OzonAction Kigali Fact Sheet 2

Current Use of HCFCs and HFCs

Background:

Fluorocarbon chemicals have properties that make them well suited to a range of applications. However, they also have unfavourable environmental properties, especially those related to ozone depletion and to climate change. This has led to the phase-out process for ozone depleting substances (ODS[1]) and the more recent phase-down process for hydrofluorocarbons (HFCs) that have high GWP. There are five main markets for the various fluorocarbon molecules and blends:

1. Refrigerants in RACHP (refrigeration, air-conditioning and heat pumps)
2. Propellants in aerosols
3. Blowing agents to manufacture insulating foam
4. Fire protection fluids
5. Solvents

The relative size of these main markets has changed significantly over the last 25 years. Prior to the recognition of the ozone problem, the largest use of CFCs was for aerosols. The solvent market was also significant at that time. During the phase-out of CFCs, the market structure altered and large parts of the aerosol and solvent markets switched to not-in-kind (NIK) alternatives. The RACHP market has grown in relative importance with most CFC and HCFC applications switching to HFC alternatives. Before developing a strategy for reducing use of HFCs, it is important to understand the key market sectors and sub-sectors that use both HCFCs and HFCs.

The Journey to Fluids with Zero ODP and Low GWP:

As the global community understood and began to respond to the ozone and climate issues, the users of fluorocarbons have progressed through four different generations of products.

	ODP	GWP
1st generation	Very high	Very high
2nd generation	High	High
3rd generation	Zero	High
4th generation	Zero	Low / Very low

- **1st Generation: 1940 to 1990; CFCs dominant**. CFCs were developed by chemists in the 1930s and quickly recognised as well suited to various applications, especially in refrigeration and air-conditioning. Being non-toxic and non-flammable they became a very popular choice and by the 1960s were the dominant refrigerant in many applications. Use grew rapidly in other markets such as aerosols, solvents and foam blowing.
- **2nd Generation: 1990 to 2010; HCFC use grows**. A solution to the ozone problem adopted for some applications was to switch from CFCs to certain HCFCs. HCFCs also damage the ozone layer but they are much weaker ODS than CFCs. HCFCs are only being used as "interim" solutions, with a phase-out by 2030 in Article 5 countries.
- **3rd Generation: 1995 to 2020;** HFCs become dominant. HFCs were not used prior to 1990 as they were more expensive to produce than CFCs and had no perceived benefits, prior to control of ODS under the Montreal Protocol. For many CFC applications, a switch to HFCs was the lowest cost solution, so various HFCs became very popular in non-Article 5 countries.
- **4th Generation: 2010 onwards; Lower GWP fluids**. Users of HFCs begin to search for lower GWP alternatives. Various not in kind (NIK) refrigerants such as hydrocarbons, CO_2 and ammonia are adopted in some markets, although some of their properties are not ideal for all applications (e.g. the high flammability of hydrocarbons). Fluorocarbon producers introduce various alternatives including new hydro-fluoro-olefin (HFO) molecules.

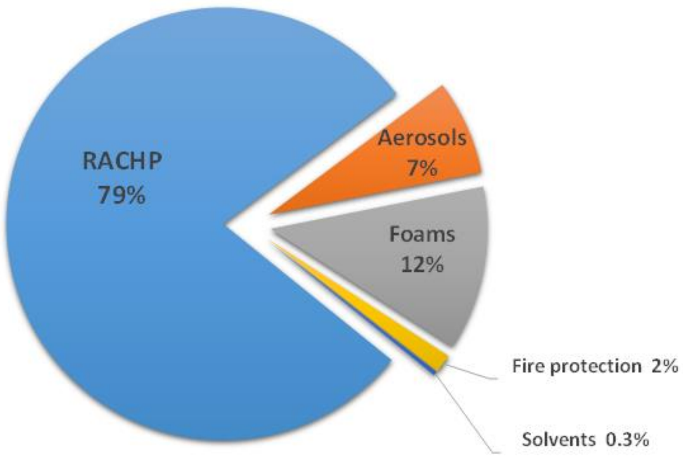
[1] See Kigali Fact Sheet 14 for a glossary of all acronyms used

Split of Use in Main Markets: Figure 1 provides an approximate split of the global HCFCs and HFCs sold in 2012, split by main market. Data for 2012 has been used as it represents a year in which there was little influence from the use of 4th Generation fluids.

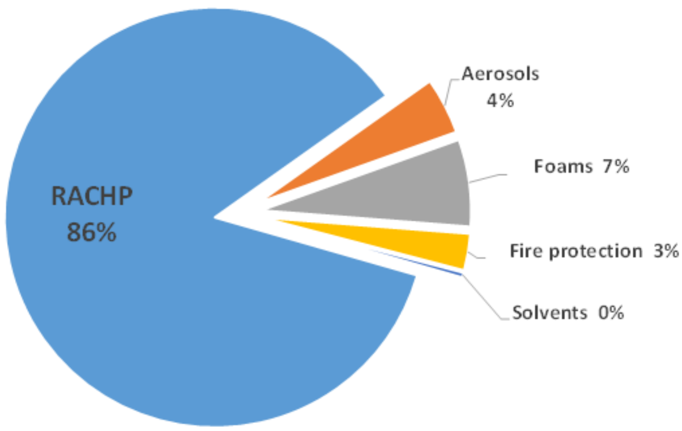
The dominance of the RACHP market is clear. The left-hand chart is the split of consumption of HCFCs plus HFCs expressed in metric tonnes. The right-hand chart is "GWP-weighted", with the consumption expressed in tonnes CO_2 equivalent[2]. The RACHP market is even more dominant in the right-hand chart because it uses particularly high GWP HFCs such as R-404A and R-410A, whilst the aerosol and foam markets use lower GWP HFCs.

Figure 1: Markets using HCFCs and HFCs, 2012

% of total metric tonnes



% of tonnes CO_2 equivalent ("GWP-weighted")



The Importance of Market Sub-Sectors: To understand how particular fluorocarbon molecules or blends are selected for specific applications it is important to recognise that the main markets illustrated in Figure 1 include a wide variety of different market sub-sectors that influence the choice of fluids used. For example, in the RACHP market, the type of equipment used is mainly based on a very similar technical process – the vapour compression cycle. However, the temperature of operation can vary considerably in different subsectors of this market. The refrigerant evaporating temperature might vary as follows:

- -40°C for freezing ice cream
- 0°C for storing chilled foods
- +10°C for air-conditioning
- +30°C for a heat pump

The optimum thermodynamic properties for each of these applications are quite different, resulting in different refrigerants being selected at these different temperature levels. The size and location of equipment can have an impact on fluid selection. A large industrial refrigeration system can use a refrigerant such as ammonia (which is toxic and slightly flammable) whereas as small air-conditioning unit in a residential location ideally requires a fluid that is non-toxic and non-flammable.

The figures overleaf provide a breakdown of the combined use of HCFCs and HFCs in different sub-sectors of the largest main markets. These are global average figures – the actual split can vary from country to country. For example, the size of the air-conditioning market will be much larger than shown in Figure 2 in very hot countries. Understanding the split of usage in a specific country is a very important step in the development of an HFC phase-down strategy (see Kigali Fact Sheet 6 for more details).

[2] See Kigali Fact Sheet 3 for an explanation of CO_2 equivalent

Figure 2: RACHP Markets, HCFC and HFC Use, 2012, GWP-weighted

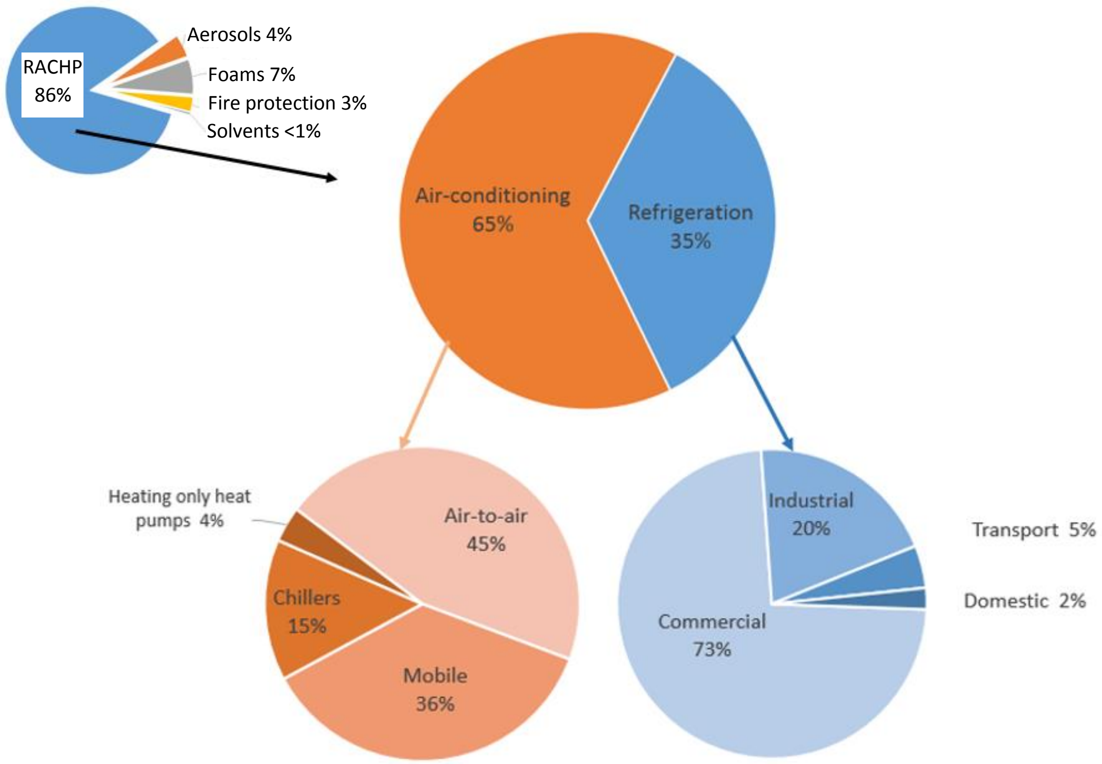


Figure 2 shows how the RACHP market can be split between air-conditioning and refrigeration and further split into sub-sectors (such as commercial refrigeration). To understand the factors that influence the choice of a specific refrigerant it is often necessary to further sub-divide RACHP markets, considering the type and size of equipment. This is illustrated in Figures 3 and 4 and illustrated for the commercial refrigeration sub-sector in Box 1 and for building air-conditioning in Box 2.

Box 1: Commercial Refrigeration

Commercial refrigeration is mainly used for food retail and catering activities. As shown in Figure 3, this sector can be split into 3 sub-sectors, based on size and design. The amount of refrigerant required is illustrated in the table below. Stand-alone systems are factory sealed, have virtually no leakage and a very small refrigerant charge. This allows a wide range of refrigerant choice, including flammable options. Central systems can be the most energy efficient option, but the large refrigerant charge and a high level of leakage, restricts the choice of refrigerant to non-flammable options.

Sub-sector	Typical refrigerant charge, kg
Stand-alone	0.1 to 0.5
Condensing unit	5 to 10
Central systems	50 to 200

Figure 3: Subsectors of refrigeration markets

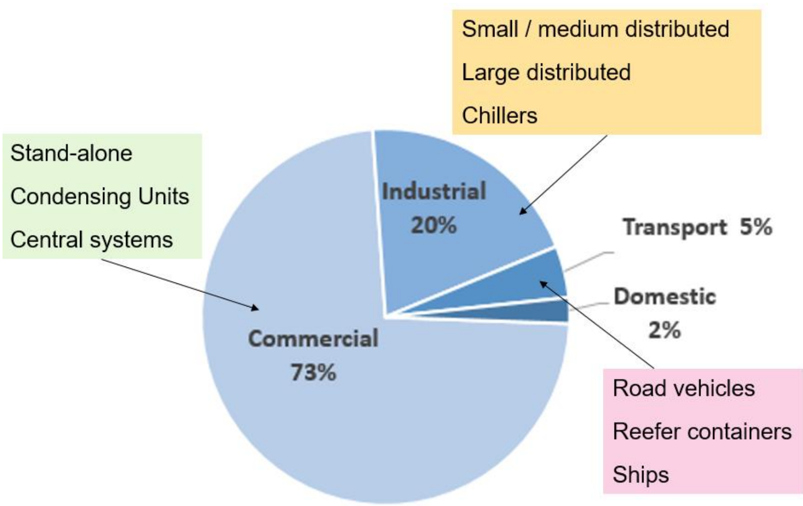
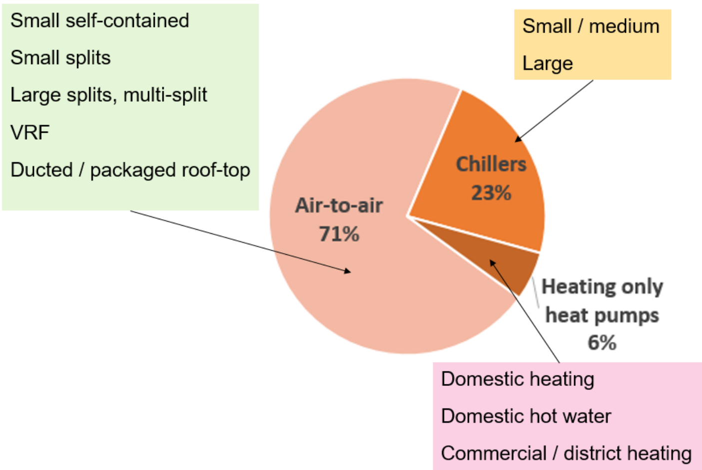


Figure 4: Subsectors of air-conditioning and heat pump markets



Box 2: Building Air-conditioning

There are many design options for building air-conditioning, varying from small systems cooling one small room to water chillers that can cool a large multi-storey building or a whole district.

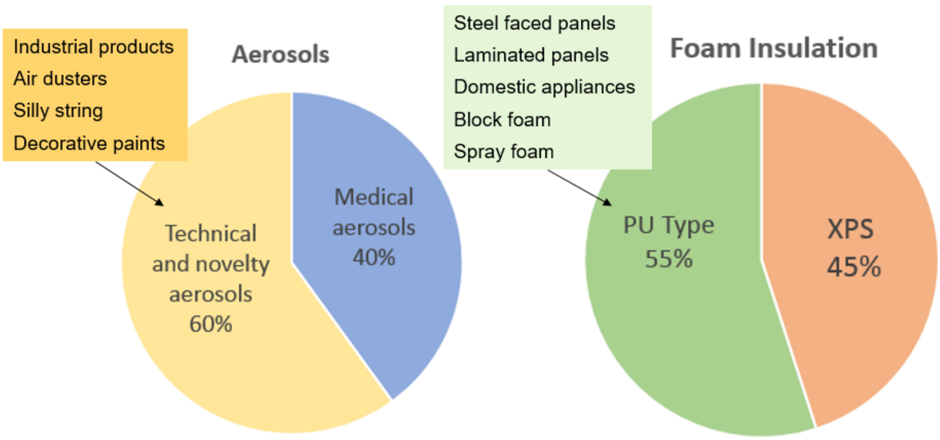
For water chillers, the refrigerant charge is high, but the equipment is usually in a limited access location e.g. a machinery room or a roof-top. This allows a wide choice of refrigerants, including flammable fluids, despite the large size.

For split systems and VRF* systems the refrigerant flows into the room being cooled, which makes the selection of a flammable refrigerant more difficult, especially for VRF systems because of their high refrigerant charge.

Sub-sector	Typical refrigerant charge, kg
Small splits	0.5 to 3
VRF	20 to 60
Water chillers	50 to 500

* VRF = variable refrigerant flow. VRF systems are sophisticated multi-split air-conditioning systems used to cool and heat medium sized buildings.

Figure 5: Subsectors of aerosol and foam markets



Box 3: Aerosols

Since the phase-out of CFCs, most aerosols are now manufactured with flammable hydrocarbon (HC) propellants. HFCs are used as propellants in situations where the cheaper HCs cannot be used. MDIs (metered dose inhalers) use HFCs to administer drugs for lung diseases such as asthma. Various technical and novelty aerosols (e.g. lubricant sprays and air-dusters) require a non-flammable propellant and currently use HFCs.

Box 4: Foam Insulation

Many Article 5 countries still use HCFCs to manufacture insulation foam. For large foam production plants making PU type foam it is often cost-effective to convert to HCs. Where flammable blowing agents cannot be used, various HFCs have been introduced, such as HFC-245fa. For example, a significant part of the PU foam market is for spray foam, that is applied to buildings in-situ – a non-flammable blowing agent is required for spray foam.