MONTREAL PROTOCOL
ON SUBSTANCES THAT DEPLETE
THE OZONE LAYER

UNEP

REPORT OF THE
TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL

MAY 2003

HCFC TASK FORCE REPORT

Montreal Protocol

On Substances that Deplete the Ozone Layer

Report of the
UNEP Technology and Economic Assessment Panel
May 2003

HCFC Task Force Report

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ES Executive Summary

In Decision XI/28, the 11th Meeting of the Parties requested the Technology and Economic Assessment Panel to study and report by 30 April 2003 at the latest on the problems and options of Article 5(1) Parties in obtaining HCFCs in the light of the freeze on the production of HCFCs in non-Article 5(1) Parties in the year 2004. This report should analyse whether HCFCs are available to Article 5(1) Parties in sufficient quantity and quality and at affordable prices, taking into account the 15 per cent allowance to meet the basic domestic needs of the Article 5(1) Parties and the surplus quantities available from the consumption limit allowed to the non-Article 5(1) Parties. Parties would consider this report at their 15th Meeting in the year 2003.

The TEAP established a Task Force to prepare the report on the availability of HCFCs to Article 5(1) countries, in consultation with the full TEAP membership. The Task Force consisted of 17 full members and 2 consulting members; it met a number of times to discuss the drafts of the report in the period February-April 2003.

This Executive Summary explains the conclusions reached in the report (shown in italics) and provides a summary of the considerations made to reach these conclusions. More detailed information is provided in the body of the report.

ES.1 The on-going role of HCFCs under the Montreal Protocol

HCFCs are, and are likely to remain, important as "transitional substances" in the replacement of CFCs in refrigeration and air conditioning, insulating and integral skin foams, cleaning, and in speciality uses. They are also substitutes for halons in some fire protection applications.

The use of HCFCs has grown to date on the basis of the following criteria:

- Reduced Ozone Depletion Potential over the ODS replaced;
- Cost-effective transition steps;
- Acceptable flammability properties, both in terms of product and process safety;
- Good thermal properties for both refrigerant and blowing agent applications;
- Availability through existing distribution channels at acceptable prices.

However, the focus from the outset has been on their transitional nature and the need to consider limiting use in order to minimise unnecessary environmental impacts.

The following table illustrates the range of HCFCs in use today and typical applications for which they are used.

Table ES-1

HCFCs in Use Today and Typical Applications

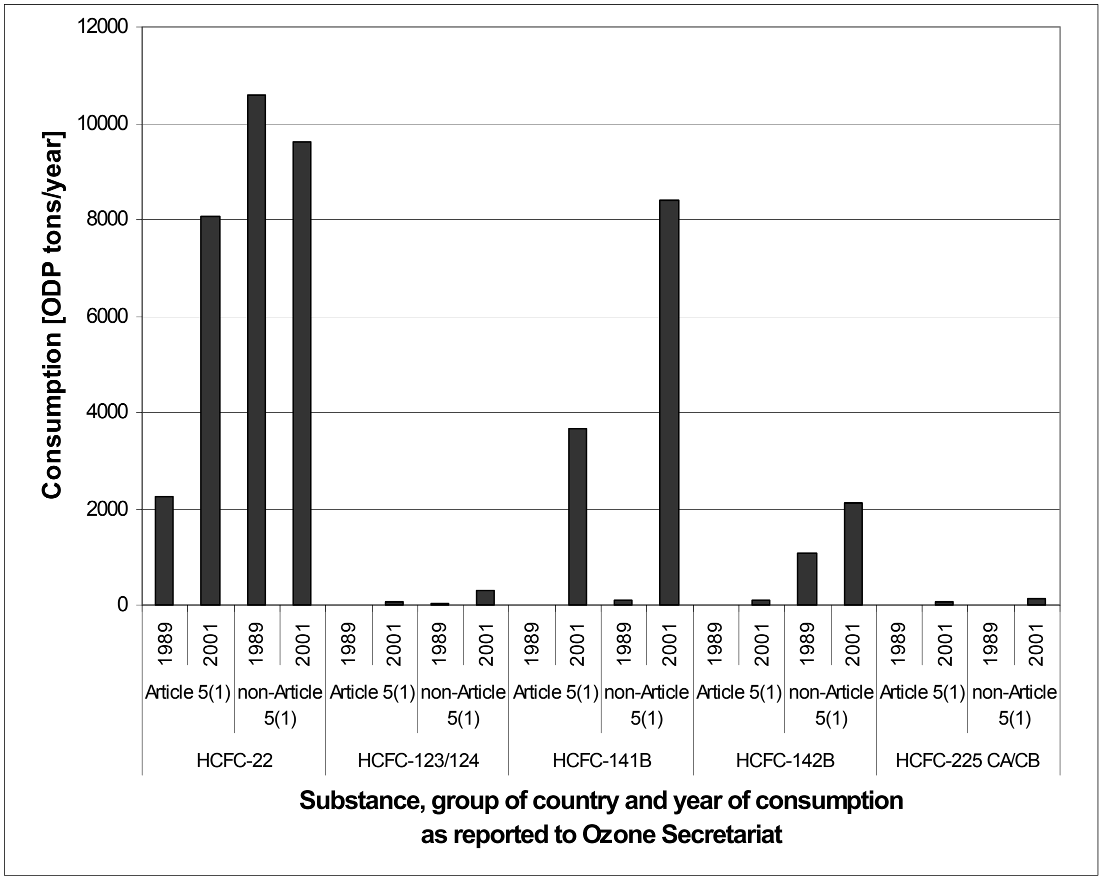
Substance	ODP	Significant use prior 1989	Replacement for / predominant use today
HCFC-22	0.055	Refrigerant for room and packed air conditioners, small water chillers	Uses as prior to 1989, plus: replaces CFC mixture R502 in commercial refrigeration equipment (non-exclusive). Replaces CFC 12 in smaller chillers, commercial and some other applications (non-exclusive). Mixture component in some CFC-12 drop-in replacements. Used in OEM and other foam applications.
HCFC-123	0.02	None	Replaces CFC-11 in centrifugal chillers and halon 1211 in portable fire extinguishers
HCFC-124	0.022	None	Mixture component in some CFC-12 drop-in replacements. Replaces CFC-114 in some heat pumps and special air conditioning equipment (non-exclusive). Also used in some sterilant mixtures
HCFC-141b	0.11	None	Replaces CFC-11 as blowing agent in rigid polyurethane foams and integral skin foams. Significant use in solvent applications.
HCFC-142b	0.065	None	Replaces CFC-12 as blowing agent in extruded polystyrene board and is a mixture component in some CFC-12 drop-in replacements
HCFC-225 ca/cb	0.025 / 0.033	None	Replaces CFC-113 and TCA as a solvent. Both isomers are used separately or as a blend

In response to on-going environmental concerns, non-Article 5(1) countries continue to reduce the consumption of HCFCs to comply with the Montreal Protocol control schedule and, in several cases, to make reductions that go beyond the Montreal Protocol requirements for compliance. National and regional bans on specific HCFC applications and the accelerated European HCFC phase-out, which also applies to the new EU member states as of 2004, are already drastically reducing global HCFC demand. This reduction in global demand will almost certainly lead to a decrease in global supply through the closure of some existing facilities and also raises the potential for restriction of imports of products made-with or containing HCFCs to the non-Article 5(1) countries.

HCFC-22 and HCFC-141b are, and will remain, the most significant HCFCs in use globally and particularly in Article 5(1) countries.

The dominant uses for HCFCs in non-Article 5(1) countries have been in the refrigeration and insulation foam sectors. These have adopted HCFC-22 and HCFC-141b as primary refrigerants and blowing agents, respectively. The graph below illustrates the trends between 1989 and 2001 for both non-Article 5(1) and Article 5(1) countries.

Figure ES-1
HCFC Consumption Trends



Developing country usage patterns are expected to follow the technology trends in non-Article 5(1) countries, although the demand for insulation foams is likely to be less because of favourable climatic conditions and differing building practices in many Article 5(1) regions.

> *Future HCFC-22 consumption is linked heavily with the growth of the refrigeration and air conditioning industry in Article 5(1) countries – most notably in China.*

Although the usage of HCFCs in non-Article 5(1) countries will continue to fall significantly over the next ten years, there are certain economies in Article 5(1) regions that will have substantial impacts on future consumption. These are particularly China, India, Brazil and other countries where population concentrations and economic growth rates are high and where living standards are expected to improve.

Information has come to the Task Force indicating substantial growth rates for the commercial refrigeration sector in China and even the most pessimistic of these projections is likely to put a burden on the on-going supply chain for HCFC-22. Nonetheless, it is recognized that any such projections have inherent uncertainties in both economic and technical components, especially over a period of 12 years or more. This has led the Task Force to highlight these uncertainties in its report.

ES.2 Uncertainties in the future demand for HCFCs

The Task Force has discussed growth scenarios at length and recognises that there are substantial uncertainties surrounding any economic projections over a period as significant as 12 years. This is particularly the case when high growth scenarios are postulated. Assumptions will only be validated with time and a further full assessment may need to be made in 3-5 years when further growth data are available.

By example, the following approach was adopted for HCFC refrigerant demand in Article 5(1) countries to deal with the unknowns associated with future economic growth rates as well as the uncertainty regarding the shift from HCFC refrigerants to alternatives. This approach resulted in two scenarios for Article 5(1) countries, one considering 'low demand' and the other one 'high demand'.

ES.2.1 Low HCFC demand

For the low demand scenario, the growth rate in the year 2000 was taken as the reference if the growth rate was above 2% in the period 1990-2000; thereafter an asymptotic decrease down to 2% in 2015 is assumed. Moreover, if --following this assumption-- the market were to double from 2000 to 2015, the growth rate is modified in order to limit the total HCFC refrigerant sales to twice the quantities sold in 2000. These assumptions are applied region by region and for each application.

ES.2.2 High HCFC demand

The growth rate assumed for the 15-year period 2000-2015 depended on several conditions:

- If the average market growth for the period 1990-2000 was lower than +7% per year, the projected market growth rate was assumed equal to the average 1990-2000 value. Under these circumstances, the period 2000-2015 is then characterised by a constant growth rate.
- If the average market growth rate for the period 1990-2000 was higher than +7% per year, the projected growth rate was assumed to decrease following an asymptotic curve, starting in 2000 with the value of the average growth during 1990-2000, and then decreasing to +7% in 2015 following an asymptote.

In order to allow for the calculation of supply/demand balances, the mean of the high and low demand scenarios was used to depict demand trends.

The Task Force recognized in its deliberations that no one method of growth assessment could be relied upon unambiguously and there were some Task Force members who felt that even the ‘low demand’ scenario was too aggressive. This also applies to the assumptions in this report related to the continuously growing global use of HCFC-22 as feedstock during the period 2002-2015. However, the assumptions will only be validated with time and a further assessment may need to be made in 3-5 years when further growth data is available.

> *There are also significant uncertainties regarding the substitution of HCFC-based technologies with other technology options and only the ‘most likely’ scenarios, based upon currently existing trends, have been considered.*

There are technical as well as economic uncertainties and these have been recognised by the Task Force. The ‘low demand’/‘high demand’ approach already described has, built in, an allowance for technology changes over the period to 2015. This not only includes primary technology switching but in some cases also includes such issues as reduced leakage rates through improved maintenance procedures, higher recovery and recycling levels and, in the case of foams and solvents, more efficient processes.

Alternative technologies include those based on hydrocarbons, HFCs and other chemicals. Not-in-kind solutions (e.g. vacuum panels) also need consideration in some sectors. However, it was clear to the Task Force that this was not a study on the technical and economic viability of alternatives and that sensitivity analyses based on such factors would be inappropriate in this setting.

The Task Force assumed that the decision of the Multilateral Fund Executive Committee to only support one transition (through the Multilateral Fund) from CFCs would remain in place, while recognizing that any change in this policy could make a substantial impact on phase-out schedules and would require further assessment.

Other economic considerations include the ability of non-HCFC options to provide equivalent or greater energy efficiency and operating economy in use.

ES.3 Supply and Demand for HCFC-22

> *According to the best current estimate, the demand for HCFC-22 (excluding feedstock demand) in Article 5(1) countries in 2015 will be three times that of the demand in 2002.*

HCFC-22 is produced by many companies in many countries and is currently used in air conditioning and refrigeration products worldwide and as a feedstock in the production of fluoropolymers. Within a limited ratio, the quantity of HCFC produced can be rapidly adjusted in "swing" plants that have the ability to swing between CFC and HCFC production. However, once CFC phase-out is completed, this flexibility will be lost. On the other hand, some CFC plants may remain operating as HCFC-22 plants to meet demand. Total production of HCFC-22 will depend on a balance of declining consumption in non-Article 5(1) countries, increasing consumption in Article 5(1) countries and global increases in feedstock demand for fluoropolymers. There is also a potential for non-Article 5(1) countries to restrict exports of HCFCs. Such restrictions would further limit available capacity to meet the demand in Article 5(1) countries.

Table ES-2
HCFC-22 Demand and Production

HCFC-22	**Demand and Production (ktonnes) (year)**			
	2002	**2005**	**2010**	**2015**
Market Demand non-A5(1)	189	180	99	37
Market Demand A5(1)	104	132	212	305
Market Demand, total	293	312	311	342
Prod. Capacity: non-A5(1)	440	410	353	335
Prod. Capacity: A5(1)	166	181	205	230
Prod. Capacity: total	606	591	558	565
Feedstock Requirement	212	239	290	337
Available Market Capacity	394	352	268	228
Unused Capacity/ Insufficient production capacity (negative)	101	40	-43	-114
Capacity Utilisation	83%	93%	100%	100%

If this scenario proves to be correct, there may already be insufficient installed capacity for HCFC-22 beyond 2005, leading to a tense supply situation. This aspect needs further consideration by the TEAP and its HCFC Task Force after the year 2004, when more production and consumption data will have been reported, and tendencies in feedstock use will have been confirmed.

With transitions still continuing out of CFC use at this time, the Task Force is conscious that the demand growth rate is volatile and that further data would be very helpful in validating current assumptions. There may already be a shortage in the supply of HCFC-22 beyond the year 2005, leading to a tense supply situation. Due to the fact that this can be expected at reasonably short term, this observation is not very sensitive to the assumptions made in the demand scenarios. It is sensitive to the assumptions made regarding feedstock production and the implicit assumption that feedstock (polymer) demand prevails over refrigerant demand. Further consideration of the HCFC-22 developments by the TEAP and its Task Force may be needed when 2004 production and consumption data have become available, i.e. after the year 2004. At that time the trends assumed in this study for feedstock production can also be confirmed. A follow-up study in 3-5 years time would help to determine whether further investment in HCFC-22 capacity would be necessary at a later stage, i.e., in 2010 or thereafter.

The introduction of additional regulatory controls in non-Article 5(1) HCFC production after 2005 (over and above the required freeze) is likely to bring forward investment plans for further HCFC-22 capacity in Article 5(1) regions. This will give these investments more opportunity for commercial return.

It is clear that Article 5(1) producers will not wish to invest if the climate at the time of investment is unfavourable. However, with the freeze on production in non-Article 5(1) countries in 2004 and additional unilateral controls in the European Union in 2008 and 2014, the market for HCFC-22 is expected to be tight from 2005 onwards, thereby encouraging further investment prior to 2010 in Article 5(1) countries.

Article 5(1) producers would not invest if there were:

- Poor prices in the HCFC-22 market place
- An uncertain regulatory future which could impinge on the life-expectance of the investment
- Heightened environmental concerns over inadvertent production of HFC-23 and the need for emission abatement (HFC-23 is a potent greenhouse gas)

However, the earlier the investment is called for, the less likely it is that these circumstances would exist in Article 5(1) countries. Ironically, therefore, the decision to limit export potential from non-Article 5(1) might inadvertently proliferate Article 5(1) investment in HCFC-22.

Should Parties wish to review these dynamics and influence investment conditions significantly, clear and timely indications will need to be given to both producers and users of HCFC-22 in order to minimise market disruption.

ES.4 Supply and Demand for other HCFCs

Demand for HCFC-141b and HCFC-142b is driven primarily by their respective uses in insulation and other foams. These applications are expected to grow throughout the period as the use of refrigeration equipment becomes more widespread and interest in energy efficiency grows.

The growing importance of energy efficiency is likely to stimulate the further use of insulation foams in non-Article 5(1) countries. However, as most non-Article 5(1) countries are phasing out the use of HCFCs in insulation foam applications, this may have little effect on demand for HCFC-141b and HCFC-142b. The one exception is in the United States where the use of HCFC-142b in extruded polystyrene will continue to be allowed until 2010.

As noted previously, in Article 5(1) countries there are less requirements for thermal insulation in buildings and demand will be driven primarily by use in the domestic and commercial refrigeration sectors.

> *The other significant use of HCFCs will be in solvent applications where both HCFC-225 and HCFC-141b will be used. These will only be used where no other alternatives are available.*

The non-foam use of HCFC-141b will be in solvent applications. Solvent use currently accounts for about 10% of overall use of HCFC-141b in developed countries and is expected to decline as alternatives become available.

HCFC-225 is used as a speciality solvent in the manufacture and maintenance of high-value electrical, precision, and optical equipment in aerospace and other applications where no alternative is currently available.

> *Individual production capacities for HCFC-141b and HCFC-142b are more difficult to determine than HCFC-22 since these chemicals are co-produced in some facilities and the process has some degree of flexibility.*

HCFC-141b and HCFC-142b can be produced independently or co-produced. The technology for co-production rests with one producer and accounts for approximately 50% of total capacity in both products. Since the ratio between the products can be fully varied, the resulting uncertainty on the global capacity of each chemical is of the order of +/- 25% .

> *Although the use of HCFC-142b in Montreal Protocol applications will be eliminated in 2010, the feedstock requirements for the chemical may mean that most co-producing facilities will be required to meet this demand in the period 2010-2015. This will limit the availability of capacity for HCFC-141b.*

Apart from its use in extruded polystyrene foams in the United States, HCFC-142b is also used in some refrigerant blends and as a feedstock, with approximately 60% of total production of HCFC-142b being used for the manufacture of VF2, which is then used to make the engineering fluoro-polymer, PVdF. The table below illustrates likely supply-demand trends.

Table ES-3
HCFC-142b Demand and Production

HCFC-142b	**Demand and Production (ktonnes) (year)**			
	2002	**2005**	**2010**	**2015**
Market Demand non-A5(1)	17	16	0	0
Market Demand A5(1)	0	0	0	0
Market Demand, total	17	16	0	0
Prod. Capacity: non-A5(1)	92	78-100	74-96	70-90
Prod. Capacity: A5(1)	5	5	5	5
Prod. Capacity: total	97	83-105	79-101	75-95
Feedstock Requirement	58	63	71	81
Available Market Capacity	39	20-42	8-30	(-6)-14
Unused Production Capacity	22	4-26	8-30	(-6)-14
Capacity Utilisation	77%	75-95%	70-90%	85-108%

As can be seen from the table, the vast majority of the available capacity for HCFC-142b in co-producing plants will need to be directed towards feedstock applications in the latter part of the period under review. This means that the capacity available for HCFC-141b production will be on the lower end of the range at that time.

However, it will be so that HCFC-141b will be available to the Article 5(1) countries under the given production capacity estimates for the entire period 2002-2015. The 2010 production capacity estimates fore HCFC-142b and HCFC-141b remain unchanged if one compares the estimates for the cases with and without the EU regulation 2037/2000 being in force. This implies that the regulation has no impact on the HCFC-141b production capacity because the producers in their estimates had probably already factored in an “adequate” phase-down process as they envisaged developments several years ago.

Regarding HCFC-141b itself, the drop in demand during the period 2005-2010 will require a substantial rationalisation of current capacity in order that producers can maintain economic production. This could create shortages of capacity in later years (2010-2015) unless the producers practise well-known ‘mothballing’ techniques.

HCFC-141b is currently produced by 9 companies in 6 countries. The projected supply-demand scenario through to 2015 is shown below:

Table ES-4
HCFC-141b Demand and Production

HCFC-141b	**Demand and Production (ktonnes) (year)**			
	2002	**2005**	**2010**	**2015**
Market Demand non-A5(1)	98	13	9	9
Market Demand A5(1)	20	24	34	43
Market Demand, total	118	37	43	52
Prod. Capacity: non-A5(1)	110	82-106	59-75	20-30
Prod. Capacity: A5(1)	20	23	29	35
Prod. Capacity: total	130	105-129	88-104	55-65
Feedstock Requirement	0	0	0	0
Available Market Capacity	130	105-129	88-104	55-65
Unused Production Capacity	12	68-92	45-61	3-13
Capacity Utilisation	91%	28-35%	41-49%	80-94%

The demand in the non-Article 5(1) countries is expected to decrease sharply after the year 2003 and amounts in use in these regions by 2015 are expected to be less than 10% of the total 2002 figure. As noted previously, the main on-going use will be for solvent applications. In contrast, within the Article 5(1) countries, the demand is forecast to rise by nearly a factor of two over the period 2002-2015. On the supply side, there is some flexibility in HCFC-141b capacity because of co-production with HCFC-142b. Nonetheless, significant plant closures are envisaged as non-Article 5(1) countries phase-out use in the key foam sector. Although a linear decrease in capacity (depicted above) suggests utilisation rates in the 25-50% range for the period 2005-2010, it is known that few operators would be able to financially support the operation of plants below 70% utilisation. If the industry were to rationalise capacity more severely than depicted to maintain this minimum, there could be later capacity shortages as demand increases further in the 2010-2015 period. These problems could, however, be overcome by the use of well-known ‘mothballing’ techniques in the chemical industry and it is expected that these will be adopted in practice.

Regarding HCFC-123, HCFC-124 and HCFC-225, no supply issues are envisaged as demand has already matured. However, there may be some shift between non-Article 5(1) and Article 5(1) consumption patterns.

HCFC-123 is produced in Canada and in China by multiple producers and is primarily used as a low-pressure refrigerant in large air conditioning chillers, with very minor use as an ingredient in specialty solvents and as a fire extinguishant. HCFC-123 is also produced as a feedstock for pharmaceutical and agricultural products. Apart from the use of HCFC-123 as a refrigerant in Europe, the use of HCFC-123 is not controlled beyond the requirements of the Montreal Protocol. With no significant change in either supply or demand envisaged, HCFC-123 is expected to be available in adequate quantities at competitive prices for the foreseeable future (until 2015).

A similar supply-demand prognosis exists for HCFC-124, which is a minor component of many refrigerant blends. HCFC-124 also has minor use as a fire extinguishant and as a component of sterilant blends.

HCFC-225 is similarly expected to be available in adequate quantities for speciality uses at high prices until 2015. HFC and not-in-kind alternatives are replacing HCFC-225 in maintenance applications and new equipment is increasingly designed to avoid dependence on substances controlled by the Montreal and Kyoto Protocols.

ES.5 Existing Regulatory Factors

The Task Force has factored in a freeze in production in non-Article 5(1) countries and two additional reduction steps in production in the European Union during 2002-2015 in all of its assessments. This has no impact on the availability of HCFC chemicals to Article 5(1) countries except in the case of HCFC-22 in the period beyond 2005. However, as mentioned above, there are significant uncertainties in projections, which will require further assessment at an appropriate juncture.

Non-Article 5(1) Parties are required to freeze production in 2004, but under current controls are allowed to continue production of about 44,500 ODP tonnes of HCFCs, with no further reductions mandated. Meanwhile their consumption will decline rapidly to comparatively low levels through both Montreal Protocol and regional regulations, thereby creating a significant surplus for export. This, however, is subject to regional and national regulations on trade in HCFCs. In the European Union, HCFC production was frozen at 1997 levels on 1 January 2000 and will be reduced by 65% by 1 January 2008 and 80% by 1 January 2014. This will reduce considerably any surplus for export. The Montreal Protocol places no limit on production by Article 5(1) Parties until 2016 and mandates a freeze in production thereafter, at the level of average 2015 production and consumption. Some of their existing HCFC facilities are typically “swing” plants capable of campaign production of CFC-11, CFC-12, or HCFC-22. (HCFC-22 capacity is usually about half that realized when producing the CFCs). Under these circumstances, the need for new HCFC capacity should be limited to HCFC-22 and even this prospect is as yet by no means certain; it should therefore possibly be revisited in 3-5 years.

A close inspection of the various Protocol amendments has revealed that the control of trade in HCFCs by the Parties to the Beijing Amendment enters into force on 1 January 2004. As at March 2003, 49 countries had ratified the Beijing Amendment and 39 countries had not ratified the Copenhagen Amendment. The HCFC producing countries that have not ratified the Beijing Amendment and all the countries that have not ratified the Copenhagen

Amendment (both producing and consuming countries) will be treated as non-Parties to the Protocol with respect to HCFCs.

These linked conclusions are self-explanatory but are potentially of considerable significance to Parties. The Task Force therefore thought it worth highlighting the implications in view of the impact that these constraints might otherwise have on supply-demand options.

In more general terms, the influence of government action on market forces, including supply and demand, can have consequences that are difficult to anticipate. The analysis here presumes that companies manufacturing HCFCs will continue to supply remaining markets in non-Article 5(1) countries as allowed by the Montreal Protocol, providing that continuing supply is profitable and meets the companies' objectives. It is possible, however, that some companies previously supplying ODSs might declare a policy of withdrawing from markets. Indeed, some have done so in previous control periods. In some instances national governments have discouraged the export of ODSs, even if allowed by the Protocol. Governments of developed and developing countries that complete their own HCFC phase-out could choose to restrict the import of products made with or containing HCFCs as a means to further protect the ozone layer and/or to create a level competitive playing field for its domestic manufacturers. Because economic conditions, market forces, government regulations, and Protocol decisions can drastically influence the supply and demand for HCFCs, this analysis considers scenarios covering only the period from 2002 to 2015 when growth in consumption is allowed for Article 5(1) countries under the current provisions of the Montreal Protocol.

ES.6 Concluding Comments

Companies depending on HCFCs for domestic and export markets will want to:

1) check with local distributors for plans for continued supply,

2) anticipate the possibility of trade barriers that can eliminate export markets,

and

3) evaluate the potential for transition to non-ODS alternatives where relevant performance criteria can be met.

It would be prudent for companies to develop contingency plans to convert to alternatives should quantities available or price levels become prohibitive to continued HCFC use.

Parties may wish to consider the advantages of an early transition to non-ODS alternatives to avoid the necessity of expanded HCFC production and subsequent increasingly high costs of phase-out, where it involves a steadily growing number of HCFC users. The phase-out of HCFC-22 in non-Article 5(1) countries would encourage the commercialisation of alternative technologies at full economy of scale and could encourage a more rapid transition in Article 5(1) countries at possibly lower ultimate cost.

Nonetheless, the most cost-effective phase-out strategy in many cases is to use HCFCs to replace CFC where non-ODS alternatives are unavailable, do not meet performance criteria or are too expensive to implement.

Delayed investment due to uncertainties regarding the likely commercial lifetimes of alternatives or replacements may prolong the use of HCFCs as companies wait for clear technical choices, which enable them to comply with both the Montreal and the Kyoto Protocol.

1 Introduction

This report is the response by the Technology and Economic Assessment Panel to Decision XI/28 of the Eleventh Meeting of the Parties to the Montreal Protocol in Beijing, 1999.

1.1 Terms of Reference; Decision XI/28

The Eleventh Meeting of the Parties decided in Decision XI/28 ("Supply of HCFCs to Parties operating under paragraph 1 of Article 5 of the Protocol"):

> To request the Technology and Economic Assessment Panel to study and report by 30 April 2003 at the latest on the problems and options of Article 5(1) Parties in obtaining HCFCs in the light of the freeze on the production of HCFCs in non-Article 5(1) Parties in the year 2004.
> This report should analyse whether HCFCs are available to Article 5(1) Parties in sufficient quantity and quality and at affordable prices, taking into account the 15 per cent allowance to meet the basic domestic needs of the Article 5(1) Parties and the surplus quantities available from the consumption limit allowed to the non-Article 5(1) Parties.
> The Parties, at their Fifteenth Meeting in the year 2003, shall consider this report for the purpose of addressing problems, if any, brought out by the report of the Technology and Economic Assessment Panel.

1.2 Composition of the Task Force

The TEAP established a Task Force to prepare the report on the availability of HCFCs to Article 5(1) countries, in consultation with the full TEAP membership. The members of the Task Force were:

Co-chairs were:
Radhey S. Agarwal (India, co-chair RTOC);
Stephen O. Andersen (USA, co-chair TEAP);

Secretary was:
Lambert Kuijpers (The Netherlands, co-chair TEAP, co-chair RTOC);

Members were:
Steve Bernhardt (USA, member RTOC);
Dariusz Butrymowicz (Poland, member RTOC);
Nick Campbell (UK, member ATOC)
Denis Clodic (France, member RTOC);
Hanh Hong Dang (Vietnam);
Anhar Karimjee (USA);
Mack McFarland (USA)
Thomas E. Morehouse (USA, TEAP Senior Expert member);

Ma Qi (China, partial participation);
Miguel Quintero (Colombia, co-chair FTOC);
K. Madhava Sarma (India, TEAP Senior Expert member);
Stephan Sicars (Germany, member RTOC);
Bert Veenendaal (USA, member FTOC);
Masaaki Yamabe (Japan, TEAP Senior Expert member);

Consulting members were:
Paul Ashford (UK, co-chair FTOC);
Tom Cortina (USA, member HTOC).

The Task Force met in Eschborn, Germany (at GTZ), 17-18 February 2003, to start the effort, distribute responsibilities, and agree on a time schedule for completion. Part of the HCFC Task Force (eleven members) met again in Washington D.C., April 2003, in several short meetings, during the Earth Technologies Forum Conference, to discuss the first draft report and to make proposals for the second draft. Parts of the second draft were discussed via e-mail. The complete second draft report was subsequently composed for discussions before and at the TEAP meeting, May 2003. The final review and completion of the document was subsequently carried out by the TEAP at its meeting in Manchester during 5- 8 May 2003.

1.3 The structure of the HCFC Task Force Report

The Task Force decided

- to study the HCFC consumption during 1990-2001 on the basis of country consumption data submitted to UNEP;
- to study the HCFC consumption in refrigeration on the basis of equipment data published in official accountancy reports, and to extrapolate the consumption towards 2015 on the basis of economic growth scenarios;
- to study the HCFC consumption in foams on the basis of usage data gathered by the Foams Technical Options Committee, and to extrapolate the consumption towards 2015 on the basis of the above mentioned growth scenarios;
- to study the HCFC consumption in cleaning solvents on the basis of current status and to extrapolate the consumption towards 2015 on the basis of the possible replacement by available alternative technologies;
- A similar methodology was adopted for fire extinguishants;
- to study the HCFC production towards 2015 on the basis of available production capacities in the world in the year 2003, extrapolating trends towards the year 2015.

The structure of the 2003 HCFC Task Force Report is as follows:

Chapter 1, “Introduction”, presents the Terms of Reference, the composition of the Task Force and the working modalities.

Chapter 2, “Montreal Protocol”, describes the background of the relevant decision XI/28, concerns of developing countries, relevant Montreal Protocol control schedules and regional regulations, as well as factors that may influence the HCFC consumption in the developing countries. Annexes 1 and 2 summarise the different control schedules and national or regional regulations and their date of entry into force.

Chapter 3, “Status of HCFC use”, describes the important HCFCs and their uses, studies consumption tendencies of the different HCFCs during the period 1989-2001. It also summarises the uses of HCFCs for feedstock.

Chapter 4, “Global Capacities for HCFC Production”, describes the HCFC production capacities (as well as the number of HCFC production facilities) available in 2002. It also describes the trend where it concerns the availability of HCFC production capacities (and HCFC production facilities) in the year 2015.

Chapter 5, 6, 7 and 8 give projections of the HCFC demand until 2015 in the refrigeration, foams, solvents and fire protection sectors.

Chapter 9 gives figures on the expected available production in the years 2002, 2005, 2010 and 2015 and compares these data with the forecasts for the total HCFC demand which is based on the demand in the different sectors. It also looks at the utilisation of the production facilities taking into account the feedstock production.

Chapter 10, “Conclusions”, presents concluding remarks where it concerns the availability of HCFCs to the Article 5(1) countries during the period 2002-2015.

2 Montreal Protocol Control Measures and HCFC Demand

Decision XI/28 responded to the concerns expressed in the Eleventh Meeting that the production freeze by non-Article 5(1) Parties by 1 January 2004 mandated by the Protocol and additional national efforts more stringent than the Protocol may lead to a scarcity of HCFCs or high prices for HCFCs for Article 5(1) Parties and thus lead to difficulties in phasing out CFCs according the prescribed time schedule.

2.1 Concerns of Article 5(1) countries

Some Article 5(1) countries expressed concern that the provisions of the Protocol allowing long-term consumption of HCFCs may prove to be irrelevant in practice because of the lack of availability and/or unaffordable prices of HCFCs. Scarcity and high prices of HCFCs will impact new equipment manufacturers, small enterprises and the servicing of equipment well into the future. For example, HFC-245fa, the prominent chemical alternative to HCFC-141b, is at least 2 to 3 times costlier than HCFC-141b at present. Much higher prices create a disincentive to a timely transition from CFCs. As the Multilateral Fund does not pay for a second transition, enterprises that have been financed by the Multilateral Fund to phase out CFCs by using HCFCs will bear the full cost of responding to accelerated HCFC scarcity and price increase.

2.2 Background on HCFCs

The London Amendment of 1990 to the Montreal Protocol recognised a list of HCFCs as transitional substances to phase out CFCs but required all Parties to report on the production, import and export of these HCFCs. The Copenhagen Amendment of 1992 included an expanded list of HCFCs in the list of controlled substances in the Protocol and prescribed control measures for the consumption, but not production, of these HCFCs by non-Article 5(1) Parties. The Copenhagen Amendment did not include a provision for controlling trade with non-Parties. Recognising that HCFCs are only transitional and not permanent replacements for CFCs, the Parties were asked to minimise the impact of the use of HCFCs on the ozone layer through many measures (Article 2F, Paragraph 7). The Copenhagen Amendment did not include any controls for Article 5(1) Parties but decided to take a decision on the measures before 1996.

At their seventh meeting in 1995, the Parties prescribed control measures for Article 5(1) Parties: a freeze in 2016 on the base year consumption of 2015, and a 100 percent phase-out by 2040. This meeting also reduced the base level of non-Article 5(1) Parties slightly.

In 1999, the Amendment by the Meeting of the Parties in Beijing mandated a production freeze on HCFCs by non-Article 5(1) Parties by the year 2004 and by the Article 5(1) Parties by the year 2016. However, producers can produce an additional 15 percent of their base level production to satisfy the basic domestic needs of Article 5(1) Parties. The Beijing Amendment also introduced trade controls with non-Parties from January 1, 2004. The Parties that have ratified the Beijing Amendment cannot trade with non-Parties. Non-Parties, in respect of HCFCs, include a State or a regional economic integration organisation that has agreed not to be bound by the control measures in effect for that substance (Article 4(9) of the Montreal Protocol). Countries that have not ratified the Copenhagen Amendment are not bound by the HCFC consumption control measures and countries that produce HCFCs but have not ratified the Beijing Amendment are not bound by the HCFC production control measures. These two categories of countries are non-Parties in respect of HCFCs. The specific control measures can be found in Annex 1. This Annex also gives the March 2003 status of ratification of both the Beijing and the Copenhagen Amendment.

Subsequently, the European Union and some other non-Article 5(1) Parties have promulgated their own regulations providing for an accelerated phase-out of HCFCs. Annex 2 provides a summary of national and regional regulations.

Consumption of HCFCs in Article 5(1) countries is still relatively low compared to non-Article 5(1) countries and specific regulations to address HCFCs have not been developed in many Article 5(1) countries. However, based on "Regulations to Control Ozone Depleting Substances: A Guidebook" (a 2000 report by UNEP DTIE Energy and OzonAction Unit, Paris and the Stockholm Environment Institute) the following Article 5(1) countries have requirements as listed below:

- Generally applicable bans on production, import, or sale of HCFCs by a certain date: Romania and Seychelles;
- Regulations banning imports or sale of certain products containing, made with or designed for use of ODS*: Bahrain, Brazil, Croatia, Egypt, Fiji, The Gambia, Indonesia, Jamaica, Jordan, Mongolia, Panama, Philippines, Romania, Seychelles, Thailand and Uruguay;
- HCFC use controls in various applications: Bahrain, China, Romania and The Gambia;
- Labelling of ODS products or equipment*: Croatia, Fiji, The Gambia, Indonesia, Jamaica, Jordan, Malaysia, Romania and Syria.
  (General category of "ODS" may include CFCs and/or HCFCs)*

2.3 Implications of the different control measures

The control measures of the Protocol and the regional and national regulations on HCFCs have led to an interesting situation.

1. The Protocol requires that non-Article 5(1) Parties reduce their consumption of HCFCs by 35% by the year 2004, by 50% by 2015 and 99.5% by 2020.

National and regional regulations have increased the pace of reduction of the consumption. The base level for production, for non-Article 5(1) Parties, is the average of the 1989 HCFC consumption plus 2.8% of the 1989 CFC consumption and the 1989 HCFC production plus 2.8% of the 1989 CFC production). The base level production plus 15% (to provide for meeting the basic domestic needs of Article 5(1) Parties) totalling about 44,500 ODP-tonnes, can continue to be produced by the non-Article 5(1) Parties undiminished after the freeze in the year 2004. This is a simplified explanation of the actual requirements of the Montreal Protocol which can be found in Article 2F(8).

2. In contrast to non-Article 5(1) Parties with their fast consumption reduction schedules, the Article 5(1) Parties can increase their consumption of HCFCs until 2015 without any limit. There are no stages of reduction in consumption prescribed for Article 5(1) Parties from 2015 until 2040, the year of their phase-out. Their consumption was about 12,000 ODP-tonnes in the year 2000; in that same year, their production was about 7,000 ODP-tonnes with about 5,000 ODP-tonnes imported from non-Article 5(1) Parties. There is no Protocol limit until the year 2016 on the production of HCFCs by Article 5(1) Parties. The Article 5(1) phase-out of CFC production mandated by the year 2010 will allow them to use some of their CFC production facilities (which total about 100,000 tonnes in capacity) to switch ("swing capacity") to the production of HCFCs, i.e. HCFC-22. This additional production is about 30,000 metric tonnes. Some concerns have been expressed to this scenario due to the likelihood of inadvertent production/emissions of HFC-23, which has a very high GWP and long atmospheric lifetime.

The Protocol currently allows:

- In non-Article 5(1) Parties: continued production at the base level indefinitely, while at the same time the consumption will decline rapidly in order to comply with Montreal Protocol controls and regional regulations.
- In Article 5(1) Parties: increasing consumption allowed until the year 2016, no controls on production until 2016 and imports of up to the maximum production allowance of HCFCs from non-Article 5(1) Parties.

2.4 Some factors which may reduce HCFC consumption

The consumption of HCFCs by the developing countries may be less than the limits allowed by the Protocol due to many reasons.

a. Some Article 5(1) HCFC manufacturers, in particular the multinationals, may reduce the production levels or even close their production facilities with or without Multilateral Fund support in the future.

b. As their phase-out of HCFCs proceeds, the non-Article 5(1) Parties may prohibit import of equipment containing HCFCs. The developing countries that export such equipment, (e.g., China, India, Malaysia) will have to shift to non-HCFC technologies in order to protect their export markets.

c. The rapid decline in demand for HCFCs in non-Article 5(1) Parties may lead to the rationalisation of the HCFC production through the creation of a few facilities owned by a small number of manufacturers. This may increase the prices of HCFCs and accelerate the shift to non-HCFC alternatives by Article 5(1) Parties, unless the Article 5(1) Parties take up the production of HCFCs on a large scale.

d. The control of trade in HCFCs by the Parties to the Beijing Amendment with non-Parties (HCFC producing countries that do not ratify the Beijing Amendment and countries that do not ratify the Copenhagen amendment will be non-Parties to the Protocol in respect to HCFCs (by March 2003, 39 Parties out of the 184 Parties that have ratified the Montreal Protocol, have not ratified the Copenhagen Amendment).

e. In addition, some Article 5(1) countries may want to either limit the increase in their dependency on a transitional substance scheduled for phase-out or initiate a multi-stage phase-out between 2015 and 2040, instead of the "crash" approach of the control schedules in the Copenhagen Amendment, by introducing national consumption restrictions.

While many HCFCs are in the list of controlled substances, only HCFC-22, -123, -124, -141b, -142b and –225ca/cb are consumed in significant quantities.

3 Status of HCFC Use

3.1 General

The hydrochlorofluorocarbons (HCFC) are a group of ozone depleting substances with an ozone depletion potential significantly lower than CFCs. Some HCFCs have been used since the 1940's - in particular HCFC-22 as a refrigerant- while for most other uses these substances have been selected as CFC replacements because their physical properties are relatively similar to those of certain CFCs. Table 3-1 provides a brief overview over those substances mentioned in Annex C, Group I of the Montreal Protocol which have a significant consumption and shows their prevalent uses.

Table 3-1

Important HCFCs, their ODP according to Annex C Group 1 to the Montreal Protocol /MPH00/ and their prevalent uses

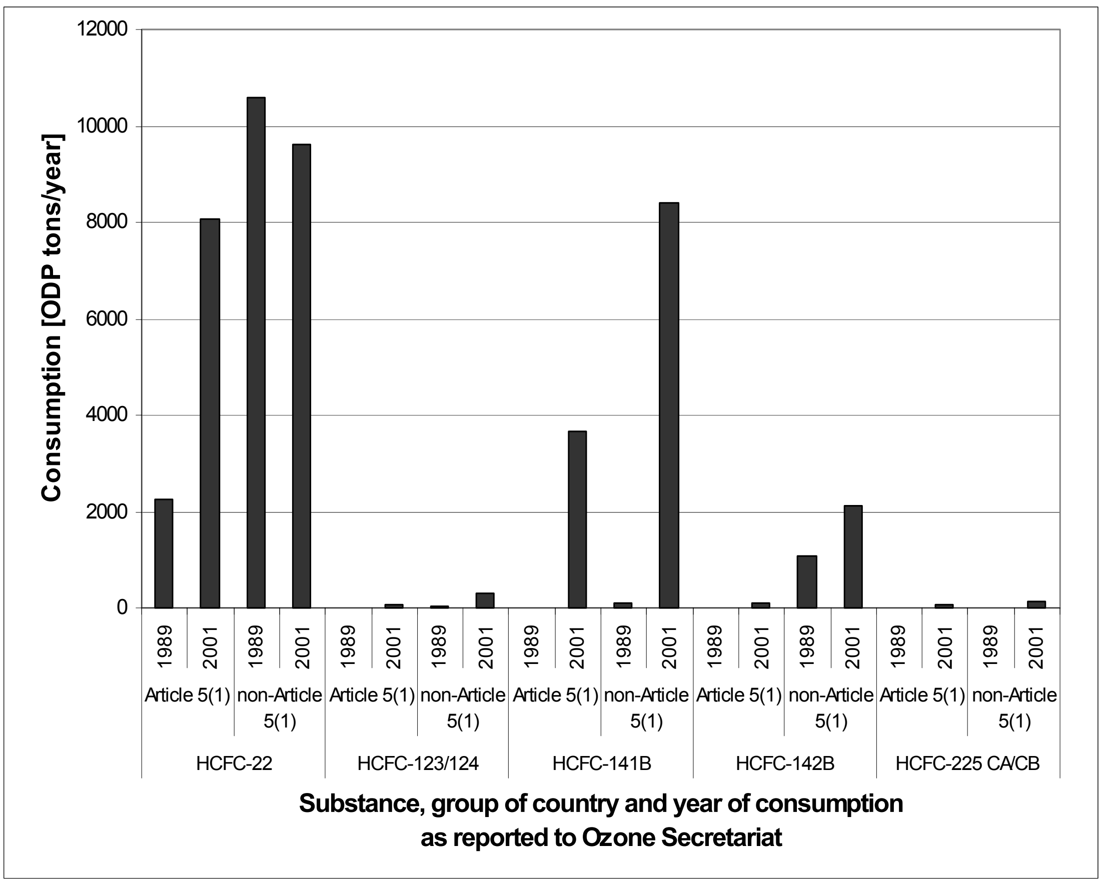
Substance	ODP	Significant use prior 1989	Replacement for / predominant use today
HCFC-22	0.055	Refrigerant for room and packed air conditioners, small water chillers	Uses as prior to 1989, plus: Replaces CFC mixture R502 in commercial refrigeration equipment (non-exclusive) Replaces CFC 12 in smaller chillers, commercial and some other applications (non-exclusive) Mixture component in some CFC-12 drop-in replacements. Used in OEM and other foam applications.
HCFC-123	0.02	None	Replaces CFC-11 in centrifugal chillers and halon 1211 in portable fire extinguishers.
HCFC-124	0.022	None	Mixture component in some CFC-12 drop-in replacements Replaces CFC-114 in some heat pumps and special air conditioning equipment (non-exclusive). Also used in some sterilant mixtures.
HCFC-141b	0.11	None	Replaces CFC-11 as blowing agent in rigid polyurethane foams and integral skin foams. Significant use in solvent applications.
HCFC-142b	0.065	None	Replaces CFC-12 as blowing agent in extruded polystyrene board and is a mixture component in some CFC-12 drop-in replacements
HCFC-225 ca/cb	0.025 / 0.033	None	Replaces CFC-113 and TCA as a solvent. Both isomers are used separately or as a blend

For all uses mentioned in Table 3-1, HCFCs are not the only alternatives. Other alternatives include non-ODS, which in several cases have additional environmental benefits such as lower GWP. However, HCFCs have properties and handling characteristics, which often allow continued use of equipment and techniques already used for handling CFCs - characteristics that most non-ODS alternatives do not share.

1989 and 2001 consumption of various HCFCs in both non-Article 5(1) countries and Article 5(1) countries is shown in Figure 3-1. It should be noted that in many cases the increase in consumption between 1989 and 2001 has not been linear. Subsequent chapters present detailed information.

Figure 3-1

Consumption of important HCFC in Article 5(1) countries and non-Article 5(1) countries in 1989 and 2001 /OZS03/



Various HCFCs are presently used in more than one application, and some are used as a feedstock for the production of other chemicals. Table 3-2 provides an estimate of the current shares of the use as feedstock and the use in different applications for the most widely produced HCFCs.

Table 3-2

HCFC uses and approximate consumption by application /VAR03/

Chemical	Refrigerant	Blowing Agent	Solvent	Fire Extinguishant	Feedstock
HCFC-22	55-65%	<5%	-	-	30-40%
HCFC-141b	<1%	90-95%	5-10%	-	-
HCFC-142b	<2%	33-43%	<1%	-	55-65%
HCFC-123	43-55%	-	<1%	<6%	40-50%
HCFC-124	75-85%	<1%	-	-	-
HCFC-225	-	-	100%	-	-

For all above applications, zero-ODP alternative technologies are available. Of those, some are based on HFCs with similar relevant technical properties as the HCFCs they replace. Those HFCs which could be used in refrigerant mixtures to replace HCFC-22 (in particular HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a) are all manufactured by more than one manufacturer and in more than one plant. HFC-245fa and HFC-365mfc, which are replacements for HCFC-141b in foam blowing applications are presently only manufactured in one plant each; both started their commercial production only recently. A second plant for HFC-245fa from a different manufacturer is presently under construction. HFC-227, which is used with HFC-365mfc in a blowing agent mixture, is produced in several plants by different manufacturers.

Since the consumption of the HCFCs in Annex C Group I of the Montreal Protocol will be limited as a group, and not by substance, the substances with small consumption influence national production and consumption obligations under the Montreal Protocol less than those with a very large consumption. This chapter will discuss the substances and their present use in terms of their relative share of ODP tonnes for Article 5(1) countries within Annex C, Group I substances. HCFC-22 has the largest share with 67.4% of the consumption, followed by HCFC-141b (30.7%), HCFC-142b (0.8%), HCFC-225 ca/cb (0.6%) and HCFC-123/HCFC-124 (0.5%). Share values are based on ODP-tonnes.

3.2 HCFC-22

HCFC-22 has been commercialized as a refrigerant since 1936. It is still mainly used as refrigerant, but has also some minor application as a component in foam blowing agents. It is also used in large quantities as feedstock for the production of important fluoropolymers. While this use does not constitute consumption by the definition of the Montreal Protocol, it nevertheless an important use for that substance and thus provides additional incentives for its continued production.

HCFC-22 was and continues to be by far the predominant refrigerant in small air conditioning equipment, such as window-mounted and through-the-wall air conditioners, non-ducted and ducted as well as packaged air conditioners; for details see /RTOC03/. Also, HCFC-22 has been used to a large extent in small water chillers of about 100 kW refrigeration capacity up to the capacity of centrifugal chillers, and to a small extent in centrifugal chillers. Finally, HCFC-22 has found widespread use as CFC-replacement in commercial refrigeration, because it offers cost advantages in certain applications over other CFC replacements. This refers both to small, plug-in units such as soft drink coolers and ice cream freezers, as well as systems installed on site in smaller shops as well as super- and hypermarkets.

Due to the large quantities of equipment produced, air conditioning uses and their service needs dominate the HCFC-22 consumption today and will largely determine the future demand. Other uses are mobile air conditioning equipment (e.g. trains, ships but not automobiles) and industrial refrigeration equipment (largely overlapping with the above market for smaller chillers).

A number of MLF projects converting the manufacturing of commercial refrigeration equipment and the compressors for it from CFC-12 to HCFC-22 technology have been approved with more than 99.5% of the phased out consumption achieved in China. These projects lead to an additional world-wide HCFC-22 consumption of 4,790 metric tonnes. More important than the replacement of CFC-12 systems is the market growth in that sub-sector. The use of commercial refrigeration equipment is increasing due to the spread of retail stores in particular in China, where the related refrigeration systems and their service are consuming almost as much HCFC-22 as small scale air conditioning

Finally, HCFC-22 is used as a mixture component in 12 different commercialised drop-in replacements for CFC-12 and 4 drop-in replacements for R-502 (mixture of 48.8% HCFC-22, 51.2% CFC-115), with a content (mass) between 22 and 75 % (average 52%) of HCFC-22 in the mixture (see also table 3-4 below). These drop-in refrigerants allow conversion of CFC-12 / R-502 equipment to non-CFC technology at a low cost. Such solutions have been used in non-Article 5(1) countries for some years to facilitate the conversion away from CFC-12 and R-502 and to allow operating CFC-12 / R-502 dedicated equipment beyond the availability of CFCs. Looking at the combined market of CFC refrigerant replacements, the use of such drop-in refrigerants with HCFCs has been minor in non-Article 5(1) countries. So far the use of such drop-in replacements in Article 5(1) countries has been even more limited, but might increase with decreasing supply of CFC-12 in those countries; China already has experience with the drop-in mixture of HCFC-22 and HCFC-142b. Alternatives to these drop-ins for existing equipment are retrofit of these systems to HFC-134a or, in specific cases, to hydrocarbons.

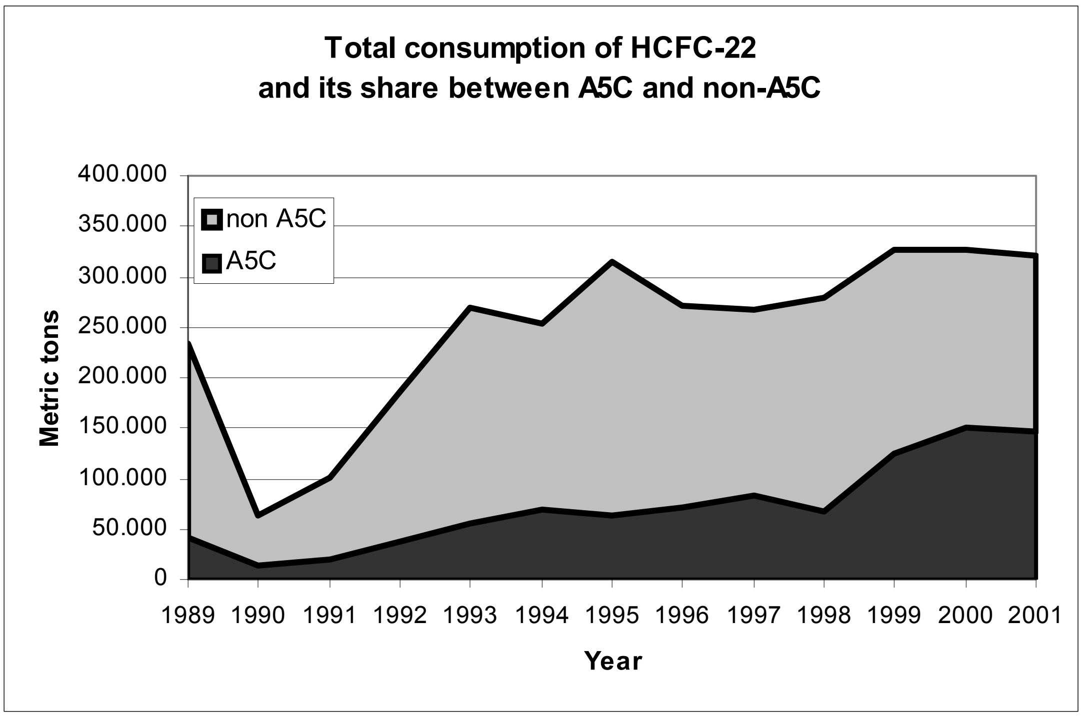
It is important to consider that use of certain refrigerants for refrigeration equipment production always leads to a service demand in subsequent years. The typical refrigeration equipment lifetime in Article 5(1) countries is 10 to 15 years and more with an increasing service need estimated to peak on average above 25% of the original filling needed annually. A major recent study in an Article

5(1) country suggests that even under optimum framework conditions, only about 33% or less of the refrigerant demand for service might be catered to through recovery and recycling measures /SIC03/. Countries now establishing a new large base of HCFC-22 equipment will probably face an increasing service related HCFC-22 demand during the compliance period from 2015 onwards, which will probably be higher than their demand for manufacturing of new equipment.

Figure 3-2 provides an overview over the development of HCFC-22 consumption in the time between 1989 and 2001.

Figure 3-2

Development of HCFC-22 consumption between 1989 and 2001 /OZS03/



Given the existing and likely future importance of small air conditioning equipment for HCFC-22 consumption, the developments in that specific market are important for any prediction of future HCFC growth. Essentially, there are three important trends in that market /JAR01; JAR02/:

- The world market for such systems is increasing significantly, largely due to a high market growth in China.
- The production of such systems is increasingly transferred from non-Article 5(1) countries to Article 5(1) countries. The important US-market for small air conditioning equipment is already to a large part supplied by products manufactured in Article 5(1) countries. Australia, Canada, Europe and New Zealand are largely supplied from Article 5(1) countries as well. In Japan the market share of products manufactured in Article

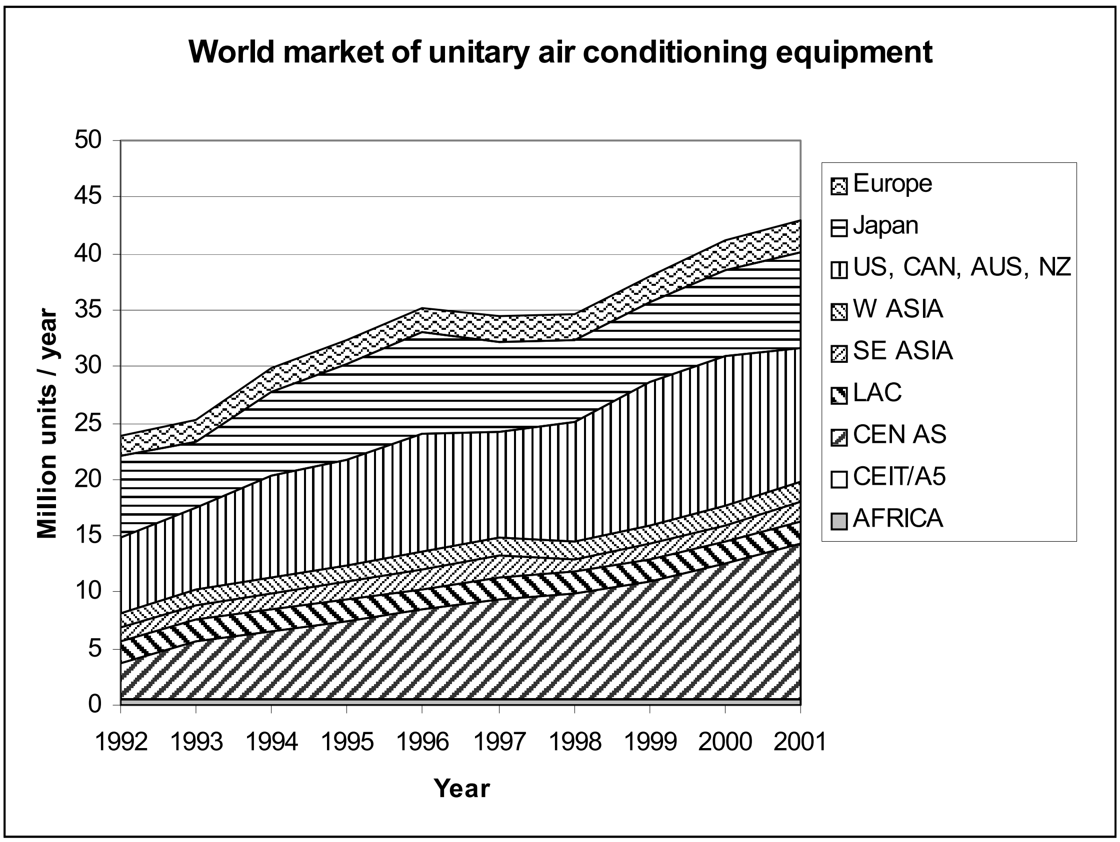
5(1) countries is said to be beyond 50%. This trend to transfer the production from non-Article 5(1) countries to Article 5(1) countries has developed over the last 5 years.

- Markets in non-Article 5(1) countries are likely to increasingly demand zero-ODP products. Starting 2008, the European Union will not allow imports of HCFC containing equipment. Japan is also likely to reduce imports. Presently there is no such legislation in the US.

Figure 3-3 provides an overview over of the market for room, split and unitary air conditioning products.

Figure 3-3

World market for unitary air conditioning products by region /JAR02; JAR03/



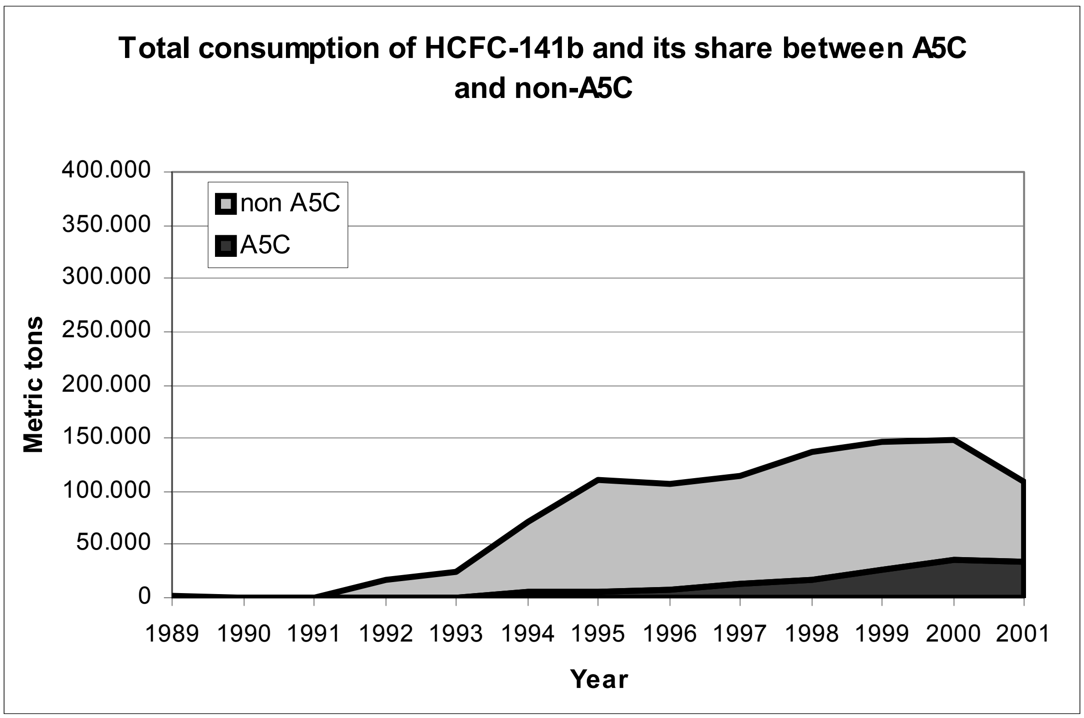
In 2001, the markets in non-Article 5(1) countries amounted to about 54% of the world market, at that time almost exclusively using HCFC-22 as refrigerant. At the same time, only about 15% of the equipment was produced in non-Article 5(1) countries /JAR02; JAR03/. In the mid-term, the exports of HCFC-containing goods like HCFC-22 air conditioners from Article 5(1) countries to non-Article 5(1) countries will decrease, and with them the related HCFC-22 consumption. The markets in developing countries might continue using HCFC-22 for their air conditioning equipment in the mid-term since it presently offers certain cost benefits to achieve any given level of energy efficiency. Co-production of both HCFC and non-ODS air conditioners in one plant is typically possible without major implications.

3.3 HCFC-141b

HCFC 141b is mainly used as foam blowing agent and for some solvent uses. Figure 3-4 provides an overview over the development of HCFC-141b consumption between 1989 and 2001.

Figure 3-4

Development of HCFC-141b consumption between 1989 and 2001 /OZS03/



HCFC-141b is mainly used as CFC-11 replacement in foam blowing applications. It is the one of the three important replacements for CFC-11 in the production of rigid polyurethane foam; this foam is used largely for insulation purposes. The other replacements are pentane (needing additional investments in safety equipment) and CO2/water (having lower thermal insulation quality). Since last year, zero ODP HFC foam blowing agents are available to produce foams with high thermal insulation.

A second important use of HCFC-141b as blowing agent is the production of integral skin foams; integral skin products are e.g. soles of shoes, but also internal parts of automobiles such as dashboards, steering wheels etc. While the experience of the Multilateral Fund shows non-ODS technologies to be sufficient for a wide variety of uses, for specific uses in the automotive field, HCFC-141b has been the only alternative.

Table 3-3

Sub-sectors in the foam sector, CFC-11 alternatives used in the MLF and the amount of CFC-11 phased out by those in approved MLF projects /MFS03/

	Alternative technology	**Phaseout in approved MLF projects**		
		ODP tonnes	***% of sub-total***	**% of total**
Rigid	HCFC-141b	28,780	57.80%	36.90%
	Pentane	19,040	38.30%	24.40%
	CO_2	1,150	2.30%	1.50%
	HCFC-22	710	1.40%	0.90%
	HFC-134a	80	0.20%	0.10%
	Sub-total rigid	*49,760*	*100.00%*	*63.90%*
Integral Skin	CO_2	3,080	68.30%	4.00%
	HCFC-141b	920	20.40%	1.20%
	Various non-halogenated	440	9.80%	0.60%
	HCFC-22	70	1.60%	0.10%
	Sub-total integral skin		*100.00%*	*5.80%*
Slabstock	Methylene Chloride	13,390	60.20%	17.20%
	Carbon dioxide	7,020	31.60%	9.00%
	Various non-halogenated	1,620	7.30%	2.10%
	HCFC (HCFC-141b, HCFC-22)	220	1.00%	0.30%
	Sub-total slabstock	*22,250*	*100.00%*	*28.60%*
Various	Various non-halogenated	1230	89.10%	1.60%
	HCFC-141b	150	10.90%	0.20%
	Sub-total various	*1,380*	*100.00%*	*1.80%*
Total	**-**	**77,900**	**-**	**100%**

The importance of these sub-sectors for Article 5(1) countries is shown in the statistics of the Multilateral Fund conversion projects. Table 3-3 provides an overview over the different sub-sectors of the foam sector and the amount of CFC phase-out in these sub-sectors.

About 38% of the CFC-11 phase-out from MLF foam sector projects approved by the end of 2002 was achieved by conversion to HCFC-141b with more than 95% of that use concentrating on the sub-sector of rigid polyurethane foam.

Table 3-4 provides a simplified overview of benefits and drawbacks of foam blowing technologies; for details please refer to Chapter 6, the foam chapter of this report.

Table 3-4

Overview of advantages and disadvantages of foam blowing agents for rigid polyurethane foam

Substance	**Advantage**	**Disadvantage**
CFC-11	Excellent properties, low price	Ozone depleting; phase-out scheduled
HCFC-141b	Good to very good properties, medium price, can with minor changes use CFC-11 equipment	Ozone depleting, interim substance, import restrictions into non-Article 5(1) countries
Pentane	Good properties, low running cost	Flammable, leading to additional investments for safety equipment; thus, also increased conversion costs from other blowing agents. Because of necessary investments only for larger systems (e.g. above 50 tonnes /ExC02/ of CFC-11); because of safety reasons not suitable for mobile systems
CO2/Water	Low price	Poor insulation properties
HFC-245fa	Good to very good properties, can be used without changes on HCFC-141b foaming equipment	High running cost
HFC-365mfc	Good to (in mixture with HFC-227ea) very good properties, can (in mixture with HFC-227ea) be used without changes on HCFC-141b foaming equipment. HFC-365mfc as the main component in certain, commercially advertised mixtures with HFC-227ea is not flammable. Other mixtures with various properties are available.	Pure HFC-365mfc is flammable.

The MLF financed an almost complete and early phase-out of the larger uses of CFC-11, since those projects were more cost effective. Therefore, the existing and eligible enterprises suitable for pentane technology have already been completed by MLF projects. Since the conversion costs to pentane technology in small companies are high in comparison to the conversion to HCFC-141b, it is likely that remaining companies will convert initially to HCFC-141b.

During the decade from 1992 to 2001, the amount of synthetic foam products in Article 5(1) countries grew significantly. Based on the consumption of CFC-11 and HCFC-141b and the project data from the MLF, an estimate was developed on how the CFC-11 consumption in Article 5(1) countries would have developed since 1991 if there would have been no Montreal Protocol; this estimate is shown in Figure 3-5.

Figure 3-5
Consumption of CFC-11 as foam blowing agent and total CFC-11 consumption replaced by alternative technologies in Article 5(1) countries /MFS03; OZS03/

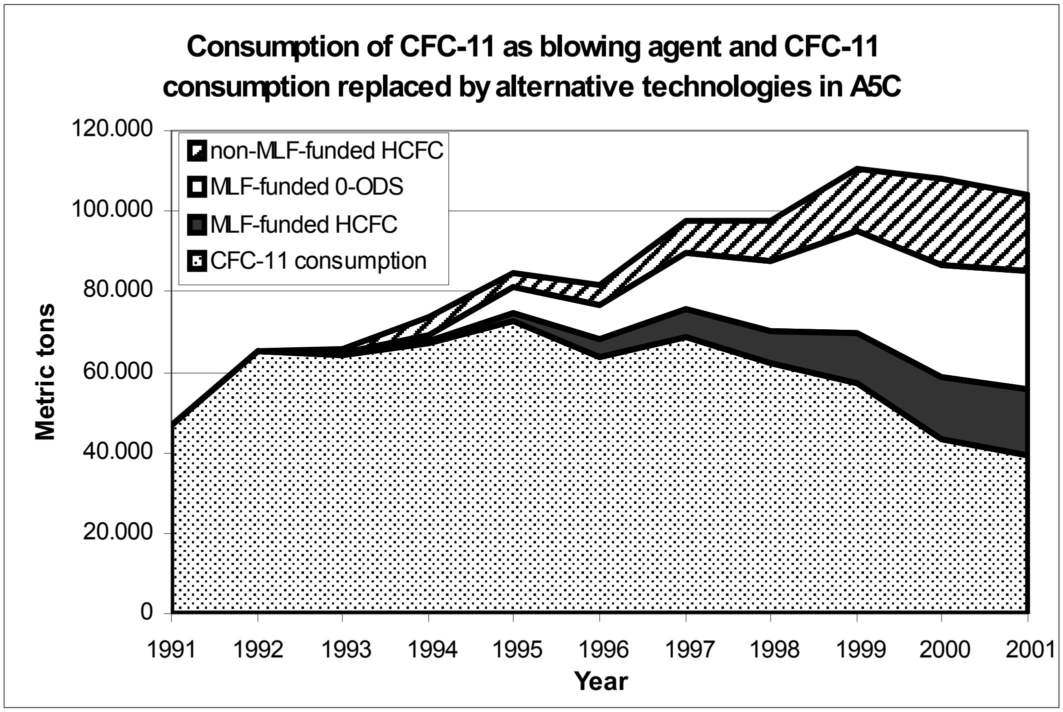


Figure 3-5 indicates that without the Montreal Protocol, there would have been a mean increase in consumption of CFC-11 for blowing in Article 5(1) countries by 5% per year between 1992 and 2001. CFC-11 consumption has been reduced by about 60% by the control measures.

Refrigerators exported from Article 5(1) countries to non-Article 5(1) countries (in particular from SE-Asia and China) are almost the only export product that use rigid polyurethane foams. The related HCFC consumption will decrease in the future because of import restrictions. In 2001 several million refrigerators using HCFC-141b foam were imported from Article 5(1) countries into non-Article 5(1) countries.

HCFC-141b and other foaming equipment can typically be used for 12-15 years before it has to be scrapped. Consequently, all equipment installed to replace CFC-11 foaming machines will likely be retired not later than 2025. HCFC-141b can be replaced by HFCs in existing foaming machines without modifications, producing similar quality foam. In future, most large foaming installations (above 200 metric tonnes per year) and where the slightly lower insulation values can be offset by an increase of foam thickness, will predominantly use pentane technology, even if HCFC-141b technology is available because of the lower operating costs of pentane technology. An exception is the US, where most major refrigerator manufacturers have committed to utilise HFC-245fa and agreed to long-term supply contracts. Unless there are cost increases, trade or legal restrictions, HCFC-141b will probably continue to be used for some time in smaller foaming operations.

HCFC-141b is also used as a solvent for several purposes, among them lubricants, coatings and cleaning fluids for aircraft maintenance and electrical, electronic or photographic equipment, mould release agents, document preservation sprays. In most cases, HCFC-141b is used as a replacement for CFC-113, although it is a much stronger solvent and can be aggressive to some plastics. Presently, the use of HCFC-141b in solvent applications is most widely found in non-Article 5(1) countries. In non-Article 5(1) countries, use as a solvent represents about 10% of the total HCFC-141b consumption.

3.4 Other HCFCs

HCFC-124 is mainly used as a component in CFC-12 replacement drop-in mixtures, similar to HCFC-22 (see above). HCFC-142b is used in a similar way in refrigeration, but most significantly in non-Article 5(1) countries as foam blowing agent. HCFC-142b is also used as a feedstock for fluorinated polymers and this application may become the market driver for HCFC-141b /HCFC-142b co-production as other uses decrease. The consumption of HCFC-142b and the combined consumption of HCFC-124 / HCFC-123 are shown in Figures 3-6 and 3-7[1].

[1] Combined presentation of HCFC-123/HCFC-124 data necessitated by data confidentiality

Figure 3-6
Development of HCFC-142b consumption between 1989 and 2001 /OZS03/

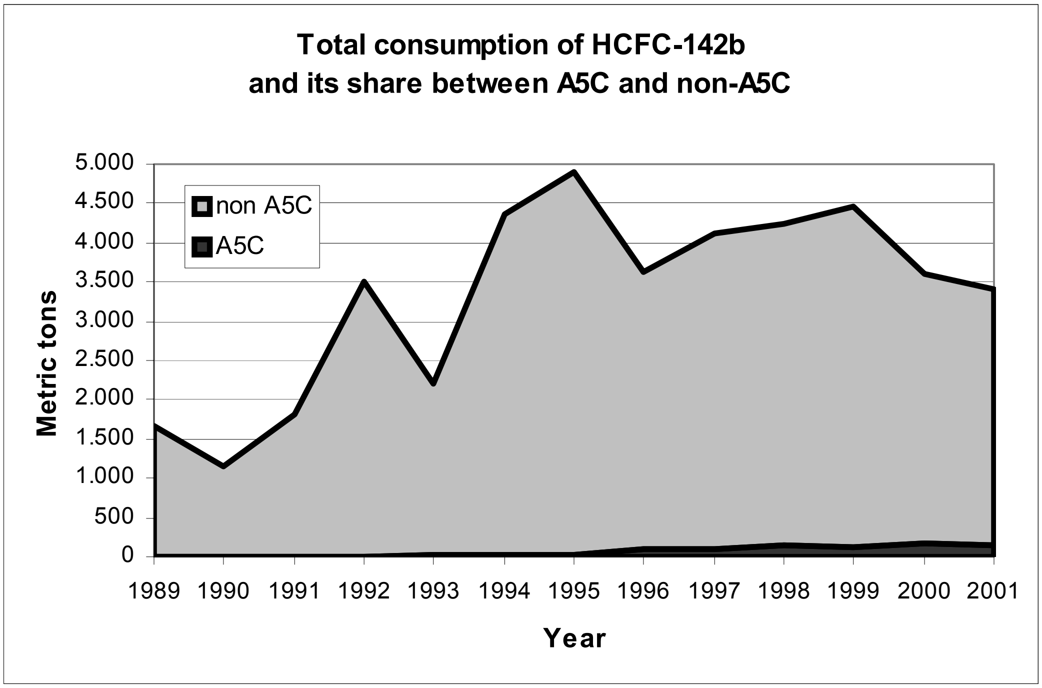
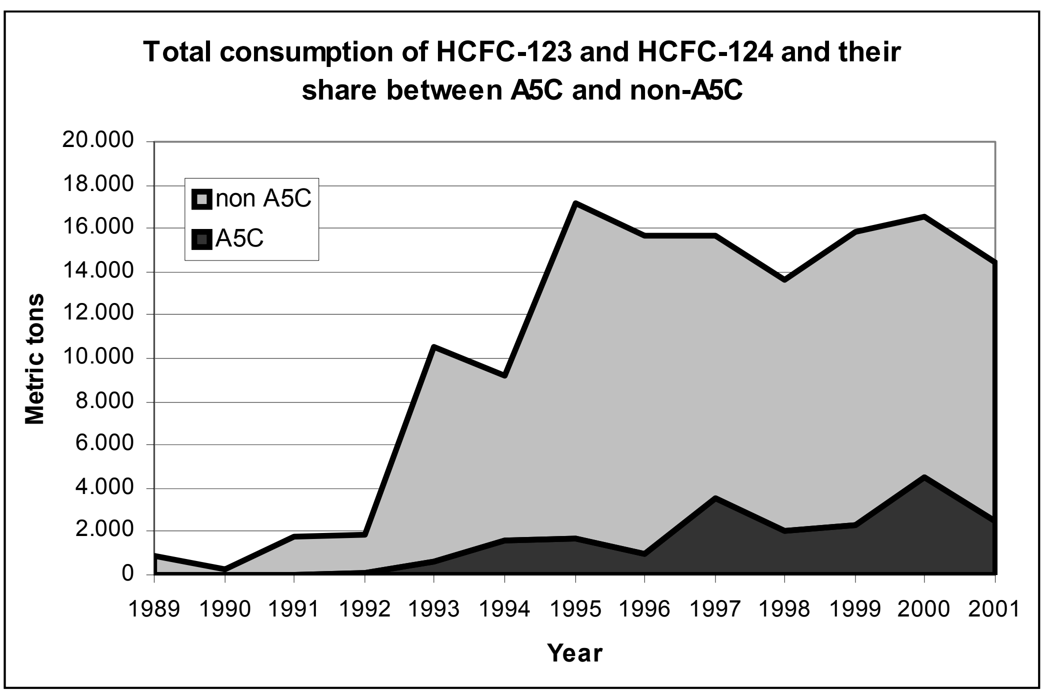


Figure 3-7
Development of HCFC-123 and HCFC-124 consumption between 1989 and 2001 /OZS03/



In comparison to the situation concerning the use of HCFC-22 in drop-in refrigerant mixtures, both the amount of mixtures concerned as well as the mass content of these substances in refrigerant mixtures is lower. Table 3-5 provides an overview of the number of mixtures presently in the market and the share of each in use.

Table 3-5

HCFCs as components of drop-in refrigerant mixtures

Substance	CFC replaced	No. of Mixtures Using the Substance	Minimum Mass Content In Mixture
HCFC-22	CFC-12	12	22%
HCFC-22	R-502 (mixture of 48.8% HCFC-22, 51.2% CFC-115)	4	38%
HCFC-142b	CFC-12	7	5.50%
HCFC-124	CFC-12	5	25%

One of the mixtures, HCFC-22 / HCFC-142b is manufactured and used in China for domestic refrigerators. This mixture has no ASHRAE designation, i.e. it is not officially acknowledged by the international refrigeration community and lacks binding standards concerning composition and quality. On the other hand, the components of this mixture can already today be manufactured in Article 5(1) countries, thus this mixture might play an important role in the replacement of CFC-12 in existing refrigeration equipment in Article 5(1) countries.

Refrigeration equipment utilising such drop-in mixtures would have been originally built for and typically operated with CFC-12 or the CFC/HCFC mixture R-502 as refrigerant. Consequently, the need for such refrigerant mixtures ceases once the equipment originally using CFCs is abandoned. The type of refrigeration equipment using CFC-12 which would be suitable for drop-in mixtures – mainly domestic and small to medium commercial equipment as well as mobile air conditioning equipment – has typical lifetimes of well below 15 years. This is also valid for the majority of equipment using R-502. Therefore the need for these mixtures ceases 15 years after the production of CFC-12 and R-502 equipment ceased, i.e. 2025 at the latest.

Among the 18 refrigerant mixtures available as drop-in replacements of CFC-12 and R-502 in existing refrigeration equipment, only one is HCFC-free. This mixture, R-413A, contains 9% (mass) of the fully halogenated PFC-218. Fully fluorinated PFCs for refrigeration purposes are considered for near-term bans in some countries because of their long atmospheric lifetime and their significant contribution to global warming.[2]

HCFC-123 can be used as an alternative fire-fighting agent to halon 1211 in limited applications. Unless there is significant increase in use by military users, long-term service needs are not expected to exceed 15 metric tonnes per year.

HCFC-123 is almost exclusively used for centrifugal chillers as both an almost exclusive retrofit solution for existing CFC-11 machines and as a energy and cost effective refrigerant for new equipment. HCFC-123 centrifugal chillers are presently built by two manufacturers in significant quantities and are installed in some non-Article 5(1) countries as well as in Article 5(1) countries. The CFC-11 technology and the HCFC-123 technology developed on its basis allow a cost effective design for which there is no non-ODS replacement yet approved; HFC-245fa is being evaluated for this application. The same cooling capacity can be provided with HFC-134a at competitive costs. Ammonia systems are technically feasible, however the system cost is likely to increase and in some cases the energy efficiency will be lower. Significant safety concerns related to the use of ammonia limit applications. HFC-134a machines are now state of the art in several non-Article 5(1) countries. The future availability of HCFC-123 over the lifetime of a chiller is uncertain, at least in those non-Article 5(1) countries which are considering legislation banning supply of HCFCs. On the other hand, North American and Japanese environmental authorities declared that they will comply with the Montreal Protocol without further controls on HCFC-123 if used in energy efficient building chillers. Centrifugal chillers typically have a useful life of more than 20 years. An HCFC-123 chiller purchased today might well have a useful life until 2030 or beyond.

HCFC-225 ca/cb is used as a cleaning solvent for electronics and precision applications, replacing there the CFC-113. An azeotropic mixture (HCFC-225ca/cb + ethanol) is recommended for defluxing and dewatering. The consumption of HCFC-225 ca/cb is shown in Figure 3-8.

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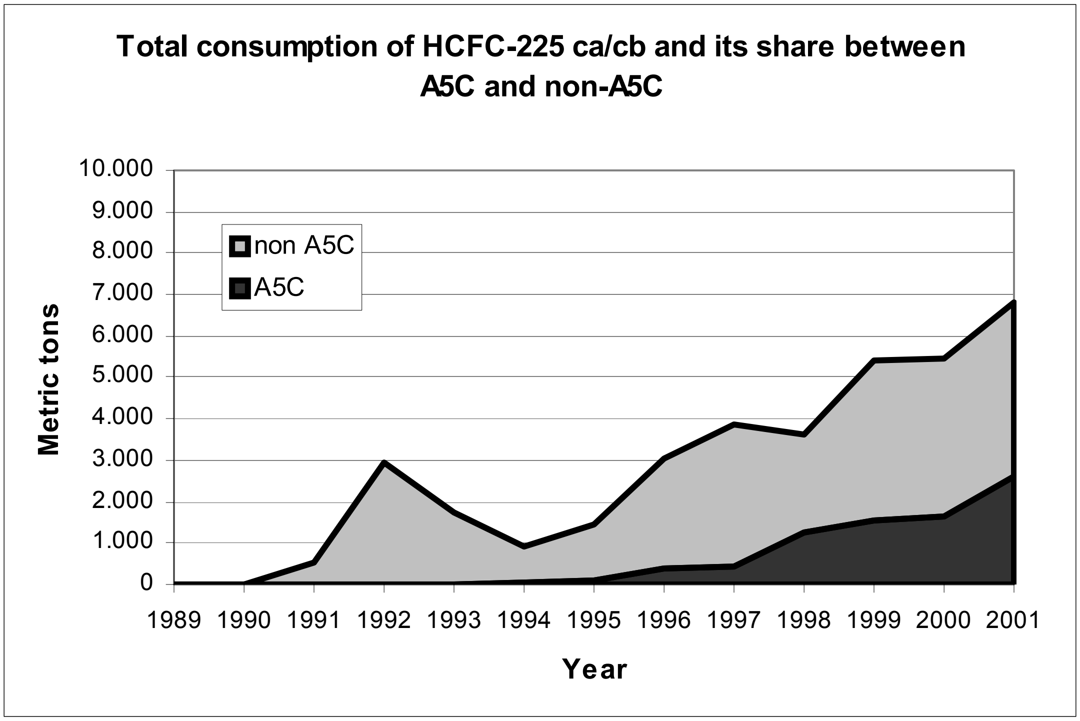
[2] Although hydrocarbons and/or their mixtures are possible replacements for CFC-12 and R-502 with minimum or no necessary changes to the refrigerant cycle, they are in this context not considered drop-ins because of the necessary safety related changes on the equipment.

Figure 3-8

Development of HCFC-225 ca / cb consumption between 1989 and 2001 /OZS03



3.5 References

/ExC02/ Report of the thirty-sixth meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol; Montreal, Canada; March 2002

/JAR02/ Japan Air Conditioning, Heating and Refrigerating News: Trends of Room / Packaged Air Conditioners in the World; Tokyo, Japan Mai 2002

/JAR01/ Japan Air Conditioning, Heating and Refrigerating News: Trends of Room / Packaged Air Conditioners in the World; Tokyo, Japan Mai 2001

/MFS03/ Inventory Database “Agency 38” of the Multilateral Fund Secretariat, containing Multilateral Fund project information as per January 2003.

/MPH00/ Handbook for the International Treaties for the Protection of the Ozone Layer Ozone Layer; fifth edition; UNEP, Ozone Secretariat; Nairobi, Kenia; 2000

/OZS03/ Information from the Ozone Secretariat based on consumption reported by parties to the Montreal Protocol, obtained February/March 2003

/RTOC03/ 2002 Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee; 2002 Assessment", Nairobi, Kenya, January 2003

/SIC03/ Sicars, Stephan: Refrigerant emissions in India and means of reduction; Presentation at the 2003 Earth Technologies Forum; Washington, D.C., USA, April 2003

/VAR03/ TEAP HCFC Task Force estimate based on personal communications with various chemical manufacturers carried out independently

4. Global capacities for HCFC production

4.1 Introduction

From a number of data sources, including UNEP and AFEAS, it is possible to make rough estimates of the capacities for the production of HCFCs in different regions. These are listed in Table 4-1 below for the year 2002. The data include production for feedstock uses (HCFC-22 and HCFC-142b). Data for HCFC-123 and HCFC-225 have each been aggregated for proprietary reasons.

Table 4-1

Estimated HCFC production capacity in the year 2002 (number of plants in brackets) (all volumes in ktonnes)

Region	HCFC-22	HCFC-141b	HCFC-142b	HCFC-123	HCFC-124	HCFC-225
Europe	185 (10)	40 (2)	40 (2)	(1)		
N America	165 (3)	50 (2)	45 (2)	(1)	8-10 (2)	(1)
Japan	90 (5)	20 (2)	7 (1)			(2)
China	125 (10)	15 (?)	5 (?)	(1)	(1)	
Asia, RoW	36 (4)	5 (1)				
S America	5 (3)					
TOTAL	**606 (36)**	**130 (7+?)**	**97 (5+?)**	**6-8 (3)**	**8-10 (3)**	**10 (3)**

It has been possible to forecast HCFC production capacities for the year 2010, based upon potential market trends and the impact of regulations in non-Article 5(1) countries. An important regulation to be considered for these estimates is the European regulation No 2037/2000, in particular its Article 3 on production. The estimates for 2010 are given in Table 4-2; they include feedstock which production is not subject to the reductions steps in the EU e.g. the year 2008 (65% reduction from base 1997 levels). The influence of the European regulation can be clearly observed in the estimated decrease of the HCFC-22 and HCFC-141b production levels by 67 and 13 ktonnes, respectively (the remaining production figures include feedstock production). It should be borne in mind that the reduction between 2002 and 2010 will not be equal to the reduction of 65% as mentioned in the EU regulation for the year 2008. It is actually lower since particularly the HCFC-22 production level had already considerably decreased between the year 2000 (the EU freeze year at baseline) and 2002. This Table on estimated capacity has been developed independently of the demand estimates.

Table 4-2

Estimated HCFC production capacity in the year 2010 (number of plants in brackets) (all volumes in ktonnes)

Region	**HCFC-22**	**HCFC-141b**	**HCFC-142b**	**HCFC-123**	**HCFC-124**	**HCFC-225**
Europe	118 (7)	27 (2)	40 (2)	(1)		
N America	165 (3)	40 (2)	45 (2)	(1)	8-10 (2)	(1)
Japan	70 (4)					(2)
China	147 (10)	21 (?)	5 (?)	(1)	(1)	
Asia, RoW	48 (4)	8 (1)				
S America	10 (3)					
TOTAL	**558 (31)**	**96 (5+?)**	**90 (4+?)**	**8-9 (3)**	**8-10 (3)**	**10 (3)**

It has also been possible to forecast HCFC production capacities for the year 2015, based upon potential market trends and the impact of regulations in non-Article 5(1) countries. The estimates for 2015 are given in Table 4-3; and they again include feedstock production. Several members of the Task Force with expertise in production independently considered the future demand scenarios included within the report over-estimate the 2010-2015 HCFC demand, especially for HCFC-22. Tables 4-2 and 4-3 on estimated capacities have been developed independently of the demand estimates. As there are differing perceptions at this time, the Task Force recommends that TEAP re-examines demand and supply estimates in 3-5 years.

Table 4-3

Estimated HCFC production capacity in the year 2015 (number of plants in brackets) (all volumes in ktonnes)

Region	**HCFC-22**	**HCFC-141b**	**HCFC-142b**	**HCFC-123**	**HCFC-124**	**HCFC-225**
Europe	105 (6)	10 (1)	40 (2)	(1)		
N America	165 (3)	15 (1)	40 (2)	(1)	8-10 (2)	(1)
Japan	65 (4)					(2)
China	160 (9)	25 (?)	5 (?)	(1)	(1)	
Asia, RoW	55 (5)	10 (1)				
S America	15 (3)					
TOTAL	**565 (30)**	**60 (3+?)**	**85 (4+?)**	**10 (3)**	**8-10 (3)**	**10 (3)**

4.2 HCFC-22

No new capacity is anticipated in Europe, Japan or North America as regulations impact on the consumption of HCFC-22. The demand for HCFC-22 as a feedstock for the manufacture of fluoropolymers will continue to grow. 30-40% of HCFC-22 production is believed to be used as a feedstock. New production of HCFC-22 is expected in China, India and South America. Some of this will result from the closure of production facilities for CFC-11 and CFC-12 and their "swing" to produce HCFC-22. This assumes that demand will be adequate to support existing capacity without non-Article 5(1) rationalisation.

4.3 HCFC-141b/HCFC-142b

HCFC-141b and HCFC-142b can be produced independently or co-produced. The technology for co-production rests with one producer and accounts for approximately 50% of total capacity in both products. Since the ratio between HCFC-141b and HCFC-142b can be fully varied, the resulting uncertainty on the global capacity of each chemical is of the order of +/- 25% . Approximately 60% of the production of HCFC-142b is used as a feedstock for VF2 which is then used as a feedstock for engineering polymers (PVDF). It is anticipated that regulations in Europe, Japan and USA, which demand an early phase-out of HCFC-141b as a foam blowing agent, will result in plant closures and reductions in capacity. However, the growing application of HCFC-142b as a feedstock will result in both products remaining available through 2015. Further capacity for the production of HCFC-141b is possible in, for example, India and China as a result of developments in the foam blowing market although this may be offset by the introduction of alternatives. The typical lifetime for a fluorochemical production plant is 25 years.

4.4 HCFC-123 and HCFC-124

Both products are produced on small manufacturing plants dedicated to HCFC-123/ HCFC-124 and also, as an intermediate with HCFC-124 in the production of HFC-125/HFC-134a. Large increases in consumption are not expected and no increase in production capacity is anticipated.

4.5 HCFC-225ca/cb

HCFC-225ca/cb is manufactured from tetrafluoroethylene and HCFC-21 on a small specific dedicated manufacturing facility by one company. It is believed that the current capacity is sufficient to meet future demand.

5 Projections of HCFC Refrigerant Demand Until 2015

5.1 Introduction - global inventories

Estimates of world-wide refrigerating and air-conditioning equipment have been made by the Center for Energy Studies (Ecole des Mines, Paris) to calculate the CFC, HCFC and HFC refrigerant markets, banks and emissions for the period 1990-2000. The Refrigerant Inventory Emission Pre-vision (RIEP) has been developed to perform those calculations. The Country Data Base (CDB) of economic, demographic and technical data provides an initial database. Then the Refrigerant Inventory Emission Pre-vision (RIEP) is used to obtain information on all the numbers and all the types of equipment in the different application sectors. This work has been financially supported by GGEEC[3] and the French EPA, ADEME[4]. Results have been presented in different papers, where the last one was presented in April 2003 /PAL03-1/.

Based on the global refrigerant inventories /Pal03-2/, the development of the HCFC market between 2003 and 2015 has been determined using the RIEP program data until 2000. Projections towards 2015 have been performed in spreadsheets using the assumptions explained in section 5.2 below. The refrigerants HCFC-22, -123, -124 are considered together, where HCFC-22 represents about 95% of the total. For Article 5(1) Countries, the projections are based on two different economic scenarios, one with a "low", and the second one with a "high" economic growth. For the non-Article 5(1) countries a single growth scenario has been taken into account.

5.2 Main applications where HCFC are used as refrigerants

The dominant application of HCFC-22, both in non-Article 5(1) countries and in Article 5(1) countries, is stationary air conditioning. This refrigerant is mainly applied in air to air systems but it can also be found in medium size chillers. The second largest application can be found in the commercial refrigeration sector where it concerns all types of systems, from condensing units in the range of 5 kW to large centralised systems in supermarkets. Moreover, HCFC-22 is also used in mobile air conditioning systems for buses, trains, and boats. In the food industry and in cold storage, HCFC-22 and ammonia were the leading refrigerants, and HCFC-22 is still the dominant refrigerant in those sectors in Article 5(1) countries.

Furthermore, HCFC-22 is used in a number of transitional, HCFC containing blends (R-401, R-402, R-408, R-411, R-412, and R-414), which have been designed as a replacement for CFC-12 and R-502. Of the non-Article 5(1)

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3 GGEEC: Greenhouse Gases Emissions Estimating Consortium

4 ADEME: French Agency for Environment and Energy Management

countries, only Europe has chosen for an early HCFC phase-out schedule, resulting in a more rapid shift to non ODS refrigerants. HCFC-22 will be used in the U.S. until 2006-2008, especially for stationary air conditioning and commercial refrigeration, even for new equipment. As mentioned in the next section, the main uncertainty in forecasting how the HCFC refrigerant markets will develop is linked to the economic growth of the Article 5(1) countries, and China in particular.

5.3 Calculation method and assumptions

The demand for HCFC refrigerants (essentially HCFC-22, -123 and -124) is projected until the year 2015. This market includes the HCFCs charged into new equipment, and the HCFCs used for the recharge of existing systems. Via the projection of the market for new equipment according to the regional economic growth rate, the refrigerant demand for new equipment is calculated. The specific use of refrigerants depends on the type of application, on the Montreal Protocol control dates and on national regulations. Phase-down and phase-out dates (Protocol) as well as the main regional regulations have been taken into account in the forecast of the refrigerant demand. Via the calculated market of new equipment and the related refrigerant charges the refrigerant bank during the period 2000-2015 can be determined.

The amount of fugitive emissions is known for each refrigeration sub-sector, and is directly related to the size of the refrigerant bank. The maintenance refrigerant market essentially compensates for the emissions. The total refrigerant market is the sum of the refrigerant demand for charging new equipment and the refrigerant demand for maintenance of existing equipment.

5.4 Growth rate calculation

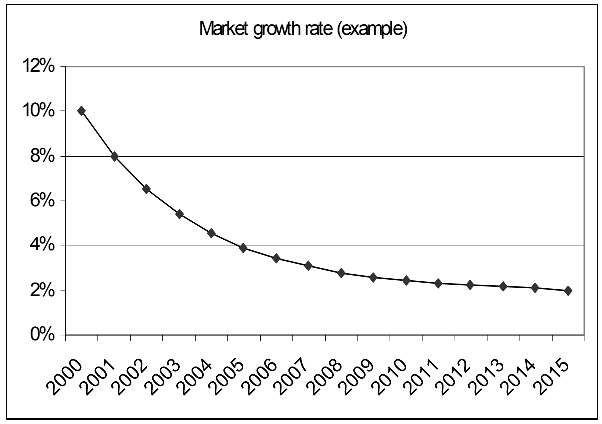
The market growth rate of new equipment has been calculated for each year from 1990 until 2000; this has been done for the different regions separately. The resulting average growth rate for a region is then used for the next 15-year period, from 2000 to 2015, together with additional assumptions.

5.4.1 Assumptions for non Article 5(1) Countries

For non-Article 5(1) countries, different positive or negative growth rates have been considered, depending on the trend observed during the period 1990-2000. Particularly in the EU and Japan, where the decrease of HCFC demand began around the year 2000, an asymptotic decrease has been applied as indicated in Figure 5-1. Figure 5-1 presents the example of the decrease following an asymptote, with 10% market growth in 2000, decreasing to 2% growth in the year 2015.

Figure 5-1

Curve describing the asymptotic trend



For countries such as the USA, where the HCFC demand remains high, a growth rate of 2% is applied up to the year 2006. Thereafter the control schedule dates of the Montreal Protocol are followed. It should be noticed that the quantity supplied from new production can be different from the demand, especially when phase-down and phase-out schedules are planned. In order not to run out of refrigerant for maintenance, users normally stockpile refrigerant in the two or more years preceding the restrictions according to the regulation. However, if one would integrate the market and the demand over a longer time frame, the integrated quantities of market and demand are nearly identical.

5.4.2 Assumptions for Article 5(1) countries

The unknowns on economic growth rates as well as the uncertainty regarding the shift from HCFC refrigerants to alternatives result in two scenarios for Article 5(1) countries, one considering the low demand and the other one the high demand.

Low HCFC demand

For the low demand scenario, the growth rate in the year 2000 is taken as the reference if the growth rate was above 2% in the period 1990-2000; thereafter a decrease down to 2% in 2015 is assumed as presented in Figure 5-1. Moreover, if --following this assumption-- the market were to double from 2000 to 2015, the growth rate is modified in order to limit the total HCFC refrigerant sales to twice the quantities sold in 2000. These assumptions are applied region by region and for each application.

High HCFC demand

The growth rate assumed for the 15-year period 2000-2015 depends on several conditions:

- If the average market growth for the period 1990-2000 is lower than +7% per year, the projected market growth rate has been assumed equal to the average 1990-2000 one; the period 2000-2015 is then characterised by a constant growth rate.
- If the average market growth rate for the period 1990-2000 is higher than +7% per year, the projected growth rate is assumed to decrease following an asymptotic curve. It starts in 2000 with the value of the average growth during 1990-2000, and then decreases to +7% in 2015 following an asymptote.

5.5 Development and projections of HCFC demand from 1990 to 2015

As indicated in section 5.1, the numbers available for the period 1990 to 2000 originate from calculations performed with RIEP. For the period 2000-2015, calculations have been carried out in spreadsheets with the assumptions as given in section 5.4. The impact of the phase-down and phase-out dates in non-Article 5(1) countries leads to a sudden decrease of the demand in those years that regulations define reduction steps in consumption levels. It can be seen in Figure 5-2 that after the dates of the enforcement, a growth still exists in the year following the year with a reduction step. These trends are caused by the absence of a certain phase-down in Article 5(1) countries but it is also related to the demand of refrigerant that still exists and that is usually covered by the refrigerant quantities stockpiled before the enforcement dates.

Figure 5-2 and Table 5-1 present the numbers for the low HCFC refrigerant demand scenario in the Article 5(1) Countries. Figure 5-3 and Table 5-2 present the figures for the high HCFC refrigerant demand.

Figure 5-2
HCFC refrigerant – Low demand.

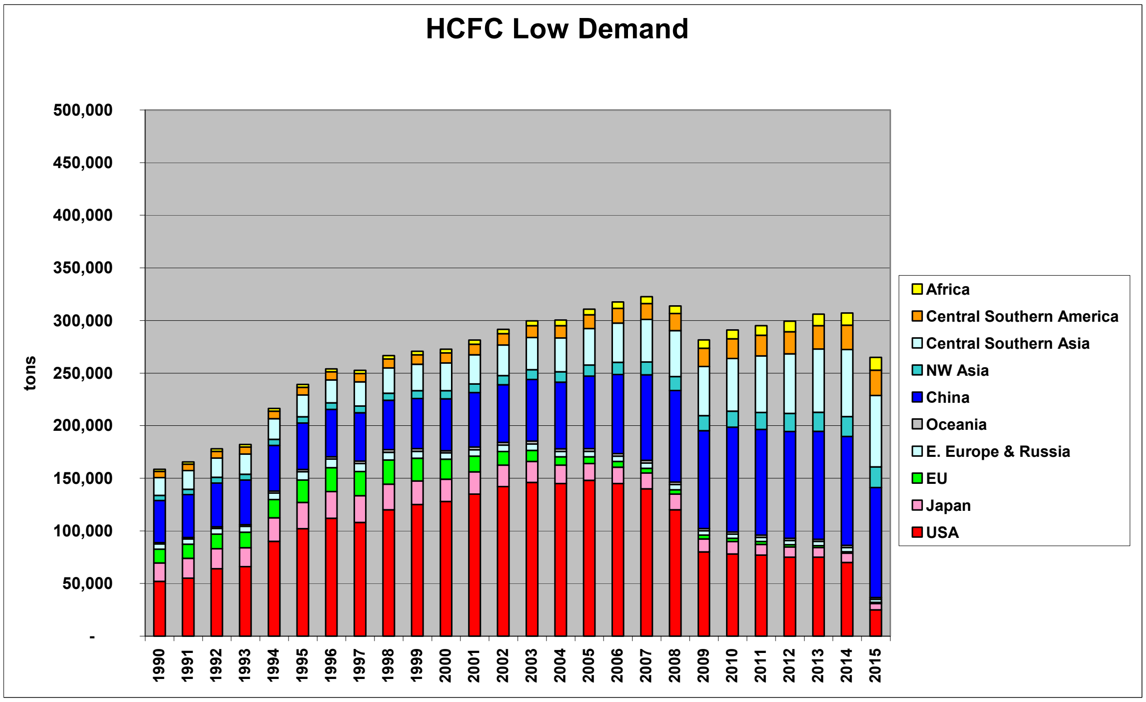


Figure 5-3
HCFC refrigerant – High demand.

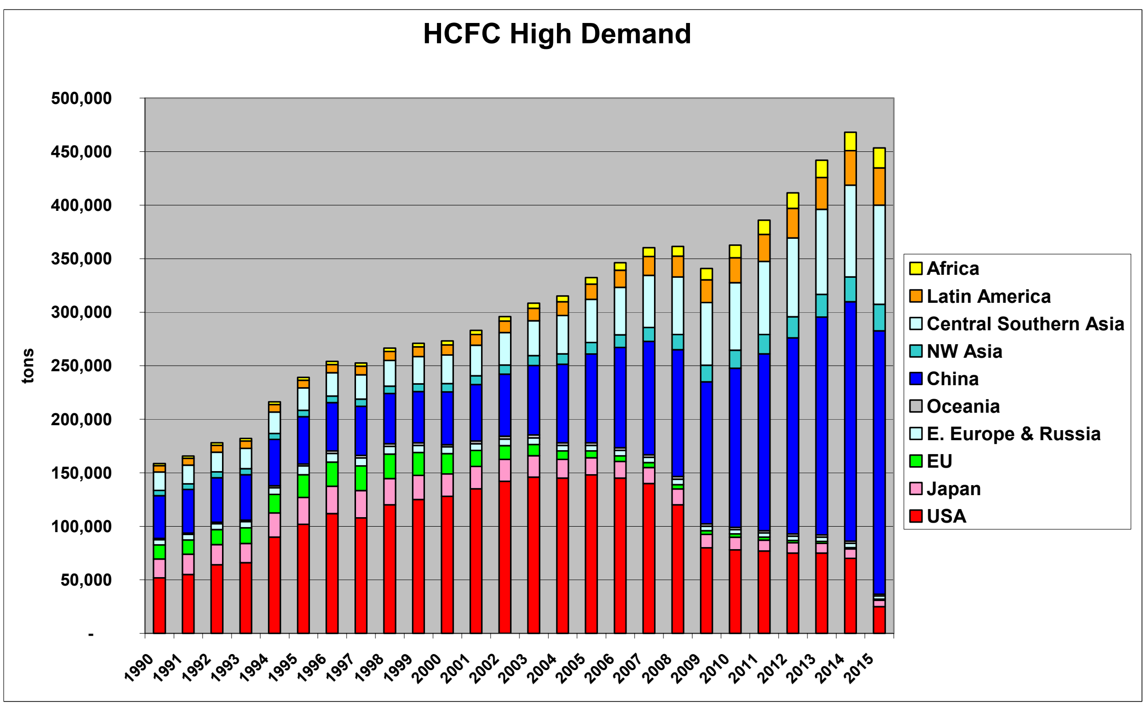


Table 5-1 *HCFC refrigerant – Low demand*

Year	Article 5(1) Countries	Non Article 5(1) Countries	Total
1990	69899	88737	158636
1991	71935	93689	165624
1992	74039	103889	177927
1993	76213	105864	182077
1994	78460	137840	216300
1995	80783	158339	239122
1996	83524	170436	253960
1997	86377	166263	252640
1998	89348	177195	266542
1999	92595	178064	270659
2000	96465	176211	272676
2001	101568	179698	281266
2002	107501	184114	291615
2003	114334	185337	299671
2004	122236	178001	300238
2005	132699	178076	310775
2006	144060	173416	317476
2007	155645	166964	322609
2008	167349	146446	313795
2009	179206	102207	281413
2010	191906	99043	290949
2011	199196	95977	295174
2012	206398	92930	299328
2013	214006	92076	306082
2014	220910	86247	307158
2015	228347	36555	264902

Table 5-2 *HCFC refrigerant – High demand.*

Year	Article 5(1) Countries	Non Article 5(1) Countries	Total
1990	69900	88737	158637
1991	71936	93689	165625
1992	74040	103889	177929
1993	76214	105864	182078
1994	78461	137840	216301
1995	80784	158339	239124
1996	83525	170436	253961
1997	86379	166263	252642
1998	89349	177195	266544
1999	92836	178064	270900
2000	96972	176211	273183
2001	103354	179698	283052
2002	111879	184114	295993
2003	123058	185337	308395
2004	137173	178001	315174
2005	154332	178076	332408
2006	172844	173416	346261
2007	193291	166964	360255
2008	215061	146446	361507
2009	238629	102207	340837
2010	263665	99043	362708
2011	289924	95977	385901
2012	318587	92930	411517
2013	349861	92076	441937
2014	381917	86247	468164
2015	416943	36555	453498

The comparison of the two series of tables and figures shows how important assumptions of growth rates are to estimate future demand. The amounts estimated are also related to the choice of the refrigerant for air conditioning (and commercial refrigeration) in China. In the case of the low demand scenario, a global HCFC refrigerant demand in the range of 300,000 metric tonnes is calculated for 2015; in the case of the high demand the calculation results in about 450,000 metric tonnes for the demand in 2015. However, since the projections are in the range of 300,000 metric tonnes for the low demand and 350,000 metric tonnes for the high demand in the year 2008, it seems that the projections will need to be updated in three to five years to obtain a better idea of the trends valid for the period 2008-2015.

5.6 References

/Pal03-1/ Palandre, L., Zoughaib, A., Clodic, D., Kuijpers, L. Estimation of the world-wide fleets of refrigerating and air-conditioning equipment in order to determine forecasts of refrigerant emissions. The Earth Technology Forum, Washington, April 2003.

/Pal03-2/ Palandre, L., Zoughaib, A., Clodic, D. Estimation of the world-wide fleets of refrigerating and air-conditioning equipment in order to determine refrigerant emission forecasts – Year 2000. Report for GGEEC and ADEME, December 2002.

6 Projections of HCFC Demand for Foams Until 2015

6.1 2001 Demand

Based on data collected by the Foams Technical Option Committee (2002 report), tables 6-2, 6-3 and 6-4 provide the foam sector demand for the year 2001 by chemical (HCFC-141b, HCFC-142b and HCFC-22). Total HCFC consumption for foams is estimated at 142,560 metric tonnes. HCFC-141b, mostly used as blowing agent for PU rigid and integral skin foams and, in a minor portion, for phenolic foam, accounts for slightly more than 75 % of the total world demand for HCFCs in foams but, if only Article 5(1) countries are considered, it represents 99.6 % of the HCFC consumption. HCFC-142b, which has the second largest share (17 % of the total), is mainly applied in non-Article 5(1) countries for polystyrene boardstock production. Some amounts, less than 2 %, are used for polyethylene foam production. The rest of the demand, concentrated on PU rigid and PS boardstock foam, is covered by HCFC-22.

Table 6-1

Global HCFC demand for year 2001

	Blowing Agent (tonnes)			
Foam type	**HCFC-141b**	**HCFC-142b**	**HCFC-22**	**Total**
Polyurethane	108,073	10	3,628	111,701
Polystyrene		23,668	5,370	29,038
Polyethylene		480		480
Phenolic	1,331			1,331
TOTAL	**109,404**	**24,158**	**8,998**	**142,560**

6.2 Future projection

6.2.1 HCFC-141b

An estimation of the global HCFC-141b demand for the period 2001-2015 is shown in Table 6-5. HCFC-141b is by far the most widely used product in the foam sector and, in Article 5(1) countries, it will continue to be a suitable transition candidate to replace the CFCs still currently used. The following points were considered in making the projection:

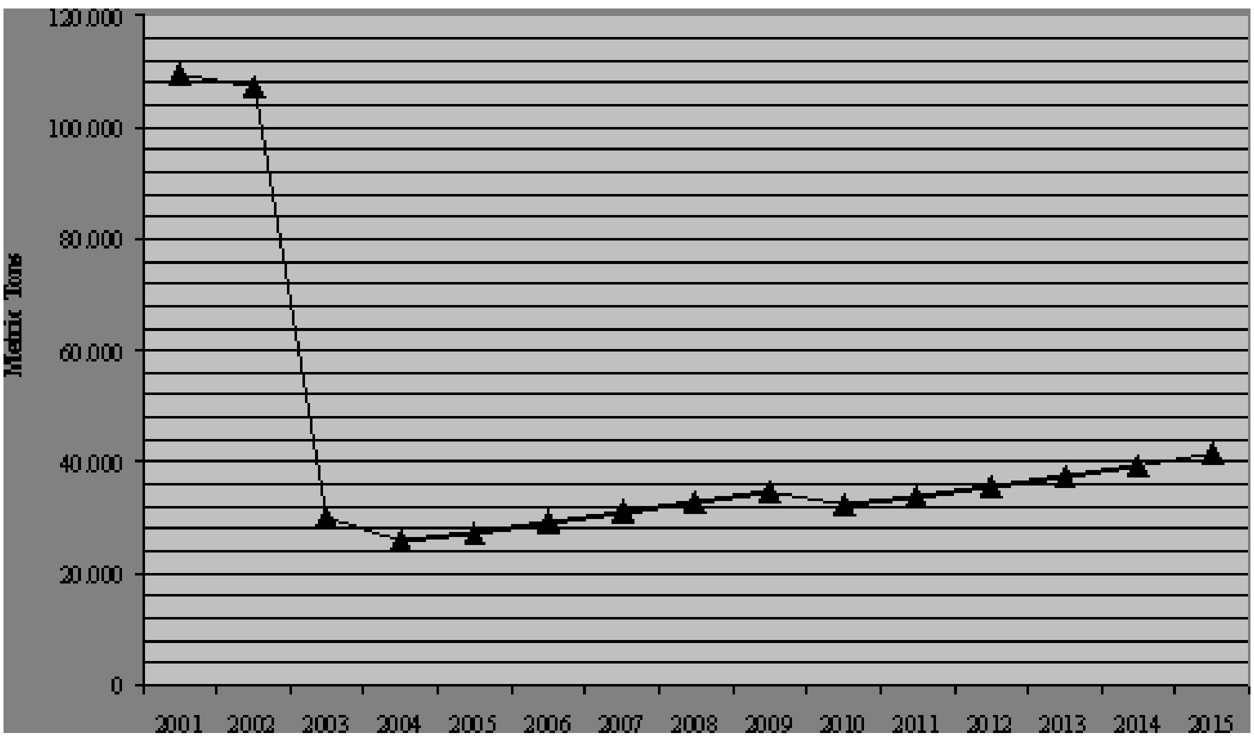
- The global demand data for 2001, described in Table 6-2 and gathered by Foams TOC, was taken as a basis.
- The growth rates of the geographic regions, corresponding to a high economic growth scenario, were taken from the estimation made by

Palandre, Zoughaib and Clodic[5], bearing in mind that the majority of the foam consumption in Article 5(1) countries is in the refrigeration industry as illustrated by Figure 6-1. Since it is essentially linked to new equipment manufacture, the average annual rates (domestic, commercial and industry) related to the refrigerant bank were used.

- There is currently a significant CFC consumption that should be gradually replaced by transitional or definitive solutions until its complete phase-out in the year 2010. An analysis of the Multilateral Fund foam projects shows that 46 % of the present CFC consumption in Article 5(1) countries will be replaced by HCFC-141b.

From Tables 6-1 and 6-5 it can be derived that the HCFC-141b demand for year 2015 is slightly higher than 40 % of the estimated world-wide consumption for 2001.

Figure 6-2
Global HCFC-141b demand (2001-2015)



[5] Palandre, L., Zoughaib, A., Clodic, D. Estimation of the worldwide fleets of refrigerating and air-conditioning equipment in order to determine refrigerant emission forecasts – Year 2000. Report for GGEEC and ADEME, December 2002.

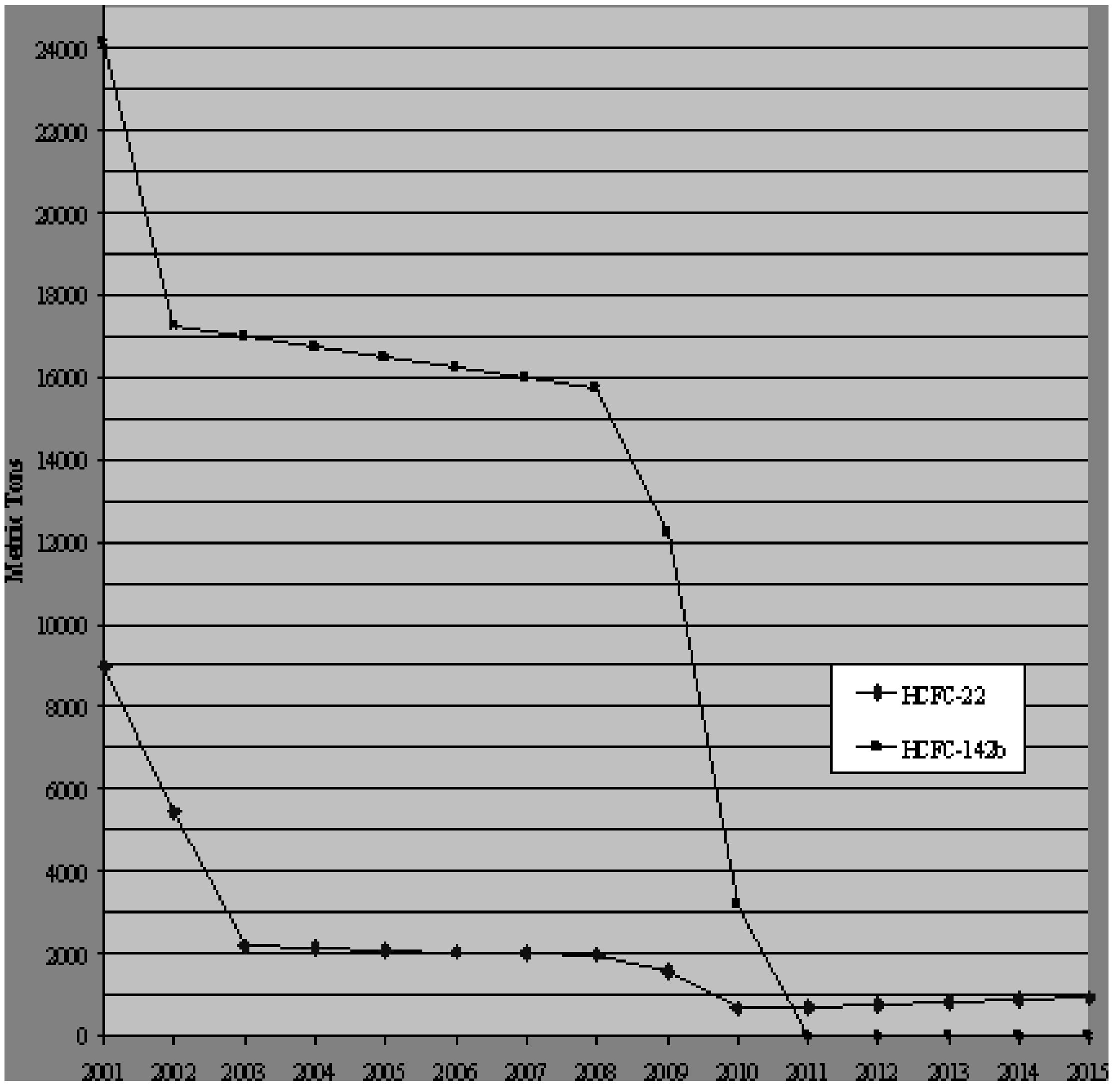
6.2.2 HCFC-142b and HCFC-22

As shown by Tables 6-3 and 6-4 the consumption of these blowing agents is almost negligible in Article 5(1) countries. The only exception is the use of HCFC-22 in Latin America for rigid foam applications, mostly in domestic refrigeration, where it is combined with HCFC-141b to lower the foam density by improving cell pressure and compression strength.

Tables 6-6 and 6-7 show the estimated future demand for HCFC-142b and HCFC-22. The following considerations were taking into account:

- These HCFCs have not been used in Europe since 2002. The conversion has been either to CO_2 or HFC based systems with significant penalties in process capacity and efficiency.
- In North America the Expanded Polystyrene (XPS) industry has not yet identified a transition away from HCFCs owing to particular challenges of the market, especially thermal insulation. Manufacturers are devoting significant resources to solve the problems associated with HFC use before the 2010 phase-out imposed by the US EPA.

Figure 6-3
Global HCFC-22 and 142b demand (2001-2015)



6.2.3 Total HCFC Demand

Figure 6-4 shows the evolution from 2003 to 2015 of the total HCFC demand in the foam sector. The expected consumption for the year 2015 is estimated at 42400 metric tonnes, 98 % of it being HCFC-141b.

Figure 6-4

HCFC demand (2001-2015) in the foam sector

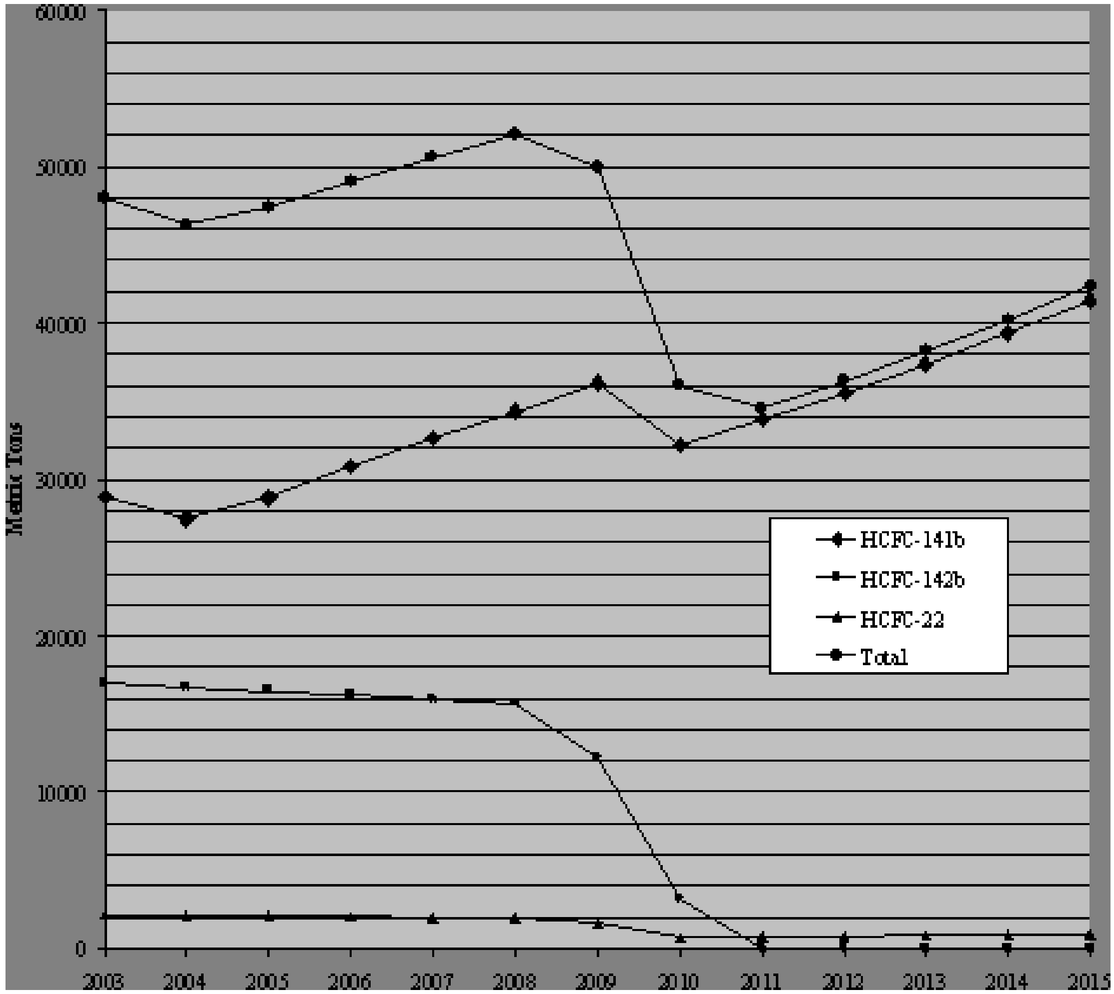


Table 6-2
HCFC – 141b demand (2001)
(metric tonnes)

			Europe	North America	Japan	RODW	CEIT	North East Asia	South Asia	Latin America	TOTAL
Applications											
PU	DOM R&F		765	10,784	144	30	480	1,968	154	4,844	19,169
	Other Applications		1,607	6,331	400	147	0	583	124	478	9,670
	Reefers, etc.		408	1,440	400	0	0	1,250	0	70	3,568
	Boardstock		1,512	34,680	1,200	0	0	0	0	0	37,392
	Continuous panels		2,940	1,512	800	40	120	96	0	140	5,648
	Discontinuous panels		3,240	2,976	770	30	126	350	110	1,352	8,954
	Spray		4,000	6,300	2,880	84	100	119	16	946	14,445
	OCF		0	0	0	0	0	0	0	0	0
	Pipes		504	702	60	16	300	400	16	48	2,046
	Blocks	Pan/Trucks	756	600	120	60	0	0	11	0	1,547
		Pipe	504	300	60	30	0	0	11	0	905
	Integral Skin		335	2,415	0	0	0	0	894	1,085	4,729
											0
Phenolic	Boardstock		261	30	206	0	0	0	0	0	497
	Blocks	Pipes	262	12	44	5	5	3	0	3	334
		Panels	66	12	16	5	5	3	0	3	110
	Panels		27	12	349	0	0	0	0	0	388
TOTAL			**17,187**	**68,106**	**7,449**	**447**	**1,136**	**4,772**	**1,336**	**8,969**	**109,402**

Table 6-3
HCFC-142b Demand (2001)
(metric tonnes)

		Europe	North America	Japan	RODW	CEIT	North East Asia	South Asia	Latin America	TOTAL
Applications										
XPS	Boardstock	6,626	13,261	3,781	0	0	0	0	0	23,668
PE	Pipe	0	320	0	0	0	0	0	0	320
	Slab	0	160	0	0	0	0	0	0	160
TOTAL		**6,626**	**13,741**	**3,781**	**0**	**0**	**0**	**0**	**0**	**24,148**

Table 6-4

HCFC-22 Demand (2001)

(metric tonnes)

		Europe	North America	Japan	RODW	CEIT	North East Asia	South Asia	Latin America	TOTAL
Applications										
PU	DOM R&F	0	1,008	0	0	0	0	0	367	1,375
	Other Applications	0	288	0	5	0	0	0	0	293
	Reefers, etc.	0	128	0	0	0	0	0	0	128
	Boardstock	0	0	0	0	0	0	0	0	0
	Continuous panels	0	720	0	0	0	0	0	0	720
	Discontinuous panels	0	794	0	0	0	0	0	0	794
	Spray	0	0	0	0	0	0	0	0	0
	OCF	0	240	0	0	0	0	0	0	240
	Pipes	0	78	0	0	0	0	0	0	78
XPS	Boardstock	3,568	1,473	329	0	0	0	0	0	5,370
TOTAL		**3,568**	**4,729**	**329**	**5**	**0**	**0**	**0**	**367**	**8,998**

Table 6-5

Global HCFC-141b Demand (2001 to 2015)

(metric tonnes)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CEIT	**1,137**	**1,190**	**1,247**	**1,308**	**1,374**	**1,446**	**1,522**	**1,606**	**1,695**	**1,791**	**1,894**	**2,007**	**2,127**	**2,257**	**2,399**
PU Rigid Foam	1,126	1,178	1,234	1,294	1,359	1,430	1,505	1,587	1,675	1,769	1,871	1,982	2,100	2,228	2,367
PU Integral Skin Foam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phenolic Foam	11	12	13	14	15	16	17	19	20	22	23	25	27	29	32
North East Asia	**4,772**	**4,994**	**5,232**	**5,487**	**5,760**	**6,052**	**6,365**	**6,702**	**7,062**	**7,448**	**7,863**	**8,309**	**8,788**	**9,302**	**9,855**
PU Rigid Foam	4,766	4,988	5,226	5,481	5,754	6,046	6,359	6,695	7,055	7,441	7,856	8,302	8,781	9,295	9,848
PU Integral Skin Foam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phenolic Foam	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7
South Asia	**1,336**	**1,342**	**1,350**	**1,358**	**1,368**	**1,378**	**1,391**	**1,404**	**1,419**	**1,435**	**1,453**	**1,472**	**1,493**	**1,517**	**1,542**
PU Rigid Foam	442	456	472	488	506	524	544	565	587	611	636	663	691	722	754
PU Integral Skin Foam	894	886	878	870	862	854	847	839	832	824	817	809	802	795	788
Phenolic Foam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Latin America	**8,971**	**9,366**	**9,786**	**10,231**	**10,703**	**11,203**	**11,733**	**12,296**	**12,853**	**13,526**	**14,199**	**14,913**	**15,672**	**16,479**	**17,338**
PU Rigid Foam	7,880	8,257	8,658	9,084	9,536	10,016	10,526	11,068	11,604	12,256	12,908	13,600	14,337	15,121	15,956
PU Integral Skin Foam	1,085	1,103	1,122	1,141	1,161	1,180	1,200	1,221	1,242	1,263	1,284	1,306	1,328	1,351	1,374
Phenolic Foam	6	6	6	6	6	7	7	7	7	7	7	7	7	7	8
PU Rigid Foam	14,214	14,879	15,590	16,347	17,155	18,016	18,934	19,915	20,921	22,077	23,271	24,547	25,909	27,366	28,925
PU Integral Skin Foam	1,979	1,989	2,000	2,011	2,023	2,034	2,047	2,060	2,074	2,087	2,101	2,115	2,130	2,146	2,162
Phenolic Foam	23	24	25	26	27	29	30	33	34	36	37	39	41	43	47
HCFC 141B for CFC Replacement	0	1,080	2,039	2,899	3,679	4,858	5,762	6,490	7,245	8,024	8,425	8,853	9,310	9,799	10,322
Total Article 5(1) Countries	**16,216**	**17,972**	**19,654**	**21,283**	**22,884**	**24,937**	**26,773**	**28,498**	**30,274**	**32,224**	**33,834**	**35,554**	**37,390**	**39,354**	**41,456**
North America	68,106	67,671	6,390	4,154	4,133	4,115	4,099	4,086	4,075	0	0	0	0	0	0
Japan	7,449	7,415	0	0	0	0	0	0	0	0	0	0	0	0	0
Europe	17,186	13,549	3,338	0	0	0	0	0	0	0	0	0	0	0	0
Rest of Developed World	447	449	450	452	250	252	254	256	258	0	0	0	0	0	0
Total Non Article 5(1) Countries	**93,188**	**89,084**	**10,178**	**4,606**	**4,383**	**4,367**	**4,353**	**4,342**	**4,333**	**0**	**0**	**0**	**0**	**0**	**0**
Global Demand	**109,404**	**107,056**	**29,832**	**25,889**	**27,267**	**29,304**	**31,126**	**32,840**	**34,607**	**32,224**	**33,834**	**35,554**	**37,390**	**39,354**	**41,456**

Table 6-6
HCFC-142b Demand (2001 to 2015)
(metric tonnes)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Europe	**6,626**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Boardstock	6,626	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polyethylene Foam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North America	**13,741**	**13,480**	**13,223**	**12,972**	**12,726**	**12,484**	**12,247**	**12,014**	**8,528**	**0**	**0**	**0**	**0**	**0**	**0**
Boardstock	13,261	13,009	12,761	12,519	12,281	12,048	11,819	11,594	8,116	0	0	0	0	0	0
Polyethylene Foam	480	471	462	453	445	436	428	420	412	0	0	0	0	0	0
Japan	**3,781**	**3,770**	**3,759**	**3,747**	**3,736**	**3,725**	**3,714**	**3,703**	**3,691**	**0**	**0**	**0**	**0**	**0**	**0**
Boardstock	3,781	3,770	3,759	3,747	3,736	3,725	3,714	3,703	3,691	0	0	0	0	0	0
Polyethylene Foam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed World	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Boardstock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polyethylene Foam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total non Article 5(1) Countries	**24,148**	**17,250**	**16,982**	**16,719**	**16,462**	**16,209**	**15,961**	**15,717**	**12,219**	**0**	**0**	**0**	**0**	**0**	**0**
Boardstock	23,668	16,779	16,520	16,266	16,017	15,773	15,533	15,297	11,807	0	0	0	0	0	0
Polyethylene Foam	480	471	462	453	445	436	428	420	412	0	0	0	0	0	0
TOTAL	**24,148**	**17,250**	**16,982**	**16,719**	**16,462**	**16,209**	**15,961**	**15,717**	**12,219**	**0**	**0**	**0**	**0**	**0**	**0**

Table 6-7
HCFC-22 Demand (2001 to 2015)
(metric tonnes)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Europe	**3,568**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
PU Rigid Foam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
XPS Boardstock	3,568	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North America	**4,728**	**4,711**	**1,418**	**1,391**	**1,365**	**1,339**	**1,313**	**1,288**	**902**	**0**	**0**	**0**	**0**	**0**	**0**
PU Rigid Foam	3,255	3,266	0	0	0	0	0	0	0	0	0	0	0	0	0
XPS Boardstock	1,473	1,445	1,418	1,391	1,365	1,339	1,313	1,288	902	0	0	0	0	0	0
Japan	**329**	**328**	**327**	**326**	**325**	**324**	**323**	**322**	**226**	**0**	**0**	**0**	**0**	**0**	**0**
PU Rigid Foam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
XPS Boardstock	329	328	327	326	325	324	323	322	226	0	0	0	0	0	0
Latin America	**367**	**392**	**419**	**447**	**477**	**510**	**545**	**582**	**621**	**663**	**709**	**757**	**808**	**863**	**922**
PU Rigid Foam	367	392	419	447	477	510	545	582	621	663	709	757	808	863	922
XPS Boardstock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non Article 5(1) Countries	**8,625**	**5,039**	**1,745**	**1,717**	**1,690**	**1,663**	**1,636**	**1,610**	**1,128**	**0**	**0**	**0**	**0**	**0**	**0**
PU Rigid Foam	3,255	3,266	0	0	0	0	0	0	0	0	0	0	0	0	0
XPS Boardstock	5,370	1,773	1,745	1,717	1,690	1,663	1,636	1,610	1,128	0	0	0	0	0	0
Total Article 5(1) Countries	**367**	**392**	**419**	**447**	**477**	**510**	**545**	**582**	**621**	**663**	**709**	**757**	**808**	**863**	**922**
PU Rigid Foam	367	392	419	447	477	510	545	582	621	663	709	757	808	863	922
XPS Boardstock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**8,992**	**5,431**	**2,164**	**2,164**	**2,167**	**2,173**	**2,181**	**2,192**	**1,749**	**663**	**709**	**757**	**808**	**863**	**922**

7 Projections of HCFC Solvent Demand Until 2015

7.1 Introduction

In the solvent sector, chemicals listed for phase-out under the Montreal Protocol include CFC-113 (1,1,2-trichloro-1,2,2-trifluoroethane), TCA (1,1,1-trichloroethane; methyl chloroform), CTC (carbon tetrachloride) and some HCFCs (hydrochlorofluorocarbons). Most of these solvents are used in the manufacturing process of electronics products, for precision cleaning of metal parts and as solvent for lubricants, adhesives and specialty coatings.

Among these solvents, HCFCs have been regarded as transitional substances and recommended only for those applications where no other suitable alternatives to CFC-113 or TCA can be applied. There are three HCFCs proposed as alternative solvents: HCFC-225, HCFC-141b and HCFC-123. HCFC-123 for use as a solvent is negligible and will not be described in this report.

The primary alternative technology for ODS solvents such as CFC-113, TCA and CTC includes no-clean, aqueous/hydrocarbon cleaning and organic solvent cleaning. In the non-Article 5(1) countries, the use of HCFCs remains minor with little conversion to HCFC, HFC (hydrofluorocarbons) or HFE (hydrofluoroethers) compounds.

The world-wide consumption of HCFCs for solvent use is estimated approximately at 1,400 ODP tonnes in 2001 (HCFC-225 (197 ODP tonnes) + HCFC-141b (ca.1,200*[1] ODP tonnes)) (the number for HCFC-141b has been calculated on the basis of the hypothesis that 10% of the worldwide consumption of HCFC-141b is used for solvent applications). HCFC-141b is mainly used as a foam blowing agent and its application as a solvent is minor, (less than 10% of worldwide production). HCFC-141b is being rapidly phased-out as a solvent in the European Union and the USA.

The STOC 2002 Report addresses the increasing use of Annex C Group I solvents, especially HCFC-141b, in Article 5(1) countries, while great progress has been made even in those countries to phase out ODSs. The reported 2001 solvent use of HCFC-141b and HCFC-225 in Article 5(1) countries is approximately 360 and 70 ODP tonnes, respectively.

The major efforts to complete the transition away from ozone-depleting substances in Article 5(1) countries are dependent on 1) the availability of information, 2) the financial and economic needs to assist in the conversion and 3) the enforcement of current regulations.

7.2 Application of HCFC Solvents

The ODP and GWP of HCFC solvents are listed in Table 7-1.

Table 7-1
ODP and GWP of HCFC Solvents

HCFC	Chemical formula	ODP	GWP[1]	Atmospheric lifetime (yr)
HCFC-123	CF_3CHCl_2	0.02	120	1.4
HCFC-141b	CH_3CCl_2F	0.11	700	9.4
HCFC-225ca	$CF_3CF_2CHCl_2$	0.025	180	2.1
HCFC-225cb	CF_2ClCF_2CHFCl	0.033	620	6.6
HCFC-225ca/cb		0.03	370	2.5-6.6

[1](Source: Climate Change 2001. Third Assessment Report of the IPCC)

The physical properties of HCFCs are summarised in Table 7-2. HCFC-225 represents an almost 1:1 mixture of HCFC-225 ca/cb. HCFC-225 is a low ODP alternative to CFC-113. It is very similar to CFC-113 in physical and chemical properties, and can form azeotropes with alcohols. It exhibits good materials compatibility and can therefore be used as a possible drop-in replacement of CFC-113 with few changes in its cleaning process.

HCFC-225 is listed as acceptable in electronics, metals, and precision cleaning by the Significant New Alternatives Policy Programs (SNAP) by the US EPA. On the other hand, HCFC-141b and its blends are listed as unacceptable in these solvent applications in the SNAP program due to its high ODP and availability of other suitable alternatives (the SNAP program finds HCFC-141b acceptable as an aerosol solvent for a few, limited applications because there are fewer alternatives available and because of the need for non-flammable solvents in those aerosol applications).

In spite of those regulations, the use of HCFC-141b, especially in degreasing applications, seems to grow in Article 5(1) countries.

Table 7-2
Physical Properties of HCFC Solvents

Compounds	HCFC-225	HCFC-141b	CFC-113
Molecular Weight	202.94	116.95	187.38
Boiling Point C	54	32.1	47.6
Freezing Point C	-131	-103.5	-35
Density (g/cm3)*	1.55	1.23	1.57
Viscosity (cps)*	0.59	0.42	0.68
Surface Tension (dyne/cm)*	16.2	18.4	17.3
Heat of Vaporization (cal/g)	33	52.8	34
Kauri-Butanol Value	31	58	31
Flash Point C	None	None	None
Flammable Limit (vol%)	None	11 to 14.8	None

* at 25 C

The major applications of HCFC-225 are summarized in Table 7-3

Table 7-3
*Application Fields of HCFC-225**

Electronics (17%)	High density Printed Wiring Assembly, Hybrid Circuit, Flexible Printed Wiring
Precision/Metal (47%)	Relay, Connector, Capacitor, Micro-switch, Magnetic Head, Ceramic Package, Miniature Bearing, Optical Device, Compressor for Air-conditioner, Engine Part
Carrier Solvent (25%)	Coating and others
Others (11%)	Dry Cleaning, Refrigerants

* An azeotropic mixture (HCFC-225ca/cb + ethanol) is recommended for defluxing and dewatering.

Because of its high ozone-depletion potential, HCFC-141b is never suitable as a substitute for 1,1,1-trichloroethane. It is suitable as a substitute for CFC-113 only when lower ozone-depleting potential alternatives, including HCFC-225, are not feasible. Because HCFCs are transitional in nature, a second conversion to a non-ozone depleting alternative will ultimately be required.

7.3 Availability

HCFC-225 has been produced by one manufacturer in Japan with a reported capacity of several thousand tonnes per year since 1991. And a new small plant (ca. 300 metric tonnes/y) is in operation in the United States (New Jersey) as of April 2003. The world-wide consumption of HCFC-225 in 2002 was reported to be ca. 6,000 metric tonnes (3,700 tonnes for non-Article 5(1) countries, and 2,300 tonnes for Article 5(1) countries). The total demand will gradually decrease and level off at around 4,000-5,000 metric tonnes during the period 2010-2015, compensating the significant decrease in non-Article 5(1) countries with a gradual increase in Article 5(1) countries.

If the projection of HCFC-225 consumption remains in this range, the present capacity of HCFC-225 production will be able to cover the worldwide supply, but if the demand in Article 5(1) countries increases far beyond this projection, some new production facilities will be needed in those countries.

As for HCFC-141b, it is rather difficult to anticipate the projection of its demand in Article 5(1) countries in the period of 2004-2015, but if the annual growth rate is assumed as 5-10%, the total consumption will reach approximately 650-700 ODP tonnes (7,500-8,000 metric tonnes) in 2015. This quantity will correspond to less than 10% of total projection of HCFC-141b consumption (mainly for blowing applications) in 2015.

7.4 Future Perspectives of Alternative Technologies

There are no substantial technical barriers to phasing out ODS solvents such as CFC-113, 1,1,1-trichloroethane and carbon tetrachloride in the Article 5(1) countries. Alternatives are available that will meet the requirements of all solvent users with very few exceptions. In addition to not-in-kind technologies, non-ozone depleting fluorinated chemicals like HFCs and HFEs have been already in the market and even new generation alternatives have been developed.

The alternative technologies that should be considered for Article 5(1) countries are listed as follows in the STOC Report 2002:

"No-clean" : This is a preferred option for the manufacture of more sophisticated circuit assemblies, where feasible. No clean process, however, requires skilled operators, increased control of incoming part quality and superior machinery.

Aqueous/hydrocarbon-surfactant cleaning : Some aqueous / hydrocarbon-surfactant cleaning technologies, with proper controls and monitoring, may have low environmental impact due to the low toxicity of the constituents, but it is not always the case. In an area with problems of water management or water supply, aqueous cleaners may be a poor choice unless efficient water recycling is possible. This technology requires a skilled workforce.

Organic solvent cleaning (with solvents less toxic than halogenated solvents): Although toxicity may be a concern for some formulations, the principal risk is derived from the high flammability of the more volatile compounds. Cautions should be used when these solvents are employed with sprays, heaters, or ultrasonic equipment.

Non- or less ozone depleting halogenated solvents (HFC, HFE): HFC and HFE are classified as non-ozone-depleting fluorinated solvents. The main environmental properties of commercialized HFCs and HFEs are listed in Table 7-4.

n-PB: The situation regarding n-propyl bromide remains unclear because its effect on the ozone layer and its chronic toxicity has not yet been established. Its ODP may vary with latitude because of its short atmospheric lifetime of only 19 days. In tropical regions, the ODP varies from 0.071 to 0.100, approaching the ODP of HCFC-141b and methyl chloroform. In middle latitudes, the ODP is much lower. For example, in the USA, the ODP is 0.013 to 0.018, lower than that of almost all HCFCs. There are anecdotal reports of neurological disorders in humans, resulting from exposure to n-PB. Animal testing for reproductive toxicity was recently completed, but testing for carcinogenicity is unlikely to be completed before the end of 2003, at the earliest. US EPA's SNAP programme expects to issue a preliminary ruling on n-PB in mid-2003. Under these circumstances, the world production capacity for the manufacture of n-PB is increasing, although the consumption is currently stable. More information is available in the annual reviews of n-propyl bromide included in TEAP Progress Reports.

Table 7-4

Available HFCs and HFEs

HFC/HFE	Chemical Formula	ODP	GWP	Atmospheric Lifetime (years)
HFC-43-10mee	$CF_3CF_2CHFCHFCF_3$	0	1500	17.1
HFC-365mfc	$CF_3CH_2CF_2CH_3$	0	910	10.2
HFC-c-447ef	Heptafluorocyclopentane	0	250	3.4
HFE-449s1	$C_4F_9OCH_3$	0	320	4.1
HFE-569sf2	$C_4F_9OC_2H_5$	0	5.5	0.8
HFE-347pcf*	$CF_3CF_2OCH_2CHF_2$	0	360	2.8

* to be commercialized in 2004

Recently a new HFE solvent, HFE-347pcf, has been developed in the RITE[6] Project in Japan (Source: RITE NOW No.43 (2002)), and announced to be commercialized in early 2004 by one of the project members.

[6] RITE is an abbreviation for Research Institute of Innovative Technology for the Earth

HFC and HFE are relatively low-solvency substitutes for CFC-113 and therefore a wide variety of blends or azeotrope formulations are supplied in order to improve their solvency.

8 Projections of HCFC Demand for Fire Extinguishants Until 2015

8.1 Background

Prior to its production phase-out in 1994, halon 1211 was used extensively in hand held fire extinguishers in computer rooms, banks, aircraft, ships, clean rooms, museums, military equipment, airport flight-lines and other areas where it was important or convenient to use an extinguishant that did not leave a residue when discharged.

Following the 1994 production phase-out, many halon users changed to non-halon alternatives. Most halon 1211 users that did not require a “clean” agent changed to dry chemical extinguishers. Some that required a “clean” agent changed to carbon dioxide. However, each of these alternatives represented compromises in terms of cleanliness or firefighting effectiveness. Because there is currently no halon 1211 alternative that is equally effective, clean, and with acceptable toxicity, a small number of critical applications continue to use halon 1211 from recycled stocks. These primarily include military air, land and sea systems and civil aviation. To satisfy these needs, government and commercial organizations maintain stocks of recycled halon 1211.

One of the largest aviation halon uses has been in wheeled fire extinguishers primarily used on airport ramps at military facilities. They are the first line of defence in the event of a fire on a military aircraft while parked on a ramp. Aviation regulations typically allow a choice of agents for this application - halon, dry chemical and foam. Pre-Montreal Protocol, most militaries used halon. Today, most military organizations continue to use halon 1211, but most civil airports use dry powder or foam. In 1995, the U.S. Federal Aviation Administration concluded that a proprietary HCFC-123 blend provided an “acceptable” level of fire-fighting capability on airport ramps, and approved it for this use. Since then, approximately 50 U.S. airports have purchased this agent for use in wheeled extinguisher units used on aircraft ramps. Dry powder and foam continue to be used at most civil airports worldwide.

The second line of defence at airports are crash-rescue vehicles that respond to aircraft landing with emergencies and also respond to aircraft fires on the ground. Pre-Montreal Protocol most military installations used halon in these crash-rescue vehicles. However, both civil and military facilities now use foam, dry chemicals, or a proprietary HCFC-123 blend. A notable exception is aircraft carrier decks, which have traditionally and continue to use halon.

For fire protection inside aircraft passenger compartments, aviation regulations have traditionally demanded halon 1211. In 2002, U.S. Federal Aviation Administration approved a proprietary HCFC-123 blend with small amounts of CF_4 and argon as a replacement for halon 1211 in on-board handheld fire extinguishers. HFC-236fa is also approved for this use.

8.2 Demand

In addition to important aviation applications, HCFC-123 is being sold as a halon 1211 alternative primarily for portable fire extinguishers used in telecommunication facilities, computer rooms, office buildings, retail facilities, libraries, art galleries, warehouses, industrial facilities, rail cars, automobiles, automobile racing, delivery trucks, long- and short-haul trucks, power generation plants, commercial shipping, pleasure craft, airport gates and airport ramps. It has been sold to at least one Article 5(1) military organization. It is being sold in Argentina, Brazil, Canada, Philippines, Indonesia, Saudi Arabia, United Arab Emirates, Qatar (military), Pakistan, Slovenia, the Czech Republic, Israel, South Korea, India, the United States and some others. The total demand for these applications is indeterminable, but not-in-kind alternatives became the alternative of choice for these applications following halon phase-out.

Most military organizations continue to use halon 1211 in wheeled appliances on flight-lines and foam and dry chemical in crash / rescue trucks. As a result, military demand for HCFC-123 for firefighting applications is currently negligible.

There are approximately 13,000 commercial aircraft in the world the size of a Boeing 707 or larger that are required to carry handheld extinguishers on board. Total demand for these on-board aviation uses would not likely exceed an installed base on the order of about 300 tonnes, with an annual service tail of around 5% of that figure. The need for HCFC-123 for ramp protection remains debatable since not-in-kind alternatives have satisfied those needs in the past. This estimate for HCFC-123 demand for aviation applications could increase orders of magnitude in the event military organizations determined HCFC-123 was an appropriate alternative to halon 1211 for aviation applications.

Relative to refrigeration and other uses, the quantities needed for fire protection are negligible. In the event HCFC-123 went out of production worldwide there are currently adequate stocks of halon 1211 to satisfy critical needs into the foreseeable future.

8.3 Supply

There are two producers of HCFC-123 in the world, one on North America and one in China. Because of the limited number of producers, accurate worldwide production figures are not available. However, most of the HCFC-123 is sold into refrigeration and as a feedstock for the production of other chemicals. Compared to the estimated current worldwide demand for HCFC-123 by the refrigeration market of approximately seven thousand metric tonnes, the demand added by fire protection is estimated at 200-400 metric tonnes at maximum.

8.4 Conclusion

Most halon 1211 users with important applications continue to use halon 1211 from recycled stocks. Following the halon 1211 production phaseout in 1994, most users that did not have a compelling need for a clean agent switched to not-in-kind alternatives such as foam or dry chemicals. Military organizations overwhelmingly continuing to use halon 1211 from recycled stocks for their most critical uses, and not-in-kind alternatives, such as foam and dry chemicals, elsewhere. A halon 1211 alternative is available made from HCFC-123 blended with small amounts of CF_4 and argon. A number of users appear to be switching from not-in-kind alternatives to HCFC-123 because it is a clean agent. The U.S. Federal Aviation Administration has approved this proprietary HCFC-123 blend as a replacement for halon 1211 in some important applications; including handheld extinguishers in passenger cabins of civil aircraft.The HCFC-123 is in many cases replacing not-in-kind alternatives such as dry powder and foam for ramp protection. The total amount of HCFC-123 needed to satisfy aviation applications currently requiring halon 1211 would not likely exceed an installed base on the order of about 300 tonnes, with an annual service tail of around 5% of that figure. This excludes military applications, which continue to use halon 1211. Relative to refrigeration and other uses, quantities needed for fire protection are negligible. In the event HCFC-123 went out of production worldwide there are currently adequate stocks of halon 1211 to satisfy these uses into the foreseeable future.

9 HCFC Production Capacity Versus HCFC Demand

An analysis of the demand/ supply balance for the different HCFCs is shown below. On the basis of historic consumption and development patterns of refrigeration equipment, foam and other applications covered in chapters 5 to 8, scenarios were developed for the HCFC consumption for the period from 2002 to 2015 in both the non-Article 5(1) and the Article 5(1) countries. These scenarios are based on the current situation and trends observed in recent years.

Estimates of production capacities for 2002, 2010 and 2015 in both developed and developing countries can be found in chapter 4. Based on these figures and considerations on local and global regulations, a forecast for 2002-2015 of production capacities (and likely production levels) was calculated. The feedstock production has also been taken into account, particularly in the case of HCFC-22 and HCFC-142b. It contributes significantly to the profitability of production facilities even when there is over-supply for the markets of the HCFCs themselves.

9.1 HCFC-22

Table 9-1

Demand and production capacity forecast for HCFC-22 (2002-2015)

HCFC-22	**Demand and Production (ktonnes) (year)**			
	2002	**2005**	**2010**	**2015**
Market Demand non-A5(1)	189	180	99	37
Market Demand A5(1)	104	132	212	305
Market Demand, total	293	312	311	342
Prod. Capacity: non-A5(1)	440	410	353	335
Prod. Capacity: A5(1)	166	181	205	230
Prod. Capacity: total	606	591	558	565
Feedstock Requirement	212	239	290	337
Available Market Capacity	394	352	268	228
Unused Production Capacity/ Insufficient Production Capacity (negative)	101	40	-43	-114
Capacity Utilisation	83%	93%	100%	100%

The consumption in non-Article 5(1) countries is expected to decrease due to Montreal Protocol implementation and bans introduced under more stringent national and regional regulations. The production control schedule for the European Union causes significant decreases in production levels as of the year 2008, whereas the HCFC consumption in the EU is expected to sharply decrease already before the year 2005. Particularly in the USA and some other non-EU countries, under the scenarios used, the HCFC-22 consumption, is expected to still be significant up to the year 2010 and will decrease rapidly thereafter.

The HCFC-22 consumption for refrigeration in Article 5(1) countries is based on a refrigeration demand which has been calculated using a low and a high demand economic scenario. The data for projected HCFC-22 consumption in refrigeration have been averaged between the forecasts from the low and the high demand economic scenarios. The high increase in the HCFC-22 consumption in Article 5(1) countries is mostly due to the large increase in the numbers of commercial refrigeration equipment and unitary air conditioning products in China since these sectors are characterised by a very high growth rate during 1990-2001.

Table 9-1 shows that feedstock demand for HCFC-22 is expected to grow at 4% per annum until 2010 and at 3% thereafter. This is to meet growth in PTFE global demand during the period concerned. This feedstock demand scenario already leads to a tense supply situation for HCFC-22 in Article 5(1) countries by the year 2005, since the utilisation of the available production capacity is already at the high level of 93%. This forecast is not very sensitive to the assumptions made in the demand scenarios. However, it is sensitive to the assumptions made regarding feedstock production and the implicit assumption that feedstock (polymer) demand prevails over refrigerant demand[7].

The implication is that the average growth scenario for refrigeration applications in China which typically use HCFC-22 at present, could lead to a situation where either:

> By 2010, and potentially as early as 2007-2008, the total demand forecast cannot be met[8] by the projected capacity at that time

or

> Further capacity is installed beyond current projections to meet the increased demand, which implies that the installed capacity level in 2002 has to be increased by more than 50%.

Under normal market conditions, it would be expected that such investment would be made in the period from 2005 and even as late as 2010. However, the investment climate could be adversely affected if there were additional regulatory controls pending at that time.

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[7] Further consideration of the HCFC-22 developments by the TEAP and its Task Force may be needed when 2004 production and consumption data have become available, i.e. after the year 2004. At that time the trends assumed in this study for feedstock production can also be confirmed.

[8] Although there is a theoretical possibility that 95% capacity utilisation could be sustained, this is impossible in practice because of geographical logistics.

The Task Force has discussed these scenarios at length and recognises that there are substantial uncertainties surrounding any economic projections over a period as significant as 12 years. This is particularly the case in high growth developing markets. Accordingly, any consensus on such issues is fairly meaningless in any event.

The Task Force believes that this study has highlighted the key variables that need to be tracked in order to improve confidence in the demand projections for HCFC-22 and that this issue could be successfully revisited at a later date. The Parties may therefore wish to consider asking the TEAP to review this issue within the next three to five years.

9.2 HCFC-141b

Table 9-2

Demand and production capacity forecast for HCFC-141b (2002-2015)

HCFC-141b	**Demand and Production (ktonnes) (year)**			
	2002	**2005**	**2010**	**2015**
Market Demand non-A5(1)	98	13	9	9
Market Demand A5(1)	20	24	34	43
Market Demand, total	118	37	43	52
Prod. Capacity: non-A5(1)	110	82-106	59-75	20-30
Prod. Capacity: A5(1)	20	23	29	35
Prod. Capacity: total	130	105-129	88-104	55-65
Feedstock Requirement	0	0	0	0
Available Market Capacity	130	105-129	88-104	55-65
Unused Production Capacity	12	68-92	45-61	3-13
Capacity Utilisation	91%	28-35%	41-49%	80-94%

The demand in the non-Article 5(1) countries is expected to decrease sharply after the year 2003 and amounts in use in these regions by 2015 are expected to be less than 10% of the total 2002 figure. The main on-going use in developed countries will be for solvent applications.

In contrast, the Article 5(1) countries the demand is forecast to rise by nearly a factor of two over the period 2002-2015.

From the supply side, as mentioned in Chapter 4, there is some flexibility in HCFC-141b capacity because of co-production with HCFC-142b. Nonetheless, it is anticipated that regulations in Europe, Japan and USA, which demand an early phase-out of HCFC-141b as a foam blowing agent will result in plant closures and reductions in capacity. Although a linear decrease in capacity (depicted above) suggests utilisation rates in the 25-50% range for the period 2005-2010, it is known that few operators would be able to financially support the operation of plants below 70% utilisation. If the industry were to rationalise capacity more severely than depicted to maintain this minimum, there could be later capacity shortages as demand increases further in the 2010-2015 period. These problems could, however, be overcome by the use of well-known ‘mothballing’ techniques in the chemical industry and it is expected that these will be adopted in practice.

9.3 HCFC-142b

Table 9-3

Demand and production capacity forecast for HCFC-142b (2002-2015)

HCFC-142b	Demand and Production (ktonnes) (year)			
	2002	2005	2010	2015
Market Demand non-A5(1)	17	16	0	0
Market Demand A5(1)	0	0	0	0
Market Demand, total	17	16	0	0
Prod. Capacity: non-A5(1)	92	78-100	74-96	70-90
Prod. Capacity: A5(1)	5	5	5	5
Prod. Capacity: total	97	83-105	79-101	75-95
Feedstock Requirement	58	63	71	81
Available Market Capacity	39	20-42	8-30	(-6)-14
Unused Production Capacity	22	4-26	8-30	(-6)-14
Capacity Utilisation	77%	75-95%	70-90%	85-108%

There is no demand for HCFC-142b in the Article 5(1) countries. Moreover, it is anticipated that local regulations to implement the Montreal Protocol in the non-Article 5(1) countries will cause non-feedstock demand to fall sharply to zero in the year 2010. However, HCFC-142b will continue to be used as feedstock during the entire period 2002-2015 and will grow with demand for PVdF.

The fact that HCFC-142b can be co-produced with HCFC-141b (see Chapter 4) coupled with the fact that the ratio between the two products may be varied makes predicting the supply/demand balance of each individual substance difficult. However, according to the Task Force best estimates, the bulk of the available capacity for HCFC-142b will need to be directed towards feedstock applications in the latter part of the period under review. This means that the capacity available for HCFC-141b production will be on the lower end of the range shown in Section 9.2.

9.4 HCFC-123, HCFC-124 and HCFC-225

All these products are manufactured in small production facilities. Large increases in consumption are not expected and it is believed that the current capacity is sufficient to meet future demand.

Table 9-4
Demand and production capacity forecast for HCFC-123
(2002-2015)

HCFC-123	**Demand and Production (ktonnes) (year)**			
	2002	**2005**	**2010**	**2015**
Demand non-A5(1)	5	5	3	2
Demand A5(1)	1	2	4	4
Demand, total	6	7	7	6
Production non-A5(1)	6	7	7	7
Production A5(1)	1	3	3	3
Production feedstock[1]	0	0	0	0
Prod capacity Š feedstock	7	10	10	10
Unused Production Capacity	1	3	3	4
Capacity Utilisation	87%	70%	70%	60%

[1] There is some feedstock use of HCFC-123 but, since this is never isolated, it is not considered in the above table. This explains the apparent discrepancy with Table 3-2.

Table 9-5
Demand and production capacity forecast for HCFC-124
(2002-2015)

HCFC-124	**Demand and Production (ktonnes) (year)**			
	2002	**2005**	**2010**	**2015**
Demand non-A5(1)	4	2	1	0
Demand A5(1)	0	1	4	5
Demand, total	4	3	5	5
Production non-A5(1)	9	9	9	9
Production A5(1)	0	0	0	0
Production feedstock	0	0	0	0
Prod capacity Š feedstock	9	9	9	9
Unused Production Capacity	5	6	4	4
Capacity Utilisation	44%	33%	56%	56%

Table 9-6
Demand and production capacity forecast for HCFC- 225
(2002-2015)

HCFC-225	**Demand and Production (ktonnes) (year)**			
	2002	**2005**	**2010**	**2015**
Demand non-A5(1)	4	4	3	2
Demand A5(1)	2	2	3	4
Demand, total	6	6	6	6
Production non-A5(1)	10	10	10	10
Production A5(1)	0	0	0	0
Production feedstock	0	0	0	0
Prod capacity Š feedstock	10	10	10	10
Unused Production Capacity	4	4	4	4
Capacity Utilisation	60%	60%	60%	60%

Indeed, some of these projected utilisation rates are not likely to be sustainable in the long-term and some further industry rationalisation may result.

10 Conclusions

- HCFCs are, and are likely to remain, important as "transitional substances" in the replacement of CFCs in refrigeration and air conditioning, insulating and integral skin foams, cleaning, and in specialised uses. They are also substitutes for halons in some fire protection applications.
- HCFC-22 and HCFC-141b are, and will remain, the most significant HCFCs in use globally and particularly in Article 5(1) countries.
- Future HCFC-22 consumption is linked heavily with the growth of the refrigeration and air conditioning industry in Article 5(1) countries – most notably in China.
- The Task Force has discussed growth scenarios at length and recognises that there are substantial uncertainties surrounding any economic projections over a period as significant as 12 years. This is particularly the case when high growth scenarios are postulated. Assumptions will only be validated with time and a further full assessment may need to be made in 3-5 years when further growth data are available.
- There are also significant uncertainties regarding the substitution of HCFC-based technologies with other technology options and only the 'most likely' scenarios, based upon currently existing trends, have been considered.
- According to the best current estimate, the demand for HCFC-22 (excluding feedstock demand) in Article 5(1) countries in 2015 will be three times that of the demand in 2002.
- If this scenario proves to be correct, there may already be insufficient installed capacity for HCFC-22 beyond 2005, leading to a tense supply situation. This aspect needs further consideration by the TEAP and its HCFC Task Force after the year 2004, when more production and consumption data will have been reported, and tendencies in feedstock use will have been confirmed.
- The introduction of additional regulatory controls in non-Article 5(1) HCFC production after 2005 (over and above the required freeze) is likely to bring forward investment plans for further HCFC-22 capacity in Article 5(1) regions. This will give these investments more opportunity for commercial return.
- Demand for HCFC-141b and HCFC-142b is driven primarily by their respective uses in insulation and other foams. These applications are expected to grow throughout the period as the use of refrigeration equipment becomes more widespread and interest in energy efficiency grows.

- The other significant use of HCFCs will be in solvent applications where both HCFC-225 and HCFC-141b will be used. These will only be used where no other alternatives are available.
- It is difficult at this time to assess how much HCFC solvent use will be required in Article 5(1) countries, but this demand is not expected to influence the need for capacity investment.
- Individual production capacities for HCFC-141b and HCFC-142b are more difficult to determine than HCFC-22 since these chemicals are co-produced in some facilities and the process has some degree of flexibility.
- Although the use of HCFC-142b in Montreal Protocol applications will be eliminated in 2010, the feedstock requirements for the chemical may mean that most co-producing facilities will be required to meet this demand in the period 2010-2015. This will limit the availability of capacity for HCFC-141b.
- Regarding HCFC-141b itself, the drop in demand during the period 2005-2010 will require a substantial rationalisation of current capacity in order that producers can maintain economic production. This could create shortages of capacity in later years (2010-2015) unless the producers practise well-known 'mothballing' techniques.
- Regarding HCFC-123, HCFC-124 and HCFC-225, no supply issues are envisaged as demand has already matured. However, there may be some shift between non-Article 5(1) and Article 5(1) consumption patterns.
- The Task Force has factored in a freeze in production in non-Article 5(1) countries and two additional reduction steps in production in the European Union during 2002-2015 in all of its assessments. This has no impact on the availability of HCFC chemicals to Article 5(1) countries except in the case of HCFC-22 in the period beyond 2005. However, as mentioned above, there are significant uncertainties in projections, which will require further assessment at an appropriate juncture.
- A close inspection of the various Protocol amendments has revealed that the control of trade in HCFCs by the Parties to the Beijing Amendment enters into force on 1 January 2004. As at March 2003, 49 countries had ratified the Beijing Amendment and 39 countries had not ratified the Copenhagen Amendment. The HCFC producing countries that have not ratified the Beijing Amendment and all the countries that have not ratified the Copenhagen Amendment (both producing and consuming countries) will be treated as non-Parties to the Protocol with respect to HCFCs.

Annex 1 Montreal Protocol Requirements

The Montreal Protocol established an HCFC baseline for non-Article 5(1) Parties at 2.8% of the 1989 CFC consumption plus the 1989 HCFC consumption. The Annex C Group I consumption phase-out schedule for non-Article 5(1) Parties under the Protocol is as follows:

- Freeze: 1 January 1996
- 35% Reduction: 1 January 2004
- 65% Reduction: 1 January 2010
- 90% Reduction: 1 January 2015
- 99.5% Reduction: 1 January 2020 and thereafter, consumption restricted to the servicing of refrigeration and air-conditioning equipment existing at that date.
- 100% Reduction: 1 January 2030

The baseline for production is the average of the baseline for consumption as mentioned above and the 1989 HCFC production plus 2.8% of the 1989 CFC production. The production is to be frozen at the baseline level from 1 January 2004.

There are no specific restrictions for use of HCFCs under the Protocol, however the Protocol states that "each Party shall endeavour to ensure that HCFC use is limited to:

(a) "those applications where more other environmentally suitable alternative substances or technologies are not available"

(b) "not outside of the areas of applications of the current controlled substances"

(c) "selected in a manner that minimises ozone depletion, in addition to meeting other environmental, safety and economic considerations."

The first HCFC control measure for Article 5(1) Parties will occur well into the phase-out regime of HCFCs in non-Article 5(1) countries. The Protocol established an HCFC baseline at 2015 for Article 5(1) Parties with a freeze in consumption and production effective 1 January 2016. For Article 5(1) Parties, a step-wise reduction schedule for consumption is not laid out as above for non-Article 5(1) Parties. Instead, the Protocol requires a 100% reduction in consumption of HCFCs as of 1 January 2040.

Non-Article 5(1) Parties have taken different approaches to implement the measures above. Several Parties have adopted phase-out schedules with reductions in different intervals and some have accelerated the phase-out. The U.S. took the unique approach of phasing out HCFCs on a chemical-by-chemical basis in order to achieve the reductions established above. The first chemical, HCFC-141b, was phased out on 1 January 2003, a year earlier than the first reduction required under the Protocol. Several Parties have established use restrictions on HCFCs in various sectors, product bans, and labelling requirements to support their phase-out plans.

Status of Ratification of the Copenhagen and Beijing Amendment

Parties to the Beijing Amendment

Barbados
Bulgaria
Burkina Faso
Burundi
Canada
Chile
Comoros
Congo
Croatia
Czech Republic
European Community
Micronesia
Finland
Gabon
Germany
Guatemala
Guinea-Bissau
Hungary
India
Japan
Jordan
Korea, DPR
Luxemburg
Madagascar
Malaysia
Maldives
Mauritius
Monaco
Netherlands
New Zealand
Norway
Palau
Panama
St. Lucia
Sao Tome and Principe
Samoa
Seychelles
Sierra Leone
Slovakia
Slovenia
Somalia
Spain
Sri Lanka
Sweden
Switzerland
Tanzania
Macedonia, The Former Yugoslav Rep of
Togo
United Kingdom
(49 Parties, March 2003)

Non-Parties to the Copenhagen Amendment

Albania
Angola
Armenia
Belarus
Bosnia and Herzegovina
Brunei Darussalam
Central African Republic
Cambodia
China **
Cote d'Ivoire
Cyprus
Dominica
Equatorial Guinea
Ethiopia
Gambia
Guinea
Kazakhstan
Kiribati
Kyrgyzstan ***
Lao, Dem. Republic
Lesotho
Libya Arab Jamahiriya
Malta
Mauritania
Myanmar
Namibia
Nauru
Nepal
Papua New Guinea
Russian Federation
Rwanda
Surinam
Swaziland
Tajikistan
Tonga
Turkmenistan
United Arab Emirates
Yugoslavia
Zambia
(39 Parties, March 2003)

** China acceded to the Copenhagen Amendment on 22 April 2003
*** Kyrgyzstan ratified the Copenhagen Amendment on 13 May 2003

Annex 2 HCFC Control Measures

Year	Required by:	Control Measure
1991/08/01	Germany	Use controls: HCFC-22 prohibited in aerosols, packaging materials, foamed dishes and trays.
1993/01/01	Netherlands	Production, trade, import and export of all insulation materials banned.
1993/02/16		Product ban: party streamers and noise horns containing HCFCs.
1993/01/01	Germany	Use controls: HCFC-22 prohibited in construction foams.
1994/01/01	Sweden	Use controls: HCFCs may only be used for the manufacture of rigid foam plastics for insulation purposes and as refrigerants.
1994/01/01	USA	Product ban: all aerosol products, pressurized dispensers and foam products containing, or manufactured with hcfcs -- except those specifically exempted by the regulations and those that are listed as essential medical devices by the food and drug administration, at 21 cfr 2.125(e) -- are banned from sale and distribution. Exempted products include: wasp and hornet sprays near high-tension power lines; solvents - lubricants, coatings, or cleaning fluids for aircraft maintenance and electrical, electronic or photographic equipment; solvents and propellants - mold release agents, document preservation sprays, spinnerette lubricant/cleaning sprays; fire suppression - portable fire extinguishers in non-residential applications; foam - closed cell insulation foam and integral skin foam for motor vehicle safety (until 1996).
1995/06/01	Denmark	Use controls: HCFCs prohibited with the exception of uses phased out at later dates as outlined below.
1995/06/01	EU	Use controls*: HCFCs prohibited in aerosols and foams (except safety and insulation uses outlined below).

Year	Required by:	Control Measure
1996/01/01	**Montreal Protocol**	**Non-article 5(1): freeze: 2.8% of 1989 CFC consumption plus 1989 HCFC consumption**
1996/01/01	Australia	54% consumption reduction on protocol baseline
1996/01/01	Denmark	Use controls: HCFCs prohibited for production of jointing foam, rigid polyurethane, excluding insulating foam, flexible and rigid p/u integral foam, rigid p/u insulating foam for district heating pipes.
1996/01/01	EU	Use controls*: HCFCs prohibited in non-contained solvent applications except for in precision cleaning in aerospace and aeronautic applications (prohibited in 2009). HCFCs prohibited in equipment produced after 31/12/95 as refrigerants in non-confined direct evaporation systems; domestic refrigerators and freezers; motor vehicle or trailer air conditioning (except for military uses where prohibition is 1/1/08), and road public transport air conditioning.
1998/01/01	EU	Use controls*: HCFCs prohibited in equipment produced after 31/12/97 for rail public transport air conditioning and as a carrier gas for sterilisation substances in closed systems.
1998/01/01	Sweden	Phase-out of HCFCs in new equipment.
1999/01/01	EU	Freeze at 2.6% of CFC consumption in 1989 + total HCFC consumption in 1989
1999/01/01	Finland	Use controls: HCFCs prohibited in the production of integral skin foams used for safety applications; and as a solvent for purposes in which the use of HCFC compounds has not yet been banned by the Eu. Products and equipment containing the HCFC compounds in these applications may not be placed on the market.
1999/07/07	Canada	Product ban: no person shall manufacture or import a pressurized container that contains 2 kg or less of any HCFC, with some exemptions. No person shall manufacture or import plastic foam in which any HCFC has been used as a foaming agent, except for a rigid foam product or a flexible polyurethane boardstock foam product. No person shall manufacture or import for use in industrial cleaning HCFC-141b or any product containing HCFC-141b.

Year	Required by:	Control Measure
2000/01/01	Australia	60% consumption reduction on Protocol baseline
2000/01/01	Austria	Use controls: HCFCs prohibited as solvents, irrespective of the system used, and for the production of any type of foamed plastic.
2000/01/01	Canada	Product ban: no person shall offer for sale or sell a pressurized container that contains 2 kg or less of any HCFC, with some exemptions. No person shall manufacture or import any flexible polyurethane boardstock foam product in which any HCFC has been used as a foaming agent. No person shall sell or offer for sale for industrial cleaning or use in industrial cleaning HCFC-141b or any product containing HCFC-141b.
2000/01/01	Denmark	Use controls: HCFCs prohibited as mould release agents, production of flexible p/u with density <23 kg/m3, and uses in new commercial and industrial heat transfer systems and associated automatic equipment.
2000/01/01	EU	Use controls*: HCFCs prohibited in equipment produced after 31/12/99 for use as refrigerants in public distribution and cold stores and warehouses and as refrigerants for equipment of 150 kW and higher shaft input.
2000/01/01	Finland	Use controls/product ban: HCFCs prohibited as refrigerants in equipment installed and manufactured after 31/12/99 (unless such use has already been banned by the Eu) and in the production of rigid insulating foams. Products and equipment containing the HCFC compounds in these applications may not be placed on the market.
2000/01/01	Germany	Use controls: phase-out of HCFC-22in new refrigeration and air-conditioning equipment and all foam uses.
2000/01/01	Italy	Ban of use, import, and production of HCFCs with an ODP>0.065 (includes HCFC-141b)
2000/01/01	Japan	Begin gradually reducing HCFC-141b as a cleaning solvent.
2000/01/01	Switzerland	Ban on HCFCs in rigid foam, new refrigeration (servicing permitted until 2010/15 –see below) and as medical aerosol.
2000/10/01	EU	Use controls*: HCFCs prohibited in production of integral skin foams for use in safety applications and polyethylene rigid insulating foams.

Year	Required by:	Control Measure
2001/01/01	EU	Freeze at 2% of CFC consumption in 1989 + total HCFC consumption in 1989. Use controls*: HCFCs prohibited in all other refrigeration and air-conditioning equipment, where the equipment is produced on or after 1/1/01, with the following exceptions: fixed air-conditioning less than 100 kW cooling capacity (prohibited in 2002) and reversible air-conditioning/heat pump systems (prohibited in 2004) as outlined below.
2001/01/01	Norway	35% reduction in HCFC consumption
2002/01/01	Australia	65% consumption reduction on protocol baseline
2002/01/01	Austria	Use controls: HCFC prohibited as a refrigerant for any application except in equipment, which has been produced before 1/1/02.
2002/01/01	Denmark	Use controls: HCFCs prohibited in production of rigid XPS and PU insulating foam for uses other than district heating pipes, uses in existing household, commercial and industrial heat transfer systems and associated automatic equipment, and uses in research, development and laboratories.
2002/01/01	EU	15% reduction in HCFC consumption. Use controls*: HCFCs prohibited in production of extruded polystyrene rigid insulating foams, except where used for insulated transport. HCFCs prohibited in all solvent uses except for precision cleaning in aerospace and aeronautics (prohibited in 2009).
2002/01/01	Sweden	Phase-out of HCFCs for servicing existing equipment.
2002/04/01	Japan	HCFC labelling of commercial refrigeration equipment.
2002/07/01	EU	Use controls*: HCFCs prohibited in fixed air-conditioning less than 100 kW cooling capacity, where the equipment is produced after 30/6/02.
2003/01/01	EU	55% reduction in HCFCs consumption. Use controls*: HCFCs prohibited in prohibited in production of polyurethane foams for appliances, of polyurethane flexible faced laminate foams and of polyurethane sandwich panels, except where the latter two are used for insulated transport.
2003/01/01	USA	No domestic consumption of HCFC-141b unless specifically authorized due to technical constraints (e.g. Space shuttle insulation foam)

Year	Required by:	Control Measure
2004/01/01	**Montreal Protocol**	**Non-article 5(1) countries: 35% reduction in consumption; production freeze: average of base levels for production and consumption + 15% for basic domestic needs of Article 5(1) Parties**
2004/01/01	Australia	71% consumption reduction on Protocol baseline (labelling of HCFC products, under consideration in June 2003, may be imposed)
2004/01/01	Canada	35% consumption reduction
2004/01/01	EU	70% reduction in HCFC consumption. Use controls*: HCFCs prohibited in reversible air-conditioning/heat pump systems, where the equipment is produced after 31/12/03. HCFCs prohibited in production of all foams, including polyurethane spray and block foams.
2004/01/01	Japan	Production and import of HCFC-141b for foam sector banned.
2005/01/01	Germany	Phase-out of all HCFCs.
2006/01/01	Australia	76% consumption reduction on Protocol baseline
2007/01/01	Norway	60% reduction in HCFC consumption
2008/01/01	Australia	82% consumption reduction on Protocol baseline
2008/01/01	EU	75% reduction in HCFC consumption; 65% reduction in HCFC production from 1997 levels. Use controls*: HCFCs prohibited as refrigerants in road public transport, air conditioning in military uses.
2008/01/01	Italy	Production, use, sale, import, and export of all HCFCs banned
2009/01/01	EU	Use controls*: HCFCs prohibited as solvents for precision cleaning in aerospace and aeronautic applications.

Year	Required by:	Control Measure
2010/01/01	**Montreal Protocol**	**Non-article 5(1): 65% consumption reduction**
2010/01/01	Australia	87% consumption reduction on Protocol baseline
2010/01/01	Canada	No person shall manufacture, use, sell, offer for sale or import HCFC-141b, HCFC-142b or HCFC-22, except for exportation or for use as a refrigerant. Product ban: no person shall manufacture or import any product that contains or intends to contain HCFC-141b, HCFC-142b or HCFC-22.
2010/01/01	EU	100% reduction in HCFC consumption. Use controls*: virgin HCFCs prohibited in maintenance and servicing of refrigeration and air-conditioning equipment. HCFC use controls apply to the use of HCFCs in the production of products for export.
2010/01/01	Japan	HCFC-22 refrigerant (new) banned. HCFC-141b cleaning solvent banned. HCFC-142b foam banned. Begin gradually reducing HCFC-225 as a cleaning solvent.
2010/01/01	Norway	80% reduction in HCFC consumption
2010/01/01	Switzerland	Use controls: virgin HCFCs prohibited in maintenance and servicing of refrigeration and air-conditioning equipment.
2010/01/01	USA	No domestic consumption of HCFC-142b and HCFC-22, except for use in equipment manufactured before 1/1/2010 (so no production or importing for new equipment that uses these refrigerants)
2011/01/01		
2012/01/01	Australia	92% consumption reduction on Protocol baseline
2013/01/01	Norway	95% reduction in HCFC consumption
2014/01/01	Australia	98% consumption reduction on Protocol baseline
2014/01/01	EU	80% reduction in HCFC production from 1997 levels.
2015/01/01	**Montreal Protocol**	**Non-article 5(1): 90% consumption reduction**
2015/01/01	Canada	No person shall manufacture, use, sell, offer for sale or import any HCFC except for manufacture or import of HCFC for exportation or for use as a refrigerant before January 1, 2020, except for HCFC-123.
2015/01/01	EU	Use controls*: recycled HCFCs prohibited in maintenance and servicing of refrigeration and air-conditioning equipment.
2015/01/01	Japan	Same as Protocol
2015/01/01	Netherlands	Production, trade, import, and export of all products containing
2015/01/01	New Zealand	100% phase-out of HCFCs
2015/01/01	Norway	100% reduction in HCFC consumption
2015/01/01	Switzerland	Use controls: recycled HCFCs prohibited in maintenance and
2015/01/01	USA	No domestic consumption of any HCFCs, except for use as refrigerants in equipment manufactured before 1/1/2020; labelling of all HCFC products on (or before) this date.

Year	Required by:	Control Measure
2016/01/01	**Montreal Protocol**	**Article 5(1): freeze in consumption; production freeze: average off the base levels for production and consumption in year 2015 + 15% for the basic domestic needs of Article 5(1) Parties**
2016/01/01	Australia	99.5% consumption reduction on Protocol baseline
2020/01/01	**Montreal Protocol**	**Non-article 5(1): 99.5% consumption reduction (thereafter consumption restricted to servicing existing refrigeration and air-conditioning equipment)**
2020/01/01	Canada	100% phase-out except for HCFC-123 (99.5% reduction)
2020/01/01	EU	85% reduction in HCFC production from 1997 levels.
2020/01/01	Japan	HCFC-22 refrigerant (refill) banned. HCFC-225 cleaning solvent banned by 2020.
2020/01/01	USA	No domestic consumption of any HCFC-142b and HCFC-22 (refrigeration servicing tail)
2026/01/01	EU	100% reduction in HCFC production
2030/01/01	**Montreal Protocol**	**Non-article 5(1): 100% reduction**
2030/01/01	USA, Japan, Canada, Australia	100% reduction/ HCFC phase-out
2040/01/01	**Montreal Protocol**	**Article 5(1): 100% reduction**

Table Notes *The importation and placing on the market of products and equipment containing HCFCs is banned from the date that the use restriction enters into force, unless the product or equipment was manufactured before that date. The release in the EU of products and equipment containing controlled substances (HCFCs) imported from a state not Party to the Protocol is prohibited. Until 31/12/09, the use restrictions shall not apply to the use of HCFC for the production of products for export to countries where the use of HCFCs in those products is still permitted. Note: HCFC use controls do not apply to: laboratory uses, including research and development; feedstock uses; processing agent uses. Use is permitted as fire-fighting agents in existing systems to replace Halons in critical use applications subject to the conditions that the Halons are replaced completely, those withdrawn are destroyed and 70% of the destruction costs are met by the HCFC supplier.

Italy: for fire-fighting applications, products with a GWP>3400, with an ODP>0.065 and with an atmospheric lifetime of greater than 42 years are forbidden.

Netherlands: the use of HCFCs as solvents is only permitted if sufficient recapture takes place according to specific legislative requirements. The use of HCFCs as refrigerants is only permitted if refrigeration equipment is leak-tight according to the technical legislative requirements for refrigeration equipment. Maintenance and servicing of refrigeration equipment is only permitted by certified mechanics who are certified by the STEK-institute. Certificates are only issued when the mechanics are examined on theory and practice of the national requirements for refrigeration equipment.

Luxembourg: equipment disposal and product sales requirements for foams, solvents, refrigerants and fire extinguishing agents.

Spain: sales ban of all refrigerators with HCFC refrigerant or foam.

Belgium, Greece, Ireland, Portugal: no additional controls.

UK & France: refrigerant venting prohibitions.

Iceland: HCFC licenses for use of recycled HCFC-22 for servicing existing equipment.

Czech Republic: ban on HCFC for new installations and ban on import of HCFC systems. Significantly increased import tax on HCFC from 1 June 2002).