedures are used to minimise leakage.

Split systems and VRF systems include factory built indoor and outdoor units and site assembled refrigerant pipework. The latest factory built units have very low levels of leakage. Site installed pipework can have low leakage levels if it is installed using the manufacturer's recommended procedures.

Use of good end-of-life recovery procedures is essential as these systems can hold a significant refrigerant charge. A refrigerant recovery unit must be used before an old plant is dismantled to avoid emissions or the refrigerant must be pumped down in the outdoor unit and sent to a recycling plant where the refrigerant can be recovered.