FACT SHEET 8
Small Split Air-Conditioning

1. Description of market sector

This sector includes small split air-conditioning units used for the cooling of single rooms in residential and commercial buildings. It is already a large sector in terms of refrigerant consumption and continues to be a growing market. Small splits hold a dominant share of air-conditioning units below 12 kW cooling. They have become more popular than alternative products such as window units and through-the-wall units (see Fact Sheet 7).

Market sub-sectors

This market sector has not been divided into sub-sectors.

Typical system design

All units use a DX (direct expansion) vapour compression cycle. Each system consists of two factory built parts, an indoor unit and an outdoor unit. The indoor unit includes the evaporator and is installed inside the room being cooled. It is usually located at ceiling level or high on a wall, although some models are designed for floor level mounting. The outdoor unit includes a compressor and condenser. The two units are interconnected by site assembled refrigerant pipework. The outdoor unit is usually pre-charged with refrigerant during manufacture. The majority of models currently being sold are "reversible" – they can operate as an air-conditioning unit in hot weather or can provide heating as an air-to-air heat pump in cold weather. In heating mode the indoor unit functions as condenser and the outdoor unit as evaporator.

Alternative technologies

There is almost no use of alternative technologies. There is very limited use of evaporative coolers ("desert coolers") which can be used in dry climatic conditions.

Changes driven by ODS phase out

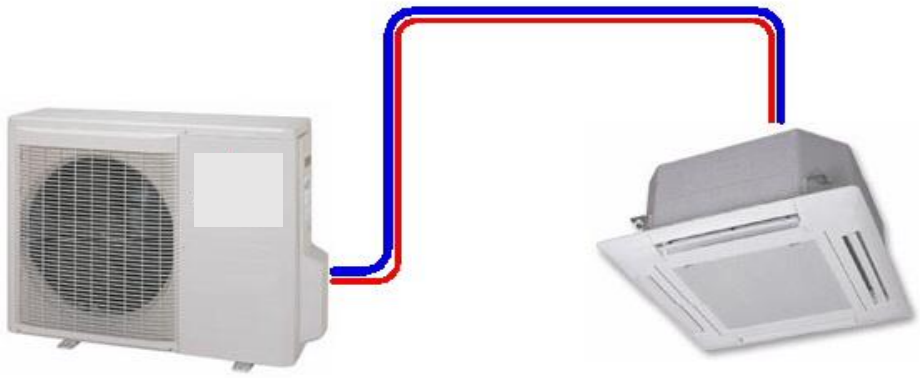
Prior to 1990 this sector used HCFC-22. From mid-1990s non-Article 5 countries started using R-407C and quickly moved on to R-410A. There is still extensive use of HCFC-22 in Article 5 countries, although R-410A is already widely available.

Table 1: Small split air-conditioning: summary of characteristics for HFC equipment

Typical refrigerant charge	0.5 to 3 kg
Typical cooling duty	2 to 12 kW
HFC refrigerants used	R-407C (GWP 1774[1]) R-410A (GWP 2088) HFC-32 (GWP 675)
Refrigeration circuit design	DX vapour compression
Manufacture / installation	Factory built units with site assembled refrigerant pipework
Typical location of equipment	Class A (access by persons not acquainted with safety precautions)
Typical annual leakage rate	1% to 4%
Main source of HFC emissions	Losses at end-of-life
Approximate split of annual refrigerant demand	New equipment: 80% Maintenance: 20%

[1] All GWP values are based on the IPCC 4th Assessment Report

Split air-conditioning:
Wall mounted indoor unit and outdoor unit



Split air-conditioning: Outdoor unit and ceiling mounted indoor unit

Split air-conditioning: Floor level indoor unit

2. Alternatives to currently used HFC refrigerants

Table 2: Lower GWP alternatives for small split air-conditioning

Refrigerant[2]	GWP	Flammability[3]	Comments
HC-290 HC-1270 *Various HC blends:* *R-432A, B, C* *R-436A, B* *R-441A*	1 to 5	3	HC-290 and HC-1270 have been used for small split air-conditioning in Europe for several years and the Far East and India since 2012. HCs can be considered for some equipment in this sector, depending on refrigerant charge, indoor unit location and room size.
HFC-32	675	2L	HFC-32 has been used for small split air-conditioning in the Far East and India since 2012 and in Europe since 2013. Several major air-conditioning manufacturers now have a number of HFC-32 models available.
R-446A R-447A *R-454B*	460 582 *460*	2L 2L *2L*	Newly developed HFO/HFC blends with properties similar to R-410A are being considered for small split air-conditioning.
Blends awaiting ASHRAE number	*250 to 700*	*2L*	*Blends under development with properties similar to R-410A.*

R-410A is the dominant HFC refrigerant in new split air-conditioning. It allows use of compact compressors and provides good efficiency. Alternatives need to be able to match these characteristics. There is currently no cost-effective non-flammable alternative to R-410A. To use a lower GWP alternative it will be necessary to move to one of the flammable options shown in Table 2. Where flammable refrigerants are not acceptable due to safety requirements and building codes, the non-flammable R-410A might still be required. Use of other non-flammable HFCs such as HFC-134a is not considered feasible as the efficiency will drop and the pipe sizes and heat exchanger sizes will increase. This will lead to larger charges and may not reduce the GWP-weighted charge.

Hydrocarbons, such as HC-290, can be used in some split air-conditioning models with good efficiency if the refrigerant charge can be minimised and/or appropriate safety measures integrated.

HFC-32 has been introduced by a number of manufacturers and is available in many regions. In Japan the range up to 7 kW now almost exclusively uses HFC-32 and several models above 7 kW are also available.

Blends R-446A, R-447A and R-454B are being introduced and other HFO/HFC blends are under development. They are expected to provide further lower flammability options in this market.

[2] *Refrigerants and text shown in italics have been added in this latest version of the Fact Sheet*

[3] Flammability categories based on ISO 817 and ISO 5149
3 = higher flammability; 2 = flammable; 2L = lower flammability; 1 = no flame propagation

With a shift to alternatives that have some level of flammability, it is necessary in all cases to apply them with consideration to the relevant safety regulations.

Pure HFOs such as HFO-1234yf would require a much larger compressor and are not being considered. R-744 cannot match the efficiency of current units for the same cost.

3. Discussion of key issues

Safety and practicality

HCs can be used in some models when the design can meet safety standards or regulations[4]. The charge permissible depends on the room size and location of the indoor unit. Higher charges are possible with ceiling mounted or wall mounted units. The permissible charge for floor mounted indoor units is very low. Depending on room size, a HC-290 charge of 0.5 to 1.5 kg may be permissible in some countries for wall and ceiling mounted models. Safety regulations may need to be updated in some regions to allow this application.

HFC-32, R-446A, R447A *and R-454B* have lower flammability and can be used for most small split units (with <12 kW cooling). Safety regulations may need to be updated in some regions to allow this application. For larger split units, see Fact Sheet 9, which discusses the use of lower flammability refrigerants in larger equipment.

Commercial availability

Some models using HC-290 are available including in some Article 5 countries such as India *and China*. A significant number of HFC-32 units have already been sold and the sales of these systems are growing rapidly.

R-446A, R-447A *and R-454B* units are being considered by some manufacturers. The timing of commercial availability is not clear. *It is also likely that other new blends will compete in this market.*

Cost

HFC-32 and HC-290 units are cost competitive with R-410A equivalents. *Costs for split units using the HFO / HFC blends shown in Table 2 are not yet known.*

Energy efficiency

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

HC-290 and HC-1270 units can achieve better energy efficiency than R-410A equivalents. As with any type of refrigerant, there is a trade-off between energy efficiency and refrigerant charge. To allow use of a higher flammability refrigerant it is necessary to minimise the refrigerant charge. However, to achieve maximum energy efficiency it may be necessary to increase the charge (e.g. to use larger heat exchangers with lower approach temperatures). This will limit the size of HC split air-conditioning units that can achieve the required efficiency standards.

Applicability in high ambient

R-410A units are currently used at high ambient. HFC-32 and HC-290 both have higher critical temperatures than R-410A which makes them better suited to operation in high ambient temperature than R-410A. Recent studies showed the degradation of capacity and COP of HC-290 relative to

[4] e.g. ISO 5149 or EN 378

HCFC-22 at high ambient temperature to be within 3%. For HFC-32, various studies show COP degradation within 10% of that of HCFC-22 at high ambient.

The main challenge for high ambient conditions is the balance between energy efficiency and maximum refrigerant charge limits for safety. The heat load per m² of floor area is higher than in cooler climates which leads to higher refrigerant charges per m² of occupied space. Several countries in the high ambient region apply challenging minimum energy efficiency requirements, leading to even higher refrigerant charges. This makes it harder to use higher flammability refrigerants for split 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

HCs: Maintenance technicians need training that addresses handling of higher flammability refrigerants. Currently there are not many technicians that have HC split air-conditioning experience. The manufacturers that have introduced HC-290 have established training programmes for their installation and maintenance technicians.

HFC-32, HFO/HFC blends: 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

The majority of emissions from small split air-conditioning occur at end-of-life. To minimise these emissions, refrigerant recovery equipment must be used prior to dismantling a split unit. Alternatively, refrigerant can be pumped down into the outdoor unit which can then be shipped to a recycling plant which recovers the refrigerant.

Small split air-conditioning include factory built indoor and outdoor units and site assembled refrigerant pipework. The latest factory built units have extremely low levels of leakage. Site installed pipework can have low leakage levels if it is installed using the manufacturers recommended procedures. Many small split units operate for their whole operating life without needing refrigerant top-up. *At end-of-life it is possible to "pump-down" all the refrigerant into the outdoor unit and then dismantle the system. The outdoor unit can be sent to a specialist waste recovery plant where the refrigerant can be recovered with minimum emissions.*