MONTREAL PROTOCOL

ON SUBSTANCES THAT DEPLETE

THE OZONE LAYER

UNEP

Technology and Economic Assessment Panel

SUPPLEMENT TO THE IPCC/ TEAP REPORT

November 2005

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The text of this report is composed in Times New Roman.

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The opinions expressed are those of the Panel and its Task Forces and do not necessarily reflect the reviews of any sponsoring or supporting organisation.

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Executive Summary

At the twenty-fifth meeting of the Open-ended Working Group (Montreal, 27-30 June, 2005), the EC, Norway, New Zealand and UK tabled a paper containing two proposals, which were endorsed by the Open-ended Working Group:

- *To recommend that further consideration of the IPCC/TEAP Special Report is placed on the agenda for the Seventeenth Meeting of the Parties.*
- *To request TEAP to provide, by 31 October 2005, a supplementary report to the Seventeenth Meeting of the Parties that elaborates clearly the ozone depletion implications of the issues raised in the Special Report. In particular, the report should estimate current and projected levels of ozone-depleting substances contained and emitted from banks, expressed as ODP tonnes; project atmospheric concentrations of ozone-depleting substances under the "Mitigation" and "Business as Usual" scenarios that appear in the Special Report, and their associated impact on the ozone layer; estimate costs of mitigation measures described in the report in cost per ODP tonne.*

Chlorofluorocarbons (CFCs), halons, and hydrochlorofluorocarbons (HCFCs) being phased out under the Montreal Protocol contribute to ozone depletion and climate change, while hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) controlled under the United Nations Framework Convention on Climate Change and its Kyoto Protocol contribute only to climate change. About 20% of ODSs have been or are being replaced with hydrofluorocarbons, which generally have Global Warming Potentials (GWPs) that are significantly lower than the GWPs of the ODSs they replace and are in many cases better contained and more likely to be recovered during servicing or at end-of-life.

The IPCC/TEAP Special Report describes the banks and emissions in all relevant sectors in kg CO_2 equivalent, this being the typical way emissions are considered for determining global warming impacts. This Supplement to the Special Report more clearly presents the impacts on the ozone layer from the viewpoint of emissions reductions, expressed in ODP tonnes.

The scope of the Special Report itself is limited to the sectors and applications that have used HFCs or PFCs as substitutes for ODSs. Since HFCs have only been used to replace approximately 20% of the previous ODS consumption, and PFC use has been limited to a minority of specialist applications, there are some former ODS-consuming sectors that have used little or no HFCs and hence are not included within the scope of the Special Report. This means that historic emissions of ODSs, assessed by using bottom-up methods per sector in the Special Report, do not represent a complete assessment of the historic ODS emissions. Accordingly, there is an inevitable systematic error arising from comparison with emissions derived from atmospheric measurements. However, the applications in which ODS banks have been generated (fire protection, rigid insulating foam, refrigeration and air conditioning) are also those, which have adopted HFCs as significant substitutes and hence are included within the Special Report. This means that bank assessments are likely to be reasonably complete.

A further source of systematic error is the lack of information on use patterns of ODSs in Article 5(1) countries, resulting in it being difficult to establish whether emissions in these regions are prompt (less than 1 year) or spread over a longer period.

In parallel, random errors can emerge because of, for example, uncertainties over the statistical distribution of life cycles. Most bottom-up models function by using average life-times to determine the likely timing of emissions. Accordingly, random errors can occur, particularly when the assessment period is short (e.g. one year).

The results of these uncertainties are that the emissions estimates derived from the aggregation of bottom-up assessments are not always consistent with emissions estimates derived from atmospheric concentrations. However, the use of several sources of information, including bottom-up estimates, reported production and use data, plus atmospheric measurements mean that trends can be clearly established, which give confidence in the information presented in the Special Report and further reported in this Supplement. Additional work will be required to further characterise the sources of these errors in order to further improve confidence levels.

The emissions of the major banked chemicals in fire protection, refrigeration and air conditioning equipment occur primarily during the use phase, reflecting the more dynamic nature of the use-phase for such equipment and the need for routine servicing. For rigid insulating foam, emissions are much more focused during initial processing and, particularly, at end-of-life. In all cases, the management of the decommissioning process at end-of-life is a key determinant in ultimate emission levels.

The Supplement Report sets out the key elements of the Business-As-Usual (BAU) case used in the Special Report and highlights key differences by sector and by region. The assessment elaborates the fact that current ODS recovery rates vary significantly by sector and that, within a given sector, recovery rates tend to be significantly lower in Article 5(1) countries than in non-Article 5(1) countries.

This assessment reveals that, in ODP tonnage terms, 70% (1,820 ODP ktonnes) of all banked CFC and HCFC chemicals (excluding halons) were situated in non-Article 5(1) countries in 2002. With the ongoing emission of ozone depleting substances in the period until 2015, all banks are expected to decrease. There is a huge amount of chemicals banked in foams in non-Article 5(1) countries. Because of the more rapid emissions from refrigeration and air conditioning equipment and the lack of slower emitting foams in Article 5(1) countries, the proportion of the global bank in non-Article 5(1) countries is therefore expected to increase in ODP terms by 2015 (to 75% or about 1,660 ODP ktonnes). Nevertheless, the total, global, ODS bank is expected to dcrease from 2,600 ODP ktonnes in 2002 to 2,200 ODP ktonnes in 2015.

Nevertheless, the increasing use of HCFCs in Article 5(1) countries could delay the rate of recovery of the ozone layer and increase the quantity of banked HCFCs from 37 ODP ktonnes in 2002 to 126 ODP ktonnes in 2015 under the BAU scenario.

The Mitigation Scenario in the Special Report estimated the additional reductions in ODSs and the use of their HFC (and PFC) substitutes that can be achieved by the year 2015 with technically feasible actions beyond those currently required by the Montreal Protocol. The Special Report focused on the climate benefits of such actions by presenting the results in terms of greenhouse gas units of measure (carbon dioxide equivalents). This Supplement Report presents the Mitigation Scenario emission reduction in terms of ozone units of measure (ODP tonnes).

In the refrigeration and air conditioning sector, several potential measures will be introduced progressively in the period to 2015 and will have an impact on emission patterns, even after phasing out the use of ODSs in new equipment. This also relates to specific servicing practices, such as recharging for leakage, particularly in Article 5(1) countries, where ODS (CFC) based equipment is still abundant. If measures will be implemented in the last phase of the ODS phase-out process, their main impact will be on the level of future HFC emissions in preference to ODSs. The main mitigation strategies likely to have effect on ODS emissions in the mid-term (e.g., as of 2008) are those associated with end-of-life measures in refrigeration and (mobile and stationary) air conditioning. Recovery and possible destruction may have a significant impact on the level of emissions released from the banks.

The slow emission rate from foams means that measures considered in the Mitigation Scenario will have a limited effect by 2015, although there could be incremental benefits for many years to follow. Although the Special Report dealt with these dynamics tangentially (foam emission reductions were projected to 2100), there was no systematic quantification of emission abatement over such a long period.

As mitigation strategies are more widely researched, demonstrated and commercially practised, there will be increasing precision in assessing specific mitigation costs. However, extreme care needs to be exercised in applying these data to other areas. Local factors such as practical accessibility and transport logistics can have substantial effects on the practicality and economics of recovery and destruction. In some instances (e.g. halons), it may also be important to leave banks available for future recycling and critical use.

The best estimate in the Scientific Assessment of Ozone Depletion: 2002 (WMO, 2003) projected the return of the Equivalent Effective Stratospheric Chlorine (EESC) to 1980 values in the year 2044, assuming full compliance with the Montreal Protocol. However, bank estimates in (WMO, 2003) are generally lower than in the Special Report. The same calculation using the banks of CFCs and HCFCs as estimated in this Supplement Report shows this return to 1980 values being delayed until 2046. If the further emissions from servicing refrigeration and AC equipment, occurring in the interim, are taken into account, the return of the EESC to 1980 values levels is estimated to be delayed by up to another two years at maximum (2048). Destruction of all banks in refrigeration and AC equipment as of 2008 (at end-of- life) could result in an estimated return of the EESC to 1980 values around the year 2046. Management of foam banks would also serve to accelerate the recovery of the ozone layer, but quantification of this impact is difficult because much of the emission from foam in buildings could take place at end-of-life in the period between 2035 and 2050.

This Supplement Report provides some examples of mitigation costs, points out the limitations on the use of this information, and highlights that the cost-effectiveness of mitigation measures may depend substantially on whether policy makers consider the co-benefits of ODS recovery and greenhouse gas emission abatement. It is self-evident that, if these values are combined (not always a strictly additive process), the cost-effectiveness criteria could be satisfied in local circumstances where individual analyses might have dictated otherwise.

In Article 5(1) countries, the current collection and recovery costs are likely to be greater than in non-Article 5(1) countries owing to the lack of infrastructure. Indeed, end-of-life concepts are very different in Article 5(1) countries from the ones in non-Article 5(1) countries and the degree of re-use is generally much higher.

1 Introduction

1.1 Remit

Following a discussion on the IPCC/TEAP Special Report "Safeguarding the Ozone Layer and the Global Climate System: Issues related to Hydrofluorocarbons and Perfluorocarbons" at the Twenty-fifth meeting of the Open-ended Working Group (Montreal, 27-30 June, 2005), the EC, Norway, New Zealand, and UK tabled a CRP.8, where the first two paragraphs read as follows:

- *To recommend that further consideration of the IPCC/TEAP Special Report is placed on the agenda for the Seventeenth Meeting of the Parties.*
- *To request TEAP to provide, by 31 October 2005, a supplementary report to the Seventeenth Meeting of the Parties that elaborates clearly the ozone depletion implications of the issues raised in the Special Report. In particular, the report should estimate current and projected levels of ozone-depleting substances contained and emitted from banks, expressed as ODP tonnes; project atmospheric concentrations of ozone-depleting substances under the "Mitigation" and "Business as Usual" scenarios that appear in the Special Report, and their associated impact on the ozone layer; estimate costs of mitigation measures described in the report in cost per ODP tonne.*

Following a discussion on the issue, the Open-ended Working Group agreed (1) to recommend that further consideration of the IPCC/TEAP Special Report be placed on the agenda for the Seventeenth Meeting of the Parties and (2) to request TEAP to provide, by 31 October 2005, a Supplementary Report to the Seventeenth Meeting of the Parties that elaborates clearly the ozone-depletion implications of information already in the Special Report by presenting it in terms of ozone-depleting potential and costs per ODP tonne.

Chlorofluorocarbons (CFCs), halons, and hydrochlorofluorocarbons (HCFCs) being phased out under the Montreal Protocol contribute to ozone depletion and climate change, while hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) controlled under the United Nations Framework Convention on Climate Change and its Kyoto Protocol contribute only to climate change. About 20% of ODSs are replaced with hydrofluorocarbons that generally have Global Warming Potentials (GWPs) that are significantly lower than the GWPs of the ODSs they replace and are better contained and more likely recovered at service. Furthermore, climate protection benefits are achieved during the ODS phase-out because refrigeration and air conditioning engineers use the necessity of change to thoroughly redesign systems, resulting in better efficiency, better reliability and better overall value for consumers.

The IPCC/TEAP Report describes the banks and emissions in all relevant sectors in kg CO_2-equivalent, this being the typical way emissions are considered for determining global warming impacts. This supplement to the Special Report more clearly presents the impacts on the ozone layer from emissions and emissions reductions, expressed in ODP tonnes.

1.2 Task Force

Following the meeting of the Open-ended Working Group, June 2005, TEAP established a Task Force on the Supplement to the Special Report (TFSRS), co-chaired by Lambert Kuijpers, Paul Ashford and Roberto Peixoto and consisting of:

- Stephen. O. Andersen (USA, co-chair TEAP, member Steering Committee Special Report);
- Paul Ashford (UK, co-chair FTOC, member TEAP, CLA Special Report);
- Nick Campbell (UK, member MTOC, CLA Special Report);
- Denis Clodic (France, member RTOC, CLA Special Report)
- Sukumar Devotta (India, member RTOC, CLA Special Report);
- David de Jager (The Netherlands, former TSU for the Special Report);
- Suzanne Kocchi (USA, member FTOC, LA Special Report);
- Lambert Kuijpers (The Netherlands, co-chair TEAP, co-chair RTOC, member Steering Committee Special Report);
- Roberto Peixoto (Brazil, member RTOC, CLA Special Report)
- Jose Pons Pons (Venezuela, co-chair TEAP, co-chair MTOC, member Steering Committee Special Report);
- Guus Velders (The Netherlands, CLA Special Report); and
- Dan Verdonik (USA, member TEAP, co-chair HTOC, CLA Special Report).

Drafts were produced via email-circulation; a final review was carried out by the TFSRS Task Force during the week of 7-11 November 2005. After this review, this report was considered and subsequently adopted by consensus of the UNEP Technology and Economic Assessment Panel (TEAP) as established under the Montreal Protocol.

1.3 The Structure of the Report

The structure of this Supplement to the IPCC/TEAP Report is as given below. In individual chapters, particularly in chapters 3 and 4, the data that are contained in the Special Report are updated and converted to ODP ktonnes.

Chapter 1, "Introduction", presents the remit, the setting up of the Task Force and the process followed in preparing this report.

Chapter 2, "Description of sectors", describes sectors and emission sources, looks at the phase in the life-time of a product when emissions mainly occur. It presents an overview of the present status of bottom-up methods for refrigeration and the uncertainties involved in the determination of banks and emissions. It also gives some information derived from (IPCC TEAP, 2005) on the determination of emissions from annual measurements of atmospheric concentrations.

Chapter 3, "BAU Scenario", looks at the demand, banks and emissions in a Business as Usual scenario for the period 2002-2015. The assumptions for determining banks and emissions in this scenario are given. It also gives the relevant data on the development of the banks and related emissions (tables with all the data and bar chart graphs can be found in the Annex to this report). Demand, banks and emissions are considered for the world-total, and both for the non-Article 5(1) and the Article 5(1) countries. This yields insight on the percentage release from banks in different regions of the world, where banks (and emissions) may be completely different in composition.

Chapter 4, "MIT Scenario", looks at the demand, banks and emissions in a Mitigation scenario. The assumptions as used in the mitigation scenario are given, which scenario is characterised by the same banks and emissions as the Business-As- Usual scenario in the year 2002 (tables with all the data and bar chart graphs can be found in the Annex to this report). A comparison is made between the size of the banks and the level of emissions in the Business-As-Usual and the Mitigation scenario in the year 2015.

Chapter 5, "Mitigation Costs", describes the costs for the mitigation of refrigeration, foams and halon emissions. Mitigation in this context means that emissions of ODS should not have an impact on the recovery of the ozone layer.

Chapter 6, "Impacts on the Recovery of the Ozone Layer", describes the impact of emissions on the ozone and is based on the same considerations as chapter 2 in (IPCC TEAP, 2005).

Chapter 7, "Discrepancies between Emissions Determined", presents discrepancies between emissions determined from bottom-up methods and from atmospheric measurements. It looks at the relevance of the types and the levels of emissions, as well as at the relevance of the timing of the emissions and emission reductions.

Chapter 8 gives " Concluding Remarks".

In the Annex tables and bar charts are given of the demand, the banks and emissions for the years 2002 and 2015. These are expressed in ktonne product, in ktonne CO_2-equivalent and in ODP ktonne.

2 Description of sectors, emission sources and methods of assessment

2.1 Sectors and sources

Ozone Depleting Substances (ODS) and their substitutes have been or are being used in a wide range of products and processes that are already well known to the ozone community. These include refrigeration and air conditioning equipment, medical and technical aerosols, rigid and flexible foams, fire protection equipment, solvents, intermediates and process agents. The IPCC/TEAP Special Report deals only with those products and processes, which have selected HFCs or PFCs as full or partial substitutes for ODSs. Hence the main chapters of that Report have focused on refrigeration and air conditioning (chapters 4-6), rigid foams (chapter 7), medical aerosols (chapter 8) and fire protection (chapter 9). Technical aerosols and specialist solvent uses have also been covered (chapter 10), but to a lesser degree, reflecting the lower levels of use of HFCs and PFCs as substitutes. An important consequence of this scope is that the Special Report is not a comprehensive treatise on the sources of all ODSs used historically (although the atmospheric science inevitably covers all sources). Accordingly, there is no substantive coverage of sectors such as non-technical aerosols that no longer depend on fluorocarbons despite their widespread use in the second half of the 20th century and their undeniable impact on the ozone layer.

Since this Supplementary Report is to mirror the scope of the Special Report itself, it too does not cover all contributions to ODS emissions except within the atmospheric science discussion (section 2.3). Although this may seem an incomplete approach, it so happens that the sectors leading to future ODS emissions are typically the same sectors as those leading to future HFC and PFC emissions. This is particularly the case for refrigeration, air conditioning and rigid foams where much of the future ODS emission will occur from banks of refrigerant and blowing agent already accrued. As noted in the Special Report, most of these substances (or by-products released during manufacture) are greenhouse gases (GHGs), the emission of which will result in a contribution to the direct positive forcing of climate. Direct emissions of GHGs may occur during the manufacture of these substances, during the use of these substances in products and processes, and at the end of the life of the products containing these substances.

Indirect GHG emissions of applications of ODS and their replacements are the GHG emissions related to the energy consumption (fuels and electricity) during the complete lifecycle of the application (this effect is in addition to the indirect negative radiative forcing of ODSs discussed previously). Dependent on the characteristics of the energy system, indirect GHG emissions may be significant as compared to direct GHG emissions, up to an order of magnitude larger than the direct GHG emissions considered in this report. As most indirect GHG emissions are related to the use-phase of the applications concerned, energy efficiency improvements can often result in significantly greater reductions in total GHG emissions than those generated from a focus solely on reducing direct GHG emissions. This again depends on the specific energy system characteristics.

The Special Report notes that the UNFCCC addresses anthropogenic emissions by sources, and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, i.e. carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphurhexafluoride (SF_6). The Montreal Protocol, on the other hand, controls not the emission but rather the production and consumption of ozone depleting substances. Thus, the emissions due to releases of CFCs and HCFCs present in banks (e.g. refrigeration equipment, foams) are not covered in either the Montreal Protocol or Climate Convention. These emissions, if uncontrolled, will make a significant future contribution to global warming, and have relevance to the predicted recovery of the ozone layer. The emissions from banks thus are linked to tradeoffs and are a component of a balanced assessment of each sector included in this report.

HFCs and PFCs are now seldom used in aerosol, solvent, open-celled foam and other applications where they are emitted immediately. In general, the uses are focused on those applications where additional benefit can be gained by their presence (e.g. for product safety, or thermal efficiency). This is partly driven by the cost of these materials and partly by the recognition of the environmental imperative to avoid emitting gases with high global warming potential unnecessarily. Accordingly, a study of the sectors in which they are now used not only relies on a knowledge of the production and consumption of a chemical, but also on knowing the life cycle of the application in order to determine whether emission will occur and, if so, when. This will vary significantly between sectors and even between applications within sectors. For instance, foam insulation used in buildings can have an expected lifetime of 50 years or more. Since most of the emission, if it not prevented, will occur at the end-of-life of the foam, there can be substantial delays in emission which need to be factored into the atmospheric projections for ozone recovery, as well as for climate change. Indeed, the time-related implications of emissions may have a greater effect on ozone recovery than on climate change because of the catalytic role of chlorine in the degradation of stratospheric ozone.

Within the Special Report, the approach taken to time-dependence was not totally uniform. In general, projections and the impact of possible mitigation measures were assessed at 2015 and compared against the position understood for 2002. Typically, the trends for intervening years were not mapped and projections beyond 2015 were discouraged because of legitimate concerns over the reliability of consumption data beyond this date. However, for applications such as foams, it was recognised that a 15 year time-frame was too short to reflect life-cycle implications of emissions arising from the use of CFCs, which may have already taken place as far back as 1965 and which continue for HCFCs and HFCs now and in the future. Accordingly, the foams chapter in the Special Report extended its purview to 2100 in order to capture the dynamics of on-going emissions. This is an equally important facet for this Supplementary Report, bearing in mind the significant ODS banks that remain in foams at this time. However, in keeping with a Business-As-Usual and a Mitigation scenario as presented in the Special Report, this report does not specifically calculate the impact of ODS emissions from foam out to 2100.

An additional distinction for some applications (e.g. refrigeration and fire protection) is that equipment is serviced and replenished during its life-time. This creates a further use and emission pattern through the life of the equipment, which, in many cases, can be more significant than the initial charges when the equipment is manufactured. Table 2-1 summarises the distinctive aspects of each of the key applications covered in the Special Report.

One other emission source, which would deserve some consideration in this Supplementary Report, is the inadvertent creation and release of HFC-23 as a by-product of HCFC-22 production. HFC-23 has a significant global warming potential and its emission is linked to the strategies being adopted under the Montreal Protocol to curb ultimate demand for HCFCs in Article 5(1) countries, which are again directly related to future HCFC-22 emissions. Although mitigation of HFC-23 release is technically possible and economically attractive under the UNFCCC Clean Development Mechanism (CDM), the availability of funds through the sale of CDM credits obtained from the reduction of HFC-23 emissions could provide a perverse incentive for the continuation or expansion of HCFC-22 production in Article 5(1) countries in order to generate such credits. However, the discussion on this issue under the CDM is still ongoing and will be further dealt with at the upcoming UNFCCC COP-11 in Montreal, December 2005. Once this production and emission issue has been resolved there, the whole may need further consideration under the Montreal Protocol.

Table 2-1 Distinctive aspects of current ODS and GHG emissions by key sectors described in the IPCC/TEAP Special Report

Sector	Typical Gases	Life Cycle Phases of Emission*		
		Production/1st Year	*Use Phase (incl. Servicing)*	*End-of-Life (incl. waste streams)*
Refrigeration	CFC-12, HCFC-22, HFC-134a HFC/HCFC blends	Factory controlled – usually low level	Higher level dependent on frequency of servicing & practices	Maximum of one charge still to be recovered or emitted
Stationary A/C	CFC-12 HCFC-22 HFC-134a HFC/HCFC blends	Factory controlled – usually low level	Higher level dependent on frequency of servicing & practices	Maximum of one charge still to be recovered or emitted
Mobile A/C	CFC-12 HCFC-22 (buses etc.) HFC-134a	Factory controlled – usually low level	Higher level dependent on frequency of servicing & practices	Maximum of one charge still to be recovered or emitted
Rigid Foams	CFC-11 CFC-12 HCFC-141b HCFC-142b HFC-134a HFC-245fa HFC-365mfc	Losses are low where factory-controlled but can be higher for on-site application (e.g. spray foam)	Closed cell nature of foams makes losses in this phase low despite long life-time	Bulk of loss likely to occur at this phase unless recovery/destruction practised. Long-lived emissions from products disposed in landfills
Fire Protection	Halon 1211 Halon 1301 HFC-23 HFC-227ea FK 5-1-12	Factory controlled – usually low level	Higher level dependent on frequency of servicing & testing practices	Maximum of one charge still to be recovered or emitted
Medical Aerosols	CFC-11 CFC-12 CFC-114 HFC-134a HFC-227ea	Emission only delayed by length of time held in stock	Not applicable	Not applicable
Other Uses	CFC-12 CFC-113 HCFC-142b HCFC-141b HFC-365mfc	Most likely to be used in closed loops and may be recovered	Slow loss over time and may need replenishment	Destruction techniques required for spent materials

* Shaded cells denote most significant sources of emission.

2.2 Bottom-up methods and the challenge of assessing activity data

When seeking to assess emissions, it is generally necessary to develop an understanding of use patterns and emission profiles for each use within a sector over its respective lifecycle. This can be quite a complex process depending on the sector considered.

By way of example, refrigerating equipment displays a wide variety of system types, since use of refrigeration and air conditioning systems is very widespread. The quality of the bottom-up method depends on good activity (consumption or use) data. The sources of such data will depend on the nature of the equipment and a series of possible approaches are presented in turn (Ashford *et al*., 2004a and 2004c).

(1) Stand-alone mass manufactured units

For domestic refrigerators (including freezers), air-to-air AC systems, and chillers, annual statistical data are available and are issued either by manufacturer associations or by specialised companies. Those data on annual equipment sales allow the production and sale figures to be derived at the national level for nearly all the OECD countries. For a given year at the global level, the production of mass-produced equipment equals sales, if inventories do not change. Based on this equality, and taking into account economic factors such as GDP and GNP, it is possible to derive national markets of countries for which equipment statistics are not available. Once the annual production and markets are derived for all countries, the type of refrigerant is determined according to regulation and manufacturer choices. Refrigerant charges are defined depending on the refrigerating capacity. Past years are derived for the typical lifetime of that equipment, which varies between 10 to 25 years, depending on the country. Emission factors are also determined by equipment type and country specific circumstances.

(2) Integral parts of other mass manufactured units

No direct statistics are available for mobile air conditioning systems or refrigeration, but a large number of data are available for the annual market and production of cars, trucks, light commercial vehicles (LCVs), and buses in different reference sources. A ratio of the number of vehicles equipped with air-conditioning systems referred to the total number of vehicles is applied on a year-by-year basis taking into account possible rapid change in vehicle equipment. From the average lifetime of cars, and of AC systems, the bank of refrigerant is calculated (merging all charges in the total fleet of vehicles). Assuming likely emission rate and the bank, the annual servicing market is determined, and then the total refrigerant emissions including end-of-life emissions and fugitive emissions. The refrigerant recovery is determined from knowledge of the volumes of equipment processed and is adjusted for recovery efficiency.

(3) Purpose-built commercial systems

The steps for assessing emissions from commercial refrigeration units can be more data intensive and usually involve:

(i) the derivation of the activity data for each type of refrigerant from a combination of refrigerant sales data and knowledge of equipment types and their population
(ii) the application of appropriate emission and recovery factors.

For retail outlets, the method chosen is typically based on food sales area surfaces, which are the only data that can be found at the global level for both non-Article 5(1) and Article 5(1) countries. Emissions in past years are estimated for the typical lifetime of the respective equipment types, which vary between 7 and 15 years depending on the country. The percentage of the refrigerant charge, which is emitted before servicing is used in order to define the refrigerant recharge frequency. The lifetimes of supermarkets and hypermarkets are typically longer than 7 years. However, the remodelling frequency averages 7 years for non-Article 5(1) countries. This has to be taken into account because it implies significant modifications to the refrigerating circuits, which can lead to large refrigerant emissions depending on the recovery efficiency. Further details on the methodology applied can be found in (Ashford *et al.*, 2004c). A further treatment of uncertainties in the refrigeration sector is included in Chapter 7.

In contrast to refrigeration where additional use of substances can occur throughout the lifecycle during servicing, the only point of CFC, HCFC, or HFC use for a foam is at the time of its manufacture. Although the manufacturers of foam can also be small and highly dispersed businesses (cf >5,000 spray foam contractors in the US alone), the bulk of blowing agent use takes place in controlled factory environments which can be surveyed relatively easily through trade associations and by direct contact. Even in the case of the fragmented spray foam market, usage can often be characterised through a series of 'systems houses' which act as formulators for the industry and effectively 'consume' at the point of formulation.

This ability to determine, with some accuracy, the use of blowing agent at foam manufacturing level introduces an important cross-check to the modelling methodology in addition to the top-down sales statistics of the refrigerant and blowing agent suppliers and the bottom-up determinations from the stocks of buildings and equipment. However, these data are not usually available at national level and, even where it is, it can be of fairly limited value because the trading of insulation at regional level will often transfer future lifecycle emissions to a different country. Further details on the methodology applied can be found in (Ashford *et al.*, 2004c).

Confidence levels in activity data and emission factors vary by application in the refrigeration and air conditioning sector. Table 2-2 summarises the six different parameters assessed and confidence levels associated with each. It should be noticed that the confidence levels can be particularly low in the case of Article 5(1) countries, specifically for those where national statistical data are scarce.

Table 2-2 Uncertainty level (from A to E) by characteristic or data

	Domestic refrigeration	Commercial refrigeration	Refrigerated transport	Industrial refrigeration	Stationary air conditioning	Mobile air conditioning
Market and production	A	B*	C*	B/C*	A	A
Lifetime	B/D*	B	A	B	A	B
Refrigerant type	A/C*	B	A	B	B**	A
Refrigerant charge	A	B	B	B/C*	C*	A
Emission rate	B/D*	B/C	B	B/C	B	B/C**
Recovery rate	A	C	B	C	B	B/C**
	* In Article 5(1) countries lifetime, emission rates and refrigerants used are not well known.	*Calculations are based on the number of retailers. The main uncertainties are coming from the number of refrigerating equipment in convenience stores, and food specialists in Article 5(1) countries.	* Data are based on trucks market and production.	*Data are well known in food industry. Other ones (such as the chemical industry) do not communicate; then uncertainty regarding charge and equipment base is larger in this sector.	*Uncertainties about the average cooling capacity of chillers, depending on the country ** new refrigerant markets are well known but past distribution, especially between CFC-11 and CFC-12 is uncertain.	*Refrigerants used in market or production are well known but retrofit process (USA for instance) in servicing is not well estimated ** In countries where "do it yourself" servicing occurs, emission rates are difficult to estimate

0 < |A| < 5% 5 < |B| < 10% 10 < |C| < 15% 15 < |D| < 20% 20 < |E| < 25%

2.3 Atmospheric concentrations and derived emissions (IPCC TEAP, 2005)

The average residence time of a fluorocarbon in equipment or other products varies from less than a year to many decades, depending on the application. In 1974, at the time of the publication of the ozone-depletion hypothesis by Molina and Rowland, fluorocarbons were mainly used in applications such as aerosol propellants, solvents, and open-cell foams, resulting in rapid emissions of these gases to the atmosphere within a year of sale. Since use as propellants, and other applications with rapid emissions, have largely disappeared in non-Article 5(1) countries and are gradually being minimised in Article 5(1) countries, the current use of fluorocarbons is dominated by their continuing use in applications with relatively slow emissions to the atmosphere such as refrigerant and in closed-cell foam applications. The slow emission of refrigerants and blowing agents establish banks, which can emit fluorocarbons for prolonged periods and long after the use of the chemical has ceased.

As noted earlier, when calculating banks of fluorocarbon and other chemicals in refrigeration and in foams, it is necessary to study sales of equipment and/or products, lifetime aspects, leakage during use, and end-of-life issues. This bottom-up approach is based on data from surveys, which must be well designed to ensure complete coverage. However, there are usually cross-checks to ensure completeness. Emission factors for refrigeration equipment and foams have been assessed over several years. These vary significantly according to the application and good market analysis is required to ensure the use of appropriately weighted emission factors. The differences between the use and the forecast emissions applying these functions are assigned to banks, which accrue and diminish with time. Verification of the physical existence of these banks has largely served to confirm the appropriateness of the emission functions adopted, although year-to-year emission projections can have significant error bars for banks that release slowly (e.g. foams), particularly where emission projections are largely based on end-of-life practices. These year-to-year errors (explained in greater detail in Chapter 7) tend to be offset with time, making the level of confidence greater over a multiyear period.

Observations of concentrations of long-lived chemicals in the atmosphere can be used to estimate past emissions. If the lifetime of the chemical is long enough and the rate of mixing is sufficient to ensure a more or less homogeneous concentration in the whole lower troposphere, then past emissions can be derived by simple inverse modelling using the change in observed concentration and the lifetime of the chemicals (see Table TS-2 in the Technical Summary of IPCC TEAP, 2005).

Measurements of long-lived chemicals are performed frequently and with high accuracy in several measurement networks. The uncertainty in derived emissions depends on the uncertainty in the trend in observed concentration and on the uncertainty in the lifetime. Both are relatively small for most chemicals, although deriving emission estimates from small annual changes in relatively large numbers does carry some additional risk. Using different measurement networks may also yield different emissions and therefore information about the uncertainty. On this basis, the uncertainty in derived emissions is about 10% for CFC-11 and between 1% and 6% for other long-lived halocarbons.

As developed further in Chapter 7, the variances observed in the Special Report between derived emissions from atmospheric observations and those derived from bottom-up assessments arise from systematic errors (e.g. lack of SROC completeness for ODS uses and a lack of knowledge on contemporary use patterns for ODS in developing countries) as well as from random errors associated with the uncertainties in the activity data and emissions factors at sectoral level. Evidence suggests that the combination of both forms of error is sufficient to reconcile the variances, although further work would be valuable in characterising both systematic and random errors more fully.

3 Demand, banks and emissions in a BAU scenario, historic data and 2015 emissions

3.1 Assumptions BAU scenario

In the Special Report (IPCC TEAP, 2005) a Business-As-Usual (BAU) scenario was developed for the projections of the demand, banks and emissions of CFCs, HCFCs, HFCs and some PFCs (where these are used as replacements for ozone-depleting substances). In the BAU scenario different annual market growth percentages are assumed for different regions in the world. These projections assume that all existing measures will remain in place, including the Montreal Protocol (phase-out) and relevant national regulations. The Business-As-Usual case assumes the continuing application of all existing measures and the alternative scenario(s) embody improvements that could be implemented assuming global application of current best-practice emission reduction techniques. As a consequence, the usual practices and emission rates will remain unchanged up to 2015 and the recovery efficiency will not increase. This may imply that certain alternative chemicals penetrate to a certain (different) degree in certain markets. The large scale destruction of banks is not included in this BAU scenario. In order to facilitate the calculations of emissions, estimates have been made of the size of the bank of ozone-depleting substances and fluorinated gases in equipment and applications in 2002. Table 3.1 summarises the key assumptions of the Business-As-Usual (BAU) projections.

The activities underlying emissions of fluorocarbons are expected to expand significantly between now and 2015. These activities (such as the requirements for refrigeration, air conditioning and insulation) will involve a number of technologies, including CFCs and HCFCs. In non-Article 5(1) countries, the use and emissions of CFCs and HCFCs will decline as obsolete equipment is retired. In Article 5(1) countries, ozone-depleting substances (particularly HCFCs) may be used for most of the first half of this century and significant growth is expected.

3.2 Demand, banks and emissions per substance and per sector

3.2.1. General observations

Current emission profiles are largely determined by historic use patterns, resulting in a relatively high contribution (now and in the coming decades) from CFCs and HCFCs banked in equipment and foams.

Tables 3-2 and 3-3 show the banks per substance and per sector. Figure 3-1 presents the banks for the year 2002 and for the year 2015, for both the BAU and the MIT scenario. It also gives the shares of the non-Article 5(1) and the Article 5(1) countries in the total.

Table 3-1 Key assumptions in the Business-as-Usual (BAU) Scenario

Sector	Annual market growth 2002−2015 (both in BAU and MIT) (% yr^{-1})				Best practice assumptions				
Refrigeration, SAC and MAC	EU % yr^{-1}	USA % yr^{-1}	Japan % yr^{-1}	A5(1) % yr^{-1}	Type of Reduction	EU	USA	Japan	A5(1)
						BAU	BAU	BAU	BAU
Domestic refrigeration	1	2.2	1.6	2−4.8	Substance	HFC-134a / HC-600a	HFC-134a	HFC-134a	CFC-12 / HFC-134a
					Recovery	0%	0%	0%	0%
Commercial refrigeration	1.8	2.7	1.8	2.6−5.2	Substance	R-404A	HCFC-22 / R-404A	HCFC / R-404A	CFC / HCFC
					Recovery	50%	50%	50%	25%
Industrial refrigeration	1	1	1	3.6−4.0	Substance	HFC-NH_3 (35%)	HCFC / HFC-NH_3 (60%)	HCFC / HFC-NH_3 (35%)	CFC / HCFC-22
					Recovery	50%	50%	50%	15–25%
Transport refrigeration	2	3	1	3.3−5.2	Substance	HFCs	HCFCs / HFCs	HCFCs / HFCs	CFC / HCFC-22
					Recovery	50%	50%	50%	0%
SAC	3.8	3	1	5.4−6.0	Substance	HFCs	HCFCs / HFCs	HCFCs / HFCs	CFC / HCFC-22
					Recovery	50%	30%	30%	0%
MAC	4	4	1	6.0−8.0	Substance	HFC-134a / CO_2 (10%) as of 2008	HFC-134a	HFC-134a	CFC / HCFC-134a
					Recovery	50%	0%	0%	0%
					Charge	700 g	900 g	750 g	750−900 g
Foams	About 2% yr^{-1}					Assumptions on substance use (see Technical Summary section 4.4 (IPCC TEAP, 2005)			
Medical aerosols	1.5–3% yr^{-1}					Partial phase-out of CFCs			
Fire protection	−4.5% yr^{-1} (all substances)					Phase-out of halons			
Non-medical aerosols and solvents	16% increase period in total CO_2-weighted emissions over the period 2002−2015					See (IPCC TEAP, 2005)			

The largest bank of ODS (CFCs) is in foam products, which are located in the non-Article 5(1) countries. This will remain the case between 2002 and 2015. Banks of halons are also important, and are roughly split equally between non-Article 5(1) and Article 5(1) countries. This will remain the case until 2015, although the size of the bank is expected to decrease. Banks of ODS substances in refrigeration and air conditioning are relatively small (compared to the others mentioned above) and will be much smaller in the year 2015, mainly due to a decrease in the CFC banks, which can then only be found in the Article 5(1) countries. Further, more detailed data are presented below.

It should be noted, that recovery efforts and the associated costs may vary widely, to the extent that certain, large amounts of ODS in banks are virtually unrecoverable, although still existing. However, the option for destruction still remains open. For example, refrigerants are generally considered to be easily recoverable but recovery of foam blowing agents can be more complicated (see further chapter 5 in this report).

Most halon-1211 is widely dispersed in building and residential portable fire extinguishers averaging only a few kg each. Other halon-1211 has been centralised in military, aviation and large fire brigades. Collection of the widely dispersed portable extinguishers may prove to be unproductive or uneconomic in some countries. National programs that require halon owners to donate substances and to pay for destruction have resulted in recovery of only a small portion of estimated banks, with unreported quantities likely emitted or lost to avoid the expense. On the other hand, national programs offering a bounty for recovered halon and financing of destruction have demonstrated higher recovery rates.

In general, emissions, i.e., bank-turnover varies significantly from application to application: from months (e.g. solvents), several years (refrigeration applications) to over half a century (foam insulation). The banks stored in equipment and foams may leak during the use phase of the products they are part of, and at the end of the product lifecycle (in case they are not recovered or destroyed.

Table 3-2 2002 Banks of halocarbons per group of substances

Banks 2002	Product (kt product)			ODP (kt ODP)			GWP ($MtCO_2$-eq)		
	World	Non-Article 5(1) countries	Article 5(1) countries	World	Non-Article 5(1) countries	Article 5(1) countries	World	Non-Article 5(1) countries	Article 5(1) countries
Halons	168	80	88	1,173	659	514	531	330	201
CFCs	2,430	1,669	760	2,412	1,665	747	15,749	10,235	5,514
HCFCs	2,651	1,997	643	194	156	37	3,841	2,773	1,062
HFCs	544	494	49	0	0	0	1,103	992	86
PFCs	1	0	0	0	0	0	5	4	0
Total	**5,793**	**4,241**	**1,540**	**3,779**	**2,480**	**1,299**	**21,229**	**14,334**	**6,864**

Table 3-3 2002 Banks of halocarbons per application sector

Banks 2002	Product (kt product)			ODP (kt ODP)			GWP ($MtCO_2$-eq)		
	World	Non-Article 5(1) countries	Article 5(1) countries	World	Non-Article 5(1) countries	Article 5(1) countries	World	Non-Article 5(1) countries	Article 5(1) countries
Refrigeration	971	*406*	*565*	336	*66*	*270*	4,751	*1,423*	*3,328*
Stationary AC	1,193	*868*	*325*	134	*86*	*48*	2,509	*1,721*	*787*
Mobile AC	419	*352*	*67*	150	*108*	*42*	1,987	*1,500*	*487*
Foams	2,996	*2,507*	*490*	1,978	*1,555*	*423*	11,270	*9,241*	*2,029*
Medical Aerosols	12	*9*	*2*	8	*6*	*2*	75	*58*	*17*
Fire Protection	191	*99*	*92*	1,174	*659*	*514*	606	*390*	*216*
HFC-23 by-product	-	-	-	-	-	-	-	-	-
N-M Aer./Solvents	12	*0*	*0*	1	*0*	*0*	32	*0*	*0*
Total	**5,793**	***4,241***	***1,540***	**3,779**	***2,480***	***1,299***	**21,229**	***14,334***	***6,864***

Note: Not all banks data could be allocated to regions. For HFC-23 by-product, non-medical aerosols and solvents no regional breakdown in demand, banks and emissions is available.

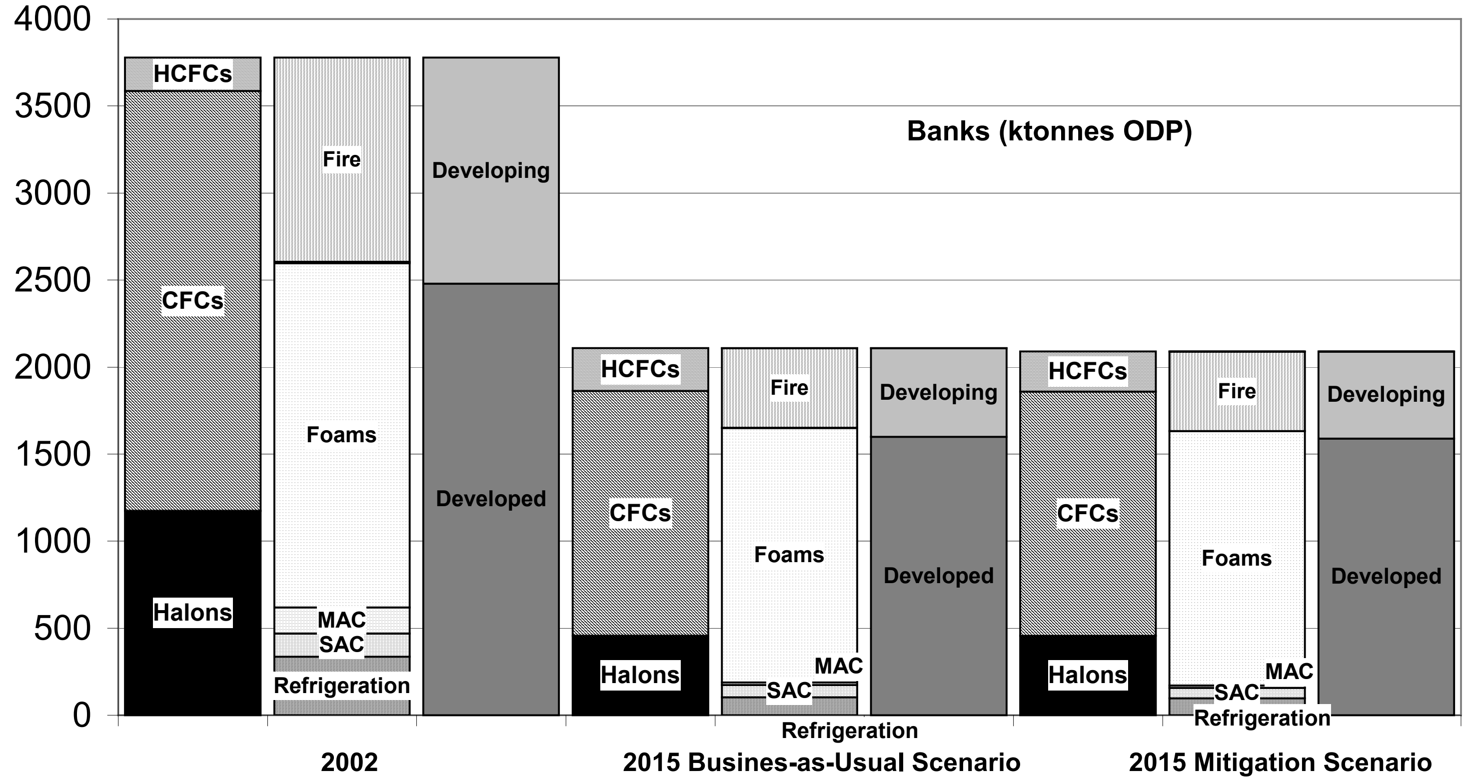

Figure 3-1 Banks of halocarbons expressed in ktonnes ODP. Breakdown per group of substances, per emission sector en per region (non-Article 5(1)/Article 5(1) countries), for 2002, 2015 Business-as-Usual Scenario, and 2015 Mitigation Scenario.

3.2.2 Specific observations related to the 2002 banks

In ktonnes, the largest bank is in foams, being almost 3,000 ktonnes, of which 1,860 ktonnes are CFCs (roughly the same in ODP-ktonnes) and 1,130 ktonnes (119 ODP-ktonnes) are HCFCs. 1,445 ktonnes of CFCs, as well as 1,050 ktonnes of HCFCs (equal to 110 ODP-ktonnes) can be found in the non-Article 5(1) countries. In the Article 5(1) countries, the CFC foams bank amounts to 414 ktonnes (414 ODP-ktonnes), the HCFC foam bank to 76 ktonnes, or 9 ODP-ktonnes. Less than 7% of the global HCFC foam bank is in the Article 5(1) countries.

In 2002, the second largest bank in ODP-ktonnes is in refrigeration, with 335 ODP-ktonnes (971 ktonnes). This amounts to 313 ODP-ktonnes of CFCs and 23 ODP-ktonnes of HCFCs. In this case, 256 ODP-ktonnes (82%) of CFCs are banked in the Article 5(1) countries, as well as 14 ODP-ktonnes of HCFCs (61%). This implies that the largest bank for refrigeration in 2002 is in the Article 5(1) countries. A large portion (186 ODP-ktonnes) is in commercial refrigeration in the Article 5(1) countries, next to 69 ODP-ktonnes in domestic refrigeration.

The halon bank amounts to a total of 168 ktonnes, of which 80 ktonnes are in the non-Article 5(1) and 88 ktonnes in the Article 5(1) countries. In ODP-ktonnes, however, the world total amounts to 1,173 ODP-ktonnes, of which 659 ODP-ktonnes (56%) in the non-Article 5(1), and 514 ODP-ktonnes (44%) in the Article 5(1) countries

3.2.3 2015 Business-As-Usual projections for banks

Between 2002 and 2015, global banks of CFCs decrease from 2,430 to 1,411 ktonnes (more or less the same in ODP-ktonnes), HCFC banks increase from 2,651 to 3,317 ktonnes (194 to 247 ODP-ktonnes). HFC banks take over for a large part since they are assumed to grow from 544 to 2950 ktonnes from 2002 to 2015.

In the non-Article 5(1) countries, CFC banks decrease from 1,669 to 1,132 ktonnes, in the Article 5(1) countries from 760 to 280 ktonnes. HCFC banks in the non-Article 5(1) countries decrease from 1,997 to 1,479 ktonnes, or 156 to 119 ODP-ktonnes. In the Article 5(1) countries they grow from 643 to 1,822 ktonnes, or from 37 to 126 ODP-ktonnes.

In the non-Article 5(1) countries, the foams bank of CFCs decreases from 1,445 to 1,108 ktonnes, the HCFC bank from 1,050 to 986 ktonnes, which for the latter implies that it decreases from 110 to 95 ODP-ktonnes. In the Article 5(1) countries, the foams CFC bank decreases from 414 to 198 ktonnes, the HCFC bank increases from 76 to 516 ktonnes, or from 9 to 61 ODP-ktonnes.

In 2015, the bank in refrigeration is still larger than the bank in stationary air conditioning (103 compared to 70 ODP-ktonnes), but the difference has become much smaller. Globally, the CFC bank decreases between 2002 and 2015 from 313 to 59 ODP-ktonnes in refrigeration, the HCFC bank, however, increases from 23 to 44 ODP-ktonnes. In the non-Article 5(1) countries, the HCFC bank decreases from 9 to 4 ODP-ktonnes, in the Article 5(1) countries, however, the HCFC bank increases from 14 to 41 ODP-ktonnes.

3.2.4 2015 Business-As-Usual projections for emissions

The activities underlying emissions of fluorocarbons are expected to grow significantly between now and 2015. These activities and services (such as refrigeration, air conditioning and insulation) will be provided by a number of technologies and substances, including CFCs and HCFCs. In non-Article 5(1) countries, use and emissions of CFCs and HCFCs will decline following the Montreal Protocol phase-out requirement (and national and regional legislation) as obsolete equipment is retired. In Article 5(1) countries, HCFCs can still be produced until 2040 and significant growth is expected. These changes, and their impacts, are reflected in the data (see data in the Annex).

The fall in CFC emissions is not accompanied by a similar increase in emissions of HFCs because of continuing trends towards non-HFC technology and substitutes with lower GWPs. In addition, but not included in the BAU scenario, capture and safe disposal of materials, that in the past were emitted, is likely to increase for HFCs since the emissions of these substances are controlled under the Kyoto Protocol. The Business-As-Usual case assumes continuing application of all existing measures and the mitigation scenario embodies improvements that could be implemented assuming global application of current best practice emission reduction techniques.

Tables 3-4 and 3-5 show the emissions per substance and per sector for the year 2002. Figure 3-2 presents the emissions for the year 2002 and for the year 2015, for both the BAU and the MIT scenario. It also gives the shares of the non-Article 5(1) and the Article 5(1) countries in the total. Where it concerns emissions, the share of the Article 5(1) countries in the total is relatively large, taking into account the relative distribution of the banks between the Article 5(1) and the non-Article 5(1) countries. Significant amounts of emissions in the Article 5(1) countries originate from refrigeration and air conditioning and from halon equipment. The emissions will have decreased substantially by 2015 due to smaller banks. In both the BAU and the MIT scenario the banks are more or less the same, however, there is a large difference in emissions due to the application of improved techniques and the further improvement of all kind of practices.

Table 3-4 2002 Emissions of halocarbons per group of substances

Emissions 2002	Product (kt yr^{-1} product)			ODP (kt yr^{-1} ODP)			GWP ($MtCO_2$-eq yr^{-1})		
	World	Non-Article 5(1) countries	Article 5(1) countries	World	Non-Article 5(1) countries	Article 5(1) countries	World	Non-Article 5(1) countries	Article 5(1) countries
Halons	11	*5*	*6*	69	*35*	*34*	30	*16*	*13*
CFCs	174	*88*	*86*	168	*87*	*81*	1,652	*814*	*838*
HCFCs	271	*133*	*128*	15	*7*	*7*	448	*218*	*223*
HFCs	124	*103*	*6*	0	*0*	*0*	434	*204*	*11*
PFCs	0	*0*	*0*	0	*0*	*0*	1	*0*	*0*
Total	**580**	***329***	***226***	**252**	***129***	***122***	**2,565**	***1,253***	***1,086***

Table 3-5 2002 Emissions of halocarbons per application sector

Emissions 2002	Product (kt yr^{-1} product)			ODP (kt yr^{-1} ODP)			GWP ($MtCO_2$-eq yr^{-1})		
	World	Non-Article 5(1) countries	Article 5(1) countries	World	Non-Article 5(1) countries	Article 5(1) countries	World	Non-Article 5(1) countries	Article 5(1) countries
Refrigeration	232	*85*	*148*	72	*13*	*59*	1,061	*293*	*768*
Stationary AC	115	*75*	*40*	18	*10*	*7*	271	*165*	*107*
Mobile AC	134	*113*	*21*	60	*48*	*13*	749	*603*	*146*
Foams	51	*42*	*10*	24	*18*	*7*	152	*116*	*35*
Medical Aerosols	12	*9*	*2*	8	*6*	*2*	75	*58*	*17*
Fire Protection	11	*5*	*6*	68	*35*	*34*	31	*17*	*14*
HFC-23 by-product	14	*0*	*0*	0	*0*	*0*	195	*0*	*0*
N-M Aer./Solvents	12	*0*	*0*	1	*0*	*0*	32	*0*	*0*
Total	**580**	***329***	***226***	**252**	***129***	***122***	**2,565**	***1,253***	***1,086***

Note: Not all emission data could be allocated to regions. For HFC-23 by-product, non-medical aerosols and solvents no regional breakdown in demand, banks and emissions is available.

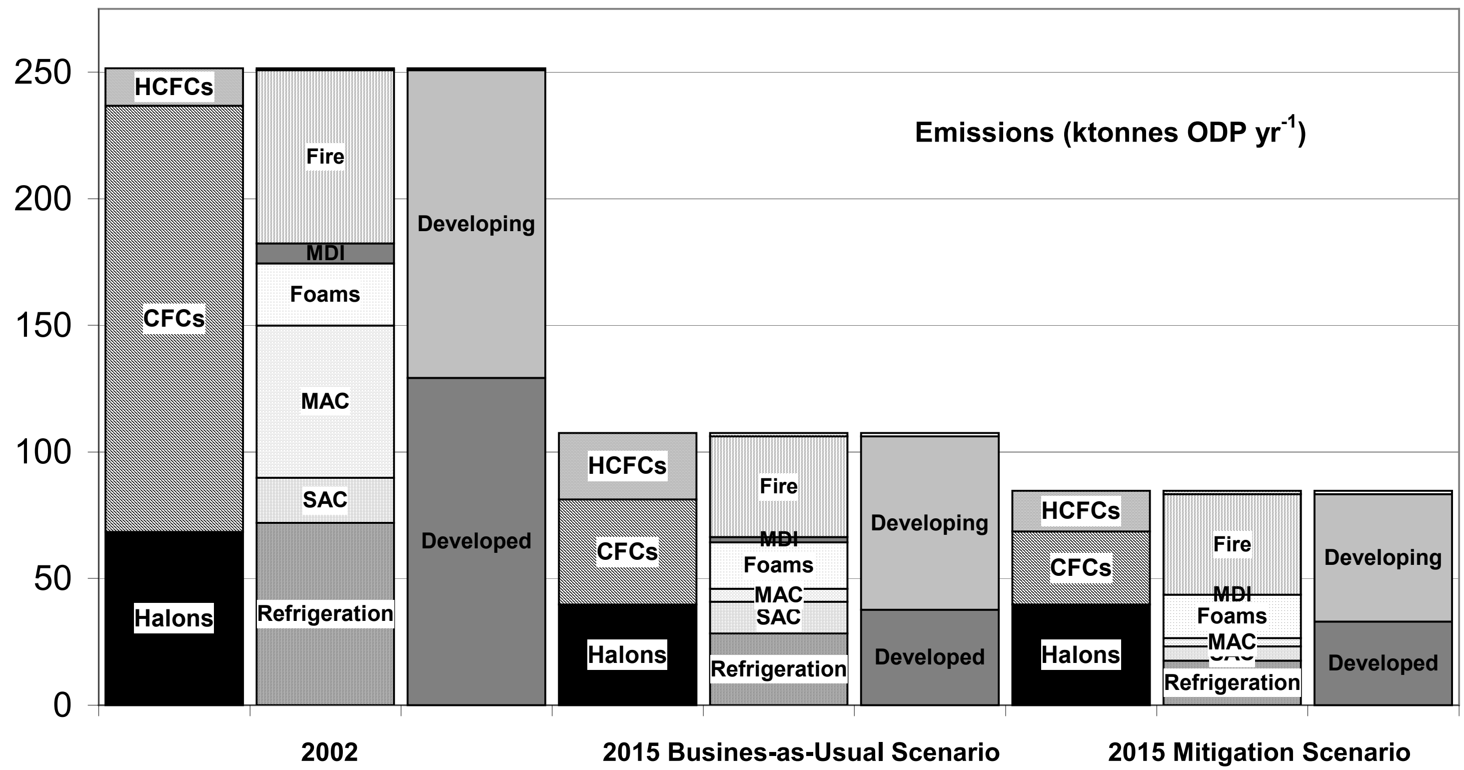

Figure 3-2 Emissions of halocarbons expressed in ktonnes yr^{-1} ODP. Breakdown per group of substances, per emission sector en per region (non-Article 5(1)/Article 5(1) countries), for 2002, 2015 Business-as-Usual Scenario, and 2015 Mitigation Scenario.

In 2002, the emissions of CFCs amount to 174 ktonnes per year, which decrease to 43 ktonnes per year in 2015. Between 2002 and 2015, the emissions of HCFCs increase from 271 to 492 ktonnes per year in 2015, or from 15 to 26 ODP-ktonnes per year.

Between 2002 and 2015, the CFC emissions in the non-Article 5(1) countries decrease from 88 to 17 ODP-ktonnes, in the Article 5(1) countries from 86 to 26 ODP-ktonnes per year.

HCFC emissions globally increase from 271 to 492 ktonnes per year (15 to 26 ODP-ktonnes), in the non-Article 5(1) they decrease from 7 to 5 ODP-ktonnes per year, in the Article 5(1) countries they increase from 7 to 20 ODP-ktonnes per year (128 to 380 ktonnes).

Halon emissions are important, but they decrease from 86 to 40 ODP-ktonnes per year between 2002 and 2015.

Although the quantity of ODS in foams banks was by far the largest, the annual emissions from refrigeration and mobile air conditioning, as well as halons, are larger than foam emissions, particularly in the year 2002. Global CFC emissions from refrigeration decrease from 65 to 12 ODP-ktonnes, in MAC they decrease from 60 to 5 ODP-ktonnes per year, however, in foams they decrease from 22 to 16 ODP-ktonnes per year, which makes foams the largest CFC emitter in the year 2015.

In refrigeration, the CFC emissions in the non-Article 5(1) countries are reduced to a very small amount, from 11 to 1 ODP-ktonne per year, in mobile air conditioning from 47 to 0, in foams from 16 to 12 ODP-ktonnes per year by 2015. HCFC emissions in the non-Article 5(1) countries decrease from 2 to 1 ODP-ktonne per year for refrigeration by 2015 (45 to 18 ktonnes), they remain constant for stationary air conditioning, at 3 ODP-ktonnes. From foam, the HCFC emissions decrease from 2 to 1 ODP-ktonne per year by 2015.

In 2015, the sum of CFC and HCFC emissions in the non-Article 5(1) countries is equal to 22 ODP-ktonnes per year, halon emissions amount to 16 ODP-ktonnes per year, which, in fact, makes the halon bank (and resulting emissions) management very important in the non-Article 5(1) countries, mindful that the bank has halved between 2002 and 2015.

CFC emissions in the Article 5(1) countries decrease from 86 to 26 ktonnes per year (or ODP-ktonnes) between 2002 and 2015. In the Article 5(1) countries, HCFC emissions increase from 128 to 380 ktonnes, or from 7 to 20 ODP-ktonnes per year.

With more or less similar bank sizes, annual emissions of halons are estimated at 35 ODP-ktonnes per year in the non-Article 5(1) countries, and 34 ODP-ktonnes per year in the Article 5(1) countries in the year 2002. The emissions are reduced to 16 ODP-ktonnes in the non-Article 5(1) and to 24 ODP-ktonnes in the Article 5(1) countries in 2015.

In the Article 5(1) countries, CFC emissions from refrigeration decrease from 55 to 11 ODP-ktonnes per year between 2002 and 2015 and are the most important emissions in 2015, followed by halon emissions. CFC emissions from stationary and mobile air conditioning and from foams are all 3-5 ODP-ktonnes per year.

HCFC emissions in the Article 5(1) countries increase for refrigeration (from 87 to 302 ktonnes, or 4 to 15 ODP-ktonnes per year between 2002 and 2015), for stationary air conditioning (33 to 60 ktonnes, or 2 to 3 ODP-ktonnes per year) as well as from 3 to 8 ktonnes per year for foam, which implies that the HCFC emissions from foam are about 1 ODP-ktonne per year in the year 2015.

4 Demand, banks and emissions in a MIT scenario, comparison of 2015 BAU and MIT

4.1 Assumptions MIT scenario

In (IPCC TEAP, 2005) a Mitigation (MIT) scenario was developed for the projections of the demand, banks and emissions of CFCs, HCFCs, HFCs and some PFCs (where these are used as replacements for ozone-depleting substances). In the MIT scenario different annual market growth percentages are assumed for different regions in the world, equal to the ones used in the BAU scenario. These projections assume that all existing measures will remain in place, including the Montreal Protocol (phase-out) and relevant national regulations. The Mitigation case assumes improved application of all existing measures and improvement in best-practice emission reduction techniques. As a consequence, the usual practices and emission rates will change during the period 2002-2015. In the case of refrigeration, the recovery efficiency is assumed to increase in all sub-sectors; charge reductions are assumed in different applications in certain regions of the world. In this scenario certain alternative chemicals penetrate to a larger degree in certain markets than assumed in the BAU scenario. However, large scale destruction of banks is again not included in this MIT scenario. In the case of foams, the dependency on HFCs is less than in the BAU scenario, there are improvements in production and installation and end-of life management is increasingly applied. In the case of medical aerosols it is assumed that there will not be CFC inhalers on the market anymore. Where it relates to halons, there is no difference between the MIT and the BAU scenario here. Table 4-1 summarises the key assumptions of the MIT projections

4.2 Demand, banks and emissions per substance and per sector

4.2.1 Difference between 2015 Business-As-Usual and Mitigation projections for banks

The difference in the size of the banks is minimal between the BAU and MIT scenario in 2015. This conclusion is related to the fact that the difference in the banks in the two scenarios is caused by the application of non-CFC, non-HCFC, low GWP refrigerants and chemicals and by charge reduction. Given the lifetime of some of the products these measures will only proliferate slowly, and more importantly, are not of any influence in CFC based products where manufacturing can be assumed to have stopped either before (in the non-Article 5(1) countries) or in the period 2002-2015.

Table 4-1 Key assumptions in the Mitigation Scenario

Sector	**Annual market growth 2002−2015 (both in BAU and MIT) (% yr^{-1})**				**Best practice assumptions**				
Refrigeration, SAC and MAC	EU % yr^{-1}	USA % yr^{-1}	Japan % yr^{-1}	A5(1) % yr^{-1}	Type of Reduction	EU MIT	USA MIT	Japan MIT	A5(1) MIT
Domestic refrigeration	1	2.2	1.6	2−4.8	Substance	HC-600a	HFC-134a / HC-600a (50%)	HC-600a	Plus HC-600a (50% in 2010)
					Recovery	80%	80%	80%	50%
Commercial refrigeration	1.8	2.7	1.8	2.6−5.2	Substance	R-404A / R-410A (50%)	R-404A / R-410A (50%)	R-404A / R-410A (50%)	R-404A / R-410A (50%)
					Recovery	90%	90%	90%	30%
					Charge	−30%	−30%	−30%	−10%
Industrial refrigeration	1	1	1	3.6−4.0	Substance	HFC-NH_3 (70%)	HCFC / HFC-NH_3 (80%)	HCFC / HFC-NH_3 (70%)	NH_3 (40−70%)
					Recovery	90%	90%	90%	50%
					Charge	−40%	−40%	−40%	−10%
Transport refrigeration	2	3	1	3.3−5.2	Substance	HFCs	HCFCs / HFCs	HCFCs / HFCs	Plus HFCs, up to 30%
					Recovery	80%	70%	70%	20−30%
SAC	3.8	3	1	5.4−6.0	Substance	HFCs	HCFCs / HFCs	HCFCs / HFCs	CFC / HCFC-22 (HFCs 30% in some A5(1))
					Recovery	80%	80%	80%	50%
					Charge		−20%	−20%	
MAC	4	4	1	6.0−8.0	Substance	HFC-134a / CO_2 (50%) as of 2008	HFC-134a / CO_2 (30%) as of 2008	HFC-134a / CO_2 (30%) as of 2008	CFC / HFC-134a
					Recovery	80%	70%	70%	50%
					Charge	500 g	700 g	500 g	750−900 g
Foams	About 2% yr^{-1}				MIT	HFC consumption reduction: A linear decrease in use of HFCs between 2010 and 2015 leading to 50% reduction by 2015. Production/installation improvements: The adoption of production emission reduction strategies from 2005 for all block foams and from 2008 in other foam sub-sectors. End-of-life management options: The extension of existing end-of-life measures to all appliances and steel-faced panels by 2010 together with a 20% recovery rate from other building-based foams from 2010.			
Medical aerosols	1.5–3% yr^{-1}				MIT	Complete phase-out of CFCs			
Fire protection	−4.5% yr^{-1} (all substances)				MIT	Not quantifiable			
	+0.4% yr^{-1} (HCFCs/HFCs/PFCs)				MIT	100% implementation of reduction options (90% emission reduction)			
Non-medical aerosols and solvents	16% increase period in total CO_2-weighted emissions over the period 2002−2015				MIT	Not quantifiable			

Hence, world-wide the banks for CFCs and HCFCs are roughly the same in both scenarios; there are small differences in the domestic and commercial refrigeration sub-sectors. HCFC banks in stationary air conditioning are smaller in the MIT scenario (878 versus 644 ktonnes, or 43 versus 32 ODP-ktonnes). There is no difference in the banked chemicals in foams, as long as it concerns ODS (on the other hand, there are small differences in HFCs banked in foams between the two scenarios).

No major differences in the trends for bank size development during 2002-2015 can be observed between the non-Article 5(1) and the Article 5(1) countries (banks in several sub-sectors are 0 to 10% smaller in the MIT scenario). As mentioned, the exception is in the stationary air conditioning sector where banks are 25% smaller in the non-Article 5(1) and 10% smaller in the Article 5(1) countries, and this applies to 2015 in the MIT scenario.

4.2.2 Difference between 2015 Business-As-Usual and Mitigation projections for emissions

World-wide, CFC emissions are 30% lower in the MIT scenario (29 versus 42 ODP-ktonnes per year); HCFC emissions are almost 40% lower (16 versus 26 ODP-ktonnes per year). Halon emissions are assumed to be the same in both scenarios. This results in 25% lower ODP-tonnes emissions per year (the savings expressed in ktonnes per year are larger, due to the fact that halons do not contribute).

Relatively, the largest reduction is in the stationary air conditioning sector with more than 50% reduction in the MIT versus the BAU scenario (6 versus 13 ODP-ktonnes per year in the BAU scenario), followed by refrigeration with a reduction of about 40%. Reductions in the foam sector are marginal, emissions are 6% lower in the MIT compared to the BAU scenario (17 compared to 18 ODP-ktonnes per year).

If one takes the reductions in HCFC emissions in the MIT scenario, then largest reductions are observed in the stationary air conditioning sector, by 67% (2 versus 6 ODP-ktonnes per year). Virtually no reductions occur in the HCFC foam sector, only some in the CFC foam sector (1 ODP-ktonne per year).

In the non-Article 5(1) countries, the reduction in CFC emissions is minimal (15 versus 16 ODP-ktonnes per year), much larger reductions, about 40%, are possible in the Article 5(1) countries. This depends of course, on the assumptions for these countries in the MIT scenario. The largest reduction can be observed in the stationary air conditioning sector (reduction by 67% in CFCs and HCFCs, both from 3 to 1 ODP-ktonne per year).

In the Article 5(1) countries, the reductions in emissions are larger for both CFCs (14 versus 25 ODP-ktonnes per year) and for HCFCs (12 versus 20 ODP-ktonnes per year). Reductions in the specific refrigeration and AC sub-sectors are all in the order of 35%, except for foam (3 compared to 4 ODP-ktonnes of CFCs per year).

4.2.3 Graphical presentation of the 2015 Business-As-Usual and Mitigation projections for banks and emissions

Figures 4-1 and 4-2 present the banks and emissions for 2002, and for the BAU and MIT projections for the year 2015. The graphs have on the horizontal axis the amounts in Mt CO_2-eq, on the vertical axis the amounts in ODP ktonnes. In both figures data are given for the world, and separately for the non-Article 5(1) and the Article 5(1) countries.

In figure 4-1 it is clearly shown that the size of the foam bank is by far the largest, both for the world and for the non-Article 5(1) countries. The difference between the foam bank in the BAU and the MIT scenario is minimal (due to the long life of rigid foam products).

Figure 4-1 shows that the halon banks decrease significantly on ODP tonnes, the difference in Mt CO_2-eq is minimal (due to the low GWP of halons).

World-wide, the banks of refrigeration, stationary and mobile air conditioning decrease in ODP terms but there are only small decreases between the BAU and MIT scenarios. The largest decrease takes place in mobile air conditioning. In refrigeration and stationary air conditioning the bank increase in GWP terms in the BAU scenario due to market growth and the application of HFC mixtures with relatively high GWP. This is offset for a large part in the MIT scenario for stationary air conditioning, and there is decrease for refrigeration and mobile air conditioning. The same dynamics between the BAU and MIT banks of refrigeration, stationary and mobile air conditioning described for the world can be observed in the case of the non-Article 5(1) countries.

In the Article 5(1) countries, the bank of halons decreases dramatically between 2002 and 2015, and this also holds for the bank in refrigeration equipment (mainly due to the large content of CFCs in the year 2002). The importance of the banks in mobile and stationary air conditioning seem to be relatively low in the Article 5(1) countries. In GWP terms the bank in stationary air conditioning increases due to market growth (and to a small degree due to application of HFC mixtures instead of HCFC-22). The foam bank is much smaller here than in the non-Article 5(1) countries and decreases to two third the amount in ODP ktonnes by the year 2015.

Figure 4-2 shows the emissions for the world as well as for the non-Article 5(1) and the Article 5(1) countries. Mobile air conditioning is now the top-emitter in the non-Article 5(1) countries in 2002 (both in ODP and in GWP terms), with a enormous decrease in 2015 for the BAU scenario and even more for the MIT scenario. Refrigeration is the top emitter in the Article 5(1) countries, with a large decrease in ODP tonnes (not so much in Mt CO_2-eq) by 2015 in the BAU scenario, and a further decrease in the MIT scenario (where the decrease in Mt CO_2-eq is quite outspoken).

In ODP tonnes, the emissions from halon systems are still very significant, in both the non-Article 5(1) and the Article 5(1) countries.

The emissions from foams are relatively small in 2002 but certainly not negligible. In the non-Article 5(1) countries, the contribution of these emissions forms the largest of all in the year 2015, not much different from the contribution of halons in ODP terms.

Refrigeration equipment remains an important source of ODP related emissions in the Article 5(1) countries by 2015 (where only the halon contribution is supposed to be larger).

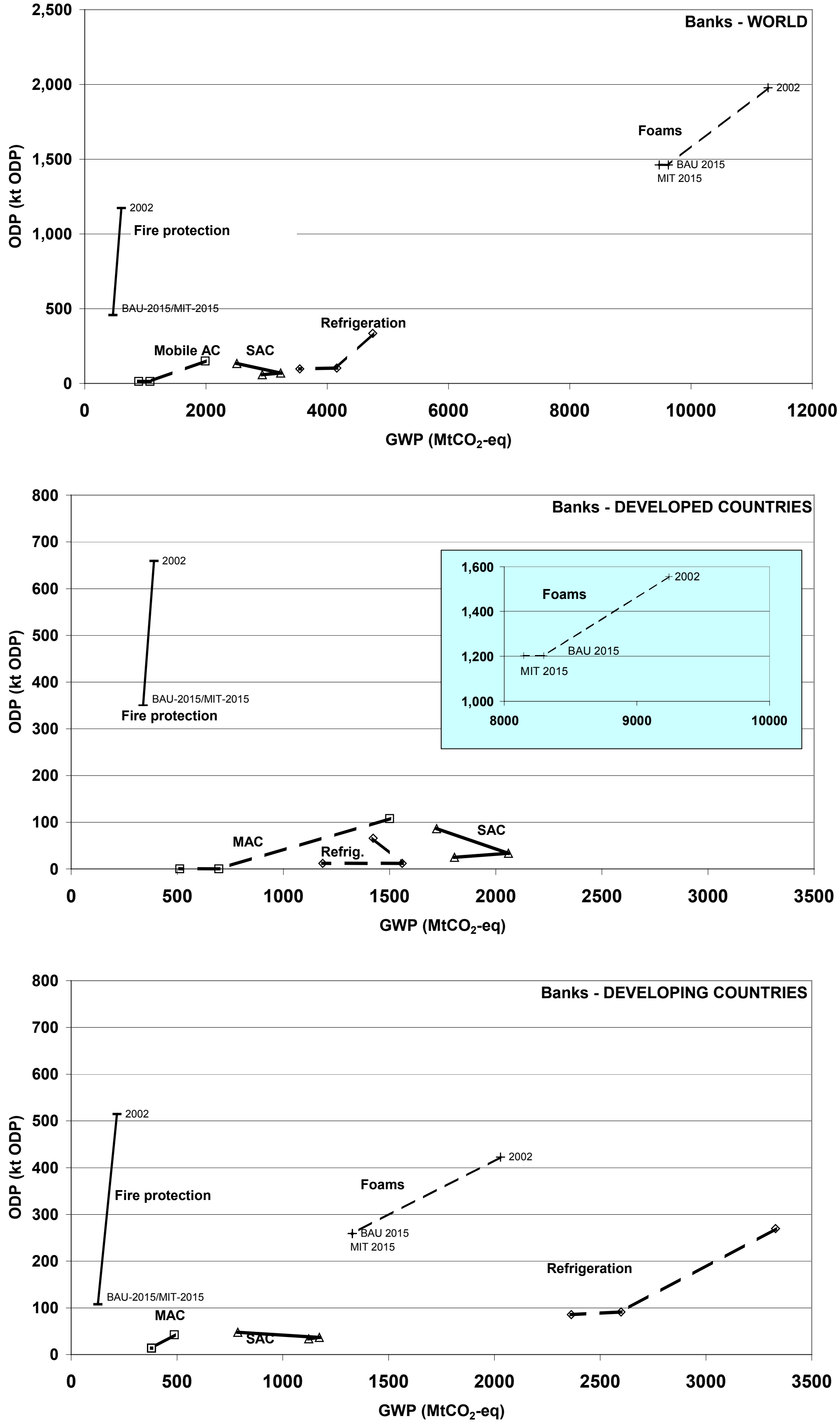

Figure 4-1 Scatter diagram for the sectoral banks of halocarbons expressed in GWP ($MtCO_2$-eq) and ODP (kt ODP) for 2002, and for 2015 in both the Business-As-Usual and the Mitigation Scenario.

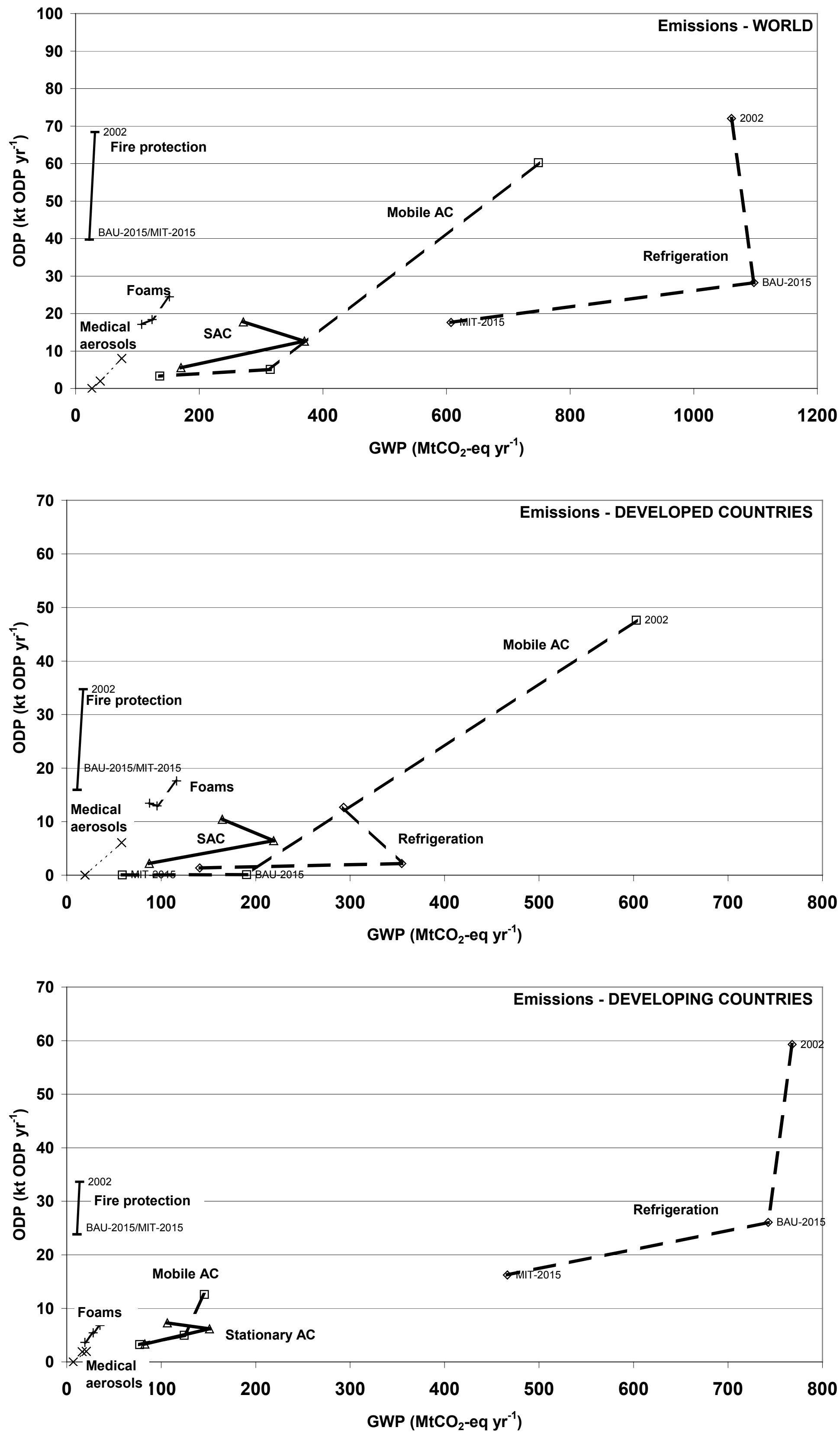

Figure 4-2 Scatter diagram for the sectoral emissions of halocarbons expressed in GWP ($MtCO_2$-eq) and ODP (kt ODP) for 2002, and for 2015 in both the Business-As-Usual and the Mitigation Scenario.

5 Mitigation Costs

5.1 Introduction

The options to reduce ODS (and GHG) emissions explored in the Special Report (IPCC TEAP, 2005) include: improved containment of substances; reduced charge of substances in equipment; end-of-life recovery and recycling or destruction of substances; increased use of alternative substances with a lower or zero global warming potential; not-in-kind technologies; acceleration of the remaining phase-outs (and less dependence on ODSs for exempted feedstock uses, process agent applications, quarantine uses, as well as essential CFC and critical MB uses, where the latter five applications are not considered in this report).

In the Special Report mitigation was considered in the context of lowering global warming impact. This implied considerations on the conversion of equipment manufacturing to certain non-ODS and also to very low GWP alternatives. Mitigation costs were derived for several sectors for avoiding certain amounts of direct global warming emissions. Mitigation of global warming contributions from substances in equipment or products was considered via a mitigation (MIT) scenario, found in chapter 4 of this report. The mitigation scenario assumed a high degree of recover and recycle, good containment, charge reduction in new equipment etc. Costs of recovery and destruction were considered in general terms in a separate chapter in the Special Report (see chapter 11 in IPCC TEAP, 2005); the MIT scenario had no real overall cost component attached to it.

Mitigation where it concerns mitigating the impact of (ODS) emissions on the ozone layer (depletion or recovery) is of a different kind. Where it concerns CFC based equipment and products, the CFC production phase-out by 1996 in the non-Article 5(1) and by 2010 in the Article 5(1) countries is important. It can reasonably be assumed that, as of 2005, no new CFC equipment will be put on the market world-wide (this specifically applies to Article 5(1) countries). CFC based equipment and products still on the market in 2002 (the starting point for the BAU and MIT scenario) will be replaced by non CFC products in the course of a number of years. For a very significant part this has already occurred in the non-Article 5(1) countries, it is occurring in the Article 5(1) countries with the assistance of the Multilateral Fund. The mitigation of the impact on the ozone layer will mainly consist of the avoiding of emissions. Where emissions during operation (which are offset by charging during servicing, which therefore does not add to the bank) are difficult to avoid, mitigation actually applies here to avoiding the release of the substances in the banks.

Clear societal value can be ascribed to preventing further emissions of ODS and GHGs. However, quantifying this value and comparing it against the cost of recovery and destruction is more difficult and there are obvious uncertainties on both sides. It is not simple matter adding current mitigation valuations from more general abatement strategies. Nevertheless, it would seem inappropriate to ignore the potential environmental benefit of potentially cost-effective measures. Accordingly, there may be a place for flexible fiscal mechanisms, which provide incentives without prescription.

Mitigation costs for emissions from banks are significantly greater than those costs traditionally supported for ODS phase-out. This is due to the fact that the cost calculation for ODS phase-out takes into consideration the annual ODS use and related phase-out in a manufacturing operation (at a cost effectiveness of about US $5-15); this is the usual procedure followed in projects submitted to the Executive Committee of the Multilateral Fund. However, the cost of avoiding the release of emissions from banks is related to the quantity of the substances itself, produced during a number of years and is therefore significantly greater. Mitigation costs for the emissions from banks may be economically justified when the additional value of greenhouse gas reduction is accounted.

In the case of concentrated sources mitigation can be practised by:
(a) the recovery of chemicals at end of life and subsequent storage (with possible emission at a much later stage, when the impact on the ozone layer recovery will be negligible). However, this option is not to be preferred because it would still mean an impact on climate at a future stage.
(b) the recovery and collection as under (a) and subsequent destruction.

The decomposition or destruction of ozone-depleting substances, including CFCs, HCFCs and halons (and actually also HFCs) can be achieved using various commercially available and successfully demonstrated technologies. A more detailed overview of destruction technologies and capabilities can be found in (IPCC TEAP, 2005).

At the present time, the quantities of fluorinated gases destroyed by the techniques described above are extremely low; potentially, they do not exceed a few thousand tonnes (IPCC TEAP, 2005). In the European Union, the EU Regulation mandates the destruction of CFCs following their recovery; this also applies to foam insulation when recovered from dismantled equipment (EC 2037/2000). Similarly, CFCs recovered from refrigeration and air-conditioning equipment must also be destroyed. The different technologies involve varying costs, effluents and emissions, energy usage, and destruction efficiencies. Further work is required to estimate whether the current number of destruction facilities globally could cope with the quantities of fluorinated gases recovered and destroyed. Another concern would apply to regions and countries where destruction facilities do not exist and where transport regulations for hazardous wastes prevent their transfer to such facilities in other countries (IPCC TEAP, 2005).

The costs for recovery and recovery/recycling by units for this purpose start at approximately US $500 per tonne. Costs for collection and storage of the recovered ODS refrigerant, including the logistics involved, can roughly be estimated between US $1,000 and 2,000 per tonne of chemical. Dependent on the degree of contamination and on the quantity delivered for destruction, contaminated and unwanted refrigerant can be destroyed for US $2,500-4,500 per tonne of chemical.

As typical costs for the entire operation, US $5 per kg of product (or US $5,000 per tonne of product) can be assumed.

In the case of HCFCs, mitigation implies the transition from ODS to non-ODS chemicals and the conversion of manufacturing equipment (which would imply an early phase-out compared to the existing regulations). Additionally it implies the collection and destruction of the banks of HCFCs. Where the costs for collection and destruction will be the same as for CFCs per kg of substance, the costs for collection and destruction are more or less 20 times as expensive per ODP-kg (US $100 per ODP-kg or US $100,000 per ODP-tonne). Here the focus is on refrigerants rather than on the blowing agent HCFC-141b.

5.2 Description of mitigation costs for the refrigeration/AC sector

Refrigeration and mobile air conditioning had an estimated bank of 460 ktonnes of CFCs in 2002, and for 2015 a bank of 70 ktonnes is predicted (world-wide). More than two thirds of this CFC bank can be found in the Article 5(1) countries. It may be assumed that destruction of *all* available CFCs would start in the year 2008; it would then concern an amount of about 280 ktonnes of CFCs world-wide. Costs for collection and destruction would be in the order of US $1,400 million. If only 10% would be collected and destroyed, the costs would still be in the order of US $140 million, where the impact on ozone layer recovery may not be significant.

If one would take into account the emissions that originate during servicing operations, these will add to the emissions from the banks (where the servicing amount over the entire period considered may be even larger than the amount present in the 2002 banks). It needs to be mentioned that there is no practical method to mitigate these emissions. For the investigations of the impacts on the ozone layer, these emissions should actually be considered next to the banks. This will give an adequate impression of the importance of destruction for an earlier recovery of the ozone layer compared to the delay caused by the emissions from servicing.

The amount of HCFCs banked in refrigeration and stationary air conditioning was 1,490 ktonnes of product (70 ODP ktonnes) and is predicted to be about 1,600 ktonnes of product in 2015 (this is dependent on whether the BAU or MIT scenario is selected). Up to 2015 (the amount of HCFCs contained in products up to 2015) collection and destruction would apply to at least 1,000 ktonnes of product, if one assumes that destruction would start in 2008. The number is high, because in the period 2008-2015 a number of HCFC products will be replaced by HFC products and products withdrawn from the market would have to be treated at end of life (recovery of the chemical contained). Destruction would imply costs in the order of US $100 billion. Taking into account that it concerns only a percentage of the CFCs assumed to be destroyed as of 2008, costs are enormously high. One should also take into account that, after 2015, equipment based on HCFCs will still be marketed. This can only be avoided if all HCFC equipment manufacturing would be converted (which will introduce a very high cost component). Otherwise it would add to the destruction costs in future (after the period 2008-2015).

5.3 Description of mitigation costs for the foam sector

Mitigation costs for foams need to be assessed in terms of the sub-sector of application (i.e. appliances or buildings) and the stage in the life-cycle within which the mitigation is proposed. An example of such an assessment is that being conducted by the Japanese Technical Center on Construction Materials (JTCCM) to evaluate the cost effectiveness of recovery of blowing agents from foams in buildings. The cost-effectiveness is the subject of the fourth and final year of the project which will conclude and report in March 2006. Preliminary indications from previous work carried out in the field (Swedish EPA, 1995) show that recovery from traditional buildings may be uneconomical. However, the fact that steel-faced panels could be processed through recapture/recycle mechanical refrigerator plants may have an impact on future achievements.

These approaches have been stimulated under the Montreal Protocol framework, even though recovery is not mandated. Under the Multilateral Fund, the finance made available for phase-out is typically capped at US $15/kg for CFC-11 (Jeffs, Ashford, Albach and Kotaji, 2004). At previous levels of activity, the mechanical recapture/recycling processes were handling domestic refrigerators at a net cost of US $15-20/unit (UNEP TEAP, 2002), although more recent information from the market suggests that this may have even fallen as low as US $10/unit. With typical recovery levels of 250-325g per unit, the cost of recapture and destruction is US $30-60 per kg of blowing agent or US $30,000-60,000 per ODP tonne. This figure would necessarily increase for HCFC-141b because of its lower ODP with costs increasing to US $250,000- US $500,000 per ODP tonne.

As noted earlier, these figures are based on mechanical recovery through refrigerator plants. In these instances, investment decisions will be based primarily on CFCs, which offer the lowest recovery cost. It could therefore be argued that later recovery of HCFCs (and indeed HFCs) should only be treated in incremental cost terms. However, such discrimination is unlikely to take place commercially.

5.4 Description of mitigation costs for halon sector

In 2008, the bank of halons would amount to 780 ODP ktonnes, or about 120 ktonnes of product (both halon-1301 and -1211). Available halon-1301 should be banked and managed for critical uses, but halon-1211 may be available for destruction. The costs for destruction of halon-1211 would be about US $500 million, which is less costly per ODP tonne than destruction of CFCs.

At the sectoral level, collection and destruction of the halon-1301 bank is counterproductive because available supply is necessary for critical uses.

Beyond the need to support long-term requirements for halon-1211 such as in commercial aircraft, military applications, etc., destruction of some halon-1211 might be made cost-effective relative to other ODS depending upon economic offsets to the extreme collection difficulties. Destruction of halon offers no benefit to climate protection due to the fact that halons are contributing to a net global cooling effect.

6 Impacts on ozone layer recovery

In the previous chapters the global banks of ozone depleting substances are given. In this chapter their potential effects on the future ozone layer are discussed using the existing and well-documented methods used in the UNEP/WMO Scientific Assessment of Ozone Depletion (WMO, 1999, 2003).

Observations of concentrations in the atmosphere constrain the past emissions, but the banks are the difference between cumulative emissions and production and have much larger uncertainties. The banks in (IPCC TEAP, 2005), which are further discussed in chapters 3 and 4 in this report are a result of the calculations of equipment and products manufactured and charged with certain amounts of ODSs; their uncertainties do not originate from emission and production figures. The reported banks of CFCs and HCFCs of Chapter 3 are considerably larger than those given in (WMO, 2003), especially for CFC-11 and CFC-12. The CFC-11 bank in 2002 is 590 ktonnes according to (WMO, 2003) compared with 1690 ktonnes according to Chapter 3 (see also Ashford *et al*., 2004c, IPCC TEAP, 2005). The CFC-12 bank in 2003 is virtually zero according to WMO (2003) compared with 710 ktonnes as follows from information given in Chapter 3.

The larger banks in Chapter 3 are characterised by significantly lower emissions of CFC-11 and CFC-12 over the past 10 years, if compared with the emissions reported in (WMO, 2003). The lower emissions cannot support the observations in the atmosphere – that is, they lead to global atmospheric concentrations about 40 ppt lower than those observed in 2002 for both CFC-11 and CFC-12. However, it should be mentioned that the banks discussed here are the banks for refrigeration, AC, foams and halons and the releases from these banks do not represent all ODS emissions. Emissions are also likely to result from direct-emissive applications, applications not considered in this Supplement Report.

The uncertainty in the accumulated top-down emissions is estimated at about 3%, based on an estimated 2–3% uncertainty in observed concentrations by different measurement networks (IPCC TEAP, 2005, Table 2-1). Based on an inverse calculation, the accumulated emissions for 1990-2001, which are needed to support the observations of CFC-11 and CFC-12, have an uncertainty of about 4%, assuming an uncertainty in the observed concentration trends of 1%. The uncertainty in cumulative production is harder to estimate. The total 1990-2001 production of CFC-11 and CFC-12 in (Ashford *et al.,* 2004b and 2004c) is about 30–35% lower than in (WMO, 2003). This difference can be largely attributed to the fact that production data not reported to AFEAS (2004) have not been taken into account, however, they are included in UNEP production data. Because the additional UNEP production is most likely used in rapid-release applications (IPCC TEAP, 2005, chapter 11), it does not change the size of the bank.

Uncertainties in accumulated emission and production add up to the uncertainty in the change in the bank from 1990 to 2002, which applies to both the bank in (WMO, 2003) and the banks given in this Supplement Report.

The virtually zero bank of CFC-12 reported in (WMO 2003) is not in agreement with the data in Chapter 3 (see also chapter 6 of IPCC TEAP, 2005), because CFC-12 is still contained in refrigeration and mobile air conditioning equipment currently operated.

The concept of Equivalent Effective Stratospheric Chlorine (EESC)[1], as defined in the 2002 Report of the Science Assessment Panel (WMO, 2003), can be used to estimate the effects of the ODSs on the ozone layer. The year of ozone layer 'recovery' is defined by a return to pre-1980 EESC values.

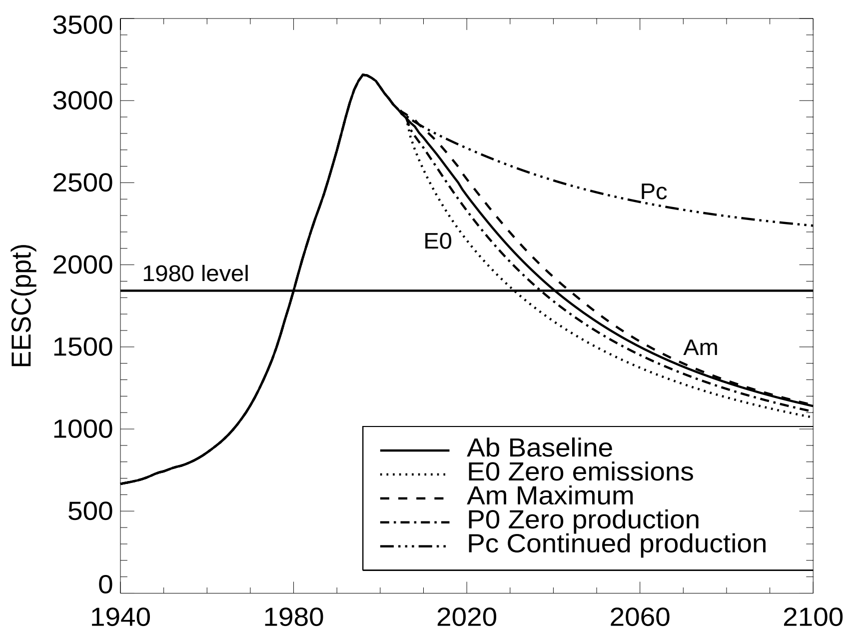

Figure 6-1 Estimates of future EESC based on the baseline scenario (Ab; solid line), the maximum scenario (Am; long-dashed line), and the hypothetical cases of zero emissions in 2003 and thereafter (E0), and zero production in 2003 and thereafter of all anthropogenic ODSs (P0). Also shown are results from the scenario with continued ODS production in the future at 1999 rates (Pc), production that is substantially larger than allowed in the fully revised and amended Montreal Protocol (Figure 1-23 from WMO, 2003).

Figure 6-1 shows the EESC for different scenarios discussed in (WMO, 2003). The maximum (Am) and zero emissions (E0) scenarios show the range of possible future

[1] EESC is the effective halogen abundance that characterises the impact of (all types) of ODS emissions on stratospheric ozone

EESC values. The hypothetical zero emissions scenario gives the lower limit of chlorine/bromine loading governed by the destruction of ODSs in the atmosphere. The zero emissions scenario could be considered as the mitigation scenario with maximum impact.

Banks 2002 (ktonnes)	**E0 (E1)**	**Ab scenario (WMO, 2003)**	**SROC/ Supplement**
CFC-11	-	594	1687
CFC-12	-	0	711
HCFC-141b	-	753	836
HCFC-142b	-	210	224
HCFC-22	-	1317	1531
Year of return of the EESC to 1980 levels	**2034 (2039)**	**2044**	**2046**

Table 6-1 Estimates of bank sizes in different scenarios and of the year of the return of the EESC to 1980 values (E0 denotes the hypothetical case that all emissions would stop in 2003, E1 the case when no emissions would occur from banks)

The maximum (Am) scenario gives the maximum EESC values based on an estimate of the maximum allowed production under the Montreal Protocol. The assumptions made for the maximum scenario of HCFCs in (WMO 2003) yield significantly lower emissions and banks than given in Chapter 3. The EESC for the maximum scenario (Am) shown in Figure 6-1 would increase slightly taking the larger banks of Chapter 3 into account.

Table 6-1 gives the typical sizes of the 2002 banks for a number of fluorocarbon chemicals for the baseline in (WMO, 2003) and of the banks in the Special Report (and in this Supplement Report).

If no emissions occurred from the ODS banks as estimated in (WMO, 2003), the date when the EESC is estimated to return to its 1980 value is 2039, or an acceleration of about five years. Finally, if emissions of all ODSs were stopped in 2003, the date when the EESC is estimated to return to its 1980 value was given as 2034 in (WMO, 2003), an acceleration of about ten years. Both values have been given in Table 6-1. The best estimate of the year when the EESC is projected to return to 1980 values for the baseline scenario of (WMO, 2003) is 2044, if the banks of all ODSs are as estimated in (WMO, 2003). It needs to be mentioned that the hypothetical bank of CFC-12 in the Ab (WMO, 2003) scenario is equal to zero, which does not reflect the real situation (see also Chapter 3). If the sizes of the banks of CFCs and HCFCs are as estimated in Chapter 3, this return to the 1980 values would be estimated to occur in the year 2046. In this case, no emissions out of the foam bank were considered to be of significant impact. The return of the EESC to its 1980 value based on an estimated maximum allowed production under the Montreal Protocol is 2048 (not mentioned in Table 6-1).

If one would take into account the emissions from servicing, which will add to the emissions from the banks (where the servicing amount over the entire period considered may be even larger than the amount present in the 2002 banks in certain sub-sectors), the return of the EESC to 1980 values levels might be delayed by another two years at maximum compared to the year 2046, for the banks in the Special Report (and in this Supplement). Destruction of all banks in refrigeration and AC equipment as of 2008 (destruction during the period after 2008 at end-of-life, the option considered in chapter 5), may have the consequence that the return of the EESC to 1980 values will again be around the year 2046.

Some emissions of banked CFCs (such as the slow emissions of CFC-11 from foams) could occur after ozone recovery. Such emissions would reduce the effect of the banks on ozone recovery but would still contribute to the positive direct radiative forcing as greenhouse gases. Thus the larger banks of some ODSs estimated in Chapter 3 could lead to a maximum delay in ozone recovery of the order of two to three years compared with the baseline scenario.

These calculations of the effects of the banks of Chapter 3 on the EESC is based on the emission functions of (WMO, 2003), resulting in somewhat different emissions and banks for CFC-12 and HCFCs in 2015 than given in Chapter 3. The effect of this on the year of recovery will be limited since most emissions will take place anyway (and affect the ozone layer) before the approximate year of recovery.

Thus, the changes in future ODS emissions as discussed here, within ranges compatible with the present uncertainties in the banks, have relatively small effects on the time at which the EESC recovers to 1980 levels and therefore on stratospheric ozone and the indirect radiative forcing of these gases. The absolute value for the EESC to return to its 1980 levels depends on uncertainties in the physical and chemical processes involved resulting in somewhat later or earlier recovery than given here (IPCC TEAP, 2005, chapter 1). The uncertainty associated with the differences between the scenarios discussed here is much smaller.

In this chapter the effects of the size of the banks of ODS on the year the EESC drops below its 1980 level has been discussed. Clearly an ODS scenario affects the stratospheric chlorine and bromine levels and thereby the ozone layer also in the period up to the year of recovery. Integrating the change in the EESC from a specific year to the year the EESC drops below its

1980 level gives another measure to compare the effects of scenarios (see WMO, 2003).

An update of scenarios of ODS and corresponding EESC calculations will be presented in the upcoming "UNEP/WMO Scientific Assessment of Ozone Depletion: 2006".

7 Discrepancies between emissions determined from bottom-up methods and from atmospheric measurements

7.1 Sources of uncertainty regarding consumption

Efforts to model the use (consumption) and emission of ODSs and their replacements by sector have been on-going since the mid-1990s. One of the advantages of working with ODSs controlled under the Montreal Protocol is that actions to quantify the historic use patterns had already been established under both the Alternative Fluorocarbon Environmental Assessment Study (AFEAS) and UNEP itself.

The AFEAS data originate from the major producers of ODSs and their alternatives and have the advantage of being split by substance and sales pattern by sector. However, one drawback is that they are only declared by 'hemisphere' to avoid disclosure of confidential business information. Since AFEAS is effectively a consortium of producers, there is also the problem that the sales from producers that are not members of AFEAS are not included. Since all of the major historic manufacturers are members of AFEAS, this is not a particular problem for historic data but has become more of an issue as production of ODSs and their substitutes has extended to newer manufacturers in Article 5(1) countries. The final point to observe on the AFEAS dataset is that the process for the allocation of sales to sectors has never been made fully transparent. For example, it is not clear as to what percentage of sales were to distributors and may have ended up in applications other than those anticipated. Additionally, there may not have been a total understanding among sales staff as to whether sales to the foam sector were destined for open-celled or close-celled applications.

UNEP's data collection efforts on the other hand are reported directly by Parties and this has provided production, consumption, import and export data at country level. However, there has been no effort during the collection of these data series to assess sales patterns by sector. In earlier years, where discrepancies between AFEAS and UNEP data were relatively minor, this was of less importance to modellers. However, as the coverage of the AFEAS dataset has become less comprehensive, and the discrepancies between UNEP and AFEAS datasets have become larger, the knowledge of sectoral end-use pattern has become less complete.

To compensate for this, modellers have moved to other sources for information, including the database of multilaterally funded projects, which provides details of original consumption and transition strategies on a project-by-project basis. Although fairly painstaking to conduct, such analysis can provide important clarification of use patterns in the Article 5(1) countries.

However, there can be some difficulties in the precise timing of transition where, for instance, projects might be completed operationally but not finalised contractually or *vice versa*. Additionally, not all the use of ODS or ODS substitutes will be covered by funded projects. Not surprisingly, therefore, the MLF Project database rarely provides a total explanation for the gap between UNEP data and AFEAS assessments bearing in mind that this gap cannot be assessed in any event at country-level because of the lack of geographic definition in the AFEAS dataset. Other sources such as Country Programmes, independent studies and local contacts all come into play as sources of further corroborative data.

In the end, the sectoral modeller builds a model based only on the use, which can be positively assigned to the sector in question. This then has to be combined with outputs from modellers addressing other sectors to assemble a bottom-up, globally complete picture of consumption, which can be compared with the global UNEP dataset. It is still usual that the bottom-up approach falls short of the UNEP total, possibly because not all actual use-sectors are covered in any bottom-up approach. However, it is typical to see greater than 80% of historic and current annual consumption covered by these methods.

For some sectors, where there are large numbers of broadly replicated equipment and market data are prevalent, it is possible to carry out an even more elaborate assessment based on the equipment data themselves. Such is the case for several types of refrigeration equipment where units are often standardised and sold globally. A primary example would be domestic refrigerators. Unitary air conditioners would be another. Accordingly, bottom-up work in the refrigeration sector tends also to have a significant component of equipment data as an additional cross-referencing factor based on assumptions about charge levels. However, it is important that such data are not relied upon in isolation because small errors in assumption at unitary level can lead to substantial errors when extrapolated to a global dataset.

Similar options exist for fire fighting equipment which is a well documented equipment market, but the same is not true for most foams (with the possible exception of that used in domestic refrigerators) because building designs are not uniform either regionally (both climates and building methods vary) or by type.

In conclusion, the usage or consumption patterns, put together within bottom-up models, probably represent the most complete sectoral analysis available. This baseline is essential for adequate emissions assessment since the lifecycle emission profiles vary so substantially. However, the lack of full sectoral coverage continues to make the assessments incomplete. In the HFC/PFC Special Report, the coverage was further limited by the scope of focusing on those sectors which have selected substitutes containing HFCs and/or PFCs. These factors are important when considering the overall evaluation of consumption and emissions from a bottom-up perspective in that report.

7.2 Sources of uncertainty regarding emission factors

It can be seen that the use of ODS, which has taken place in sectors likely to develop banks, has been well studied but continues to be an area where global data can be improved. However, before these data can be translated into a meaningful assessment of emissions, there is a need to apply appropriate emission factors to the data. Since emissions vary through the lifecycle of an application, there is also a need to keep a disciplined record of the time series of use rather than just the cumulative value of historic use at any given time. In other words, it is not just sufficient to know 'how much is in the bank'. It is also necessary to know 'when it entered the bank and when it is likely to leave'.

An additional complicating factor is that specific applications within a sector can have very different emissions profiles. This means that the use needs to be known at sub-sectoral level in order for the appropriate emission factors to be applied. This fact brings with it two potential sources of further uncertainty. The first relates to the access to historical time-series of usage at sub-sectoral (application) level. This further highlights the importance of genuinely designed bottom-up methods, which are generally better at characterising sub-sectoral definition. The second potential source is the statistical variation, which will always occur in practice around an average lifecycle characterisation. Most bottom-up models have point assumptions for matters such as the lifetime of a product or piece of equipment. Therefore, the retirement date of a piece of equipment is fixed by its year of manufacture. In reality, of course, some equipment will be retired earlier and some later.

Taking the domestic refrigerator example, it is not likely that everyone who purchased a domestic refrigerator in 1990 will have chosen to throw it away in 2005. Some will have been disposed of earlier and others will remain in operation for much longer than the assumed 15 year average. Therefore, to predict the end-of-life emissions for domestic refrigerators in 2005 is fraught with the potential of substantial over-estimation or under-estimation. This is particularly important when the bulk of emissions are assigned to end-of-life activities, as is the case with foams. Accordingly, foam emissions can carry with them substantial error bars when data are quoted on an annualised basis. However, it is usually expected to be much more accurate when longer time periods are reviewed, reflecting the fact that it is easier to predict that a given refrigerator will be retired in a ten-year time period than it is to make the same prediction for a one year time period. By way of example, the Table 7-1 illustrates the expected errors in emission for different foam blowing agents.

Table 7-1 Expected errors in emission estimates for different foam blowing agents

Blowing Agent	Annual Emission Uncertainty (2002) (tonnes / % of bank)		Key Sources in 2002	Uncertainty Level
	Upper bound	Lower bound		
CFC-11	+10,000/ 0.6%	-10,000/ -0.6%	Domestic Appliance (EoL) PU Boardstock (in-use) PU Spray (in-use)	High (for specific year) Low Low
HCFC-141b	+10,000/ 1.2%	-5,000/ -0.6%	PU Boardstock (prod/use) PU Spray (prod/use) Dom. Appliance (prod/use)	Medium (transition yr.) High (transition plus prod. losses) Low
HCFC-142b	+5,000/ 2.2%	-0/ 0.0%	XPS (prod/use) PE rigid (prod/use)	Medium (Prod. losses) High (activity)
HFCs	+2,500/ 21%	-2,500/ -21%	XPS (prod/use)	High (HFC-152a emission rate)

It can be seen from the table that uncertainties need to be specified for specific years. There may be some periods in which there is little uncertainty year-on-year about what is happening, but others in which much may be going on.

Then there are potential sources of uncertainty from the emission factors themselves. These are usually assumptions based on estimates produced from small-scale studies within a given sector. Good examples would be the determination of blowing agent levels in refrigerators and steel faced panels after 25 years. From measurements made on retained blowing agent and comparisons with the original formulations, believed to have been used in their manufacture, it is evident that losses are very low in the use phase of these respective products (typically 0.25% per annum or less). This should come as little surprise for foams encapsulated with sheet steel. Of course, this assessment makes no judgement on the blowing agent that may have been lost during the formulation of the foam system or the manufacture of the product, which are steps that have to be assessed separately.

In the case of refrigeration equipment, the servicing (top-up) demand can be another way of identifying the emissions from a sub-sector and back-calculating the relevant emission factors.

Based on the uncertainty levels indicated in Table 2-2, the uncertainties in banks and emissions for each refrigeration sub-sector are summarised in Table 7-2 below:

Table 7-2 Uncertainties by sub-sector and overall

	Bank	**Emissions ***
Domestic	+/- 17.5%	+/- 8%
Commercial	+/- 22.5%	+/- 28%
Industrial	+/- 27.5%	+/- 33%
Transport	+/- 22.5%	+/- 28.5%
Stationary AC	+/- 17.5%	+/- 22.5%
Mobile AC	+/- 12.5%	+/- 18.5%
Overall	+/- 19%	+/- 24.5%

Note: uncertainties in emissions are on an annual basis

7.3 Reconciling the discrepancies

The determination of emissions via the bottom-up method has previously revealed substantial discrepancies with the emissions calculated from atmospheric measurements of the same chemicals. However, closer analysis of these apparent discrepancies has found that even relatively small use of fluorocarbons in rapidly emitting uses in Article 5(1) countries (see Section 7.1) can dominate emissions for specific chemicals (e.g. CFC-11) in specific years (IPCC TEAP, 2005). This implies that there is a need to investigate production data, both from producers as reported to AFEAS and from countries as submitted to UNEP under the Montreal Protocol (Article 7 on data reporting), in order to determine where such emissions might appear. However, as noted previously, the key weakness in the UNEP dataset is that it makes no provision for the recording of use patterns. Nonetheless, the quantification of the gap between UNEP production and consumption data and AFEAS data is essential.

The emission factors used in the AFEAS reports themselves are derived from a consideration of the respective emission patterns and release delays for each sector but are not always as sophisticated as those used in the bottom-up assessments. By way of an example, the allocation of all HCFC-141b foam sales to "closed-cell foams" may be inappropriate in view of uses in integral skin and other more rapid-release foam applications.

This said, estimates of atmospheric concentrations based on production statistics provided by manufacturers and national governments coupled with historical emission factors were, until recently, a good match with the observations, largely because of the dominance of rapid-release applications in non-Article 5(1) countries. However, as the detailed assessment of delayed-release applications has become more important in non-Article 5(1) countries and the gap between UNEP data and AFEAS data has increased, reflecting higher levels of activity in Article 5(1) countries, the lack of use pattern data via the UNEP reporting structure is now a key impediment, particularly where usage might be occurring in rapid-release applications.

The improvement of knowledge about the use of the individual chemicals, both in the non-Article 5(1) and in the Article 5(1) countries, as well as uncertainties in emissions factors from banks following the bottom-up method remains a key objective. This has implications for the calculation of emission scenarios for the period 2002-2015, in particular the contributions from Article 5(1) countries. It may therefore be the case that the emissions are significantly larger than calculated via the bottom-up method for refrigeration and foams only because of additional contributions from rapid-release applications.

In addition, the emission factors applied to HCFCs and HFCs were derived from those developed earlier for CFCs and HCFC-22. However, there have been considerable changes in use practices in the wake of the Montreal Protocol and emission factors are subject to continual review. The view is (IPCC TEAP, 2005) that variation and uncertainties in emission factors per se are less significant overall than uncertainties in overall use pattern distributions between rapid-release applications and the delayed-release applications represented by refrigeration and foams.

This implies that, in the near future, further study is needed of the use patterns for the total production forecast for the period 2002-2015 in both the non-Article 5(1) and the Article 5(1) countries. Further study will also be needed to make more precise estimates of future emissions from banks in refrigeration and foams, given the accuracy of calculations of the size of the banks and the emissions derived from them, as well as servicing practices, and issues relating to recovery and recycling and end-of-life.

8 Concluding remarks

The Special Report concludes that the remaining banked ODSs, together with possible future ODS use in Article 5(1) countries, are significant sources of ozone depletion emissions with a related climate change impact over the next 50-100 years. There continues to be some debate about the size of these banks and on whether mitigation scenarios can be practically effective in reducing emissions, from a technical and cost point of view. However, there are already demonstrable savings being achieved in relevant sub-sectors (e.g. domestic refrigeration) in various regions of the world.

In this Supplement Report, demand, banks and emissions are considered for the world-total, as well as for the non-Article 5(1) and the Article 5(1) countries separately. This will yield insight on the percentage release from banks in different regions of the world, where banks (and emissions) may be completely different in composition.

The time-scale for action varies by sector and, for instance, foams in buildings containing ODS are unlikely to be reaching the waste stream in any significant measure prior to 2015. In contrast, most CFCs will have already been emitted from the refrigerant bank by 2015 unless action is taken to prevent this.

The best estimate of the year when the EESC (see further chapter 6) is projected to return to the 1980 values for the baseline scenario of (WMO, 2003) is 2044, if the banks of all ODSs are as estimated in (WMO, 2003). If the banks of CFCs and HCFCs are as estimated in Chapter 3, this return to the 1980 values would be estimated to occur in the year 2046. Taking into account the emissions from servicing refrigeration and AC equipment, which will add to the emissions from the banks, the return of the EESC to 1980 values levels might be delayed by another two years, at maximum (2048). Destruction of all banks in refrigeration and AC equipment as of 2008 (at end of life) may lead to a return of the EESC to 1980 values around the year 2046.

Mitigation costs for emissions from banks are significantly greater than those costs traditionally supported for ODS phase-out but may be economically justified when the additional value of greenhouse gas reduction is accounted. It therefore seems unlikely that it will be possible to extend mandates for recovery unless the cost-effectiveness calculation includes greenhouse gas benefits. At sectoral level, the halon bank would fail on both accounts due to the high expenses involved in trying to collect small quantities widely dispersed, as well as the fact that halons are contributing to a net global cooling effect. For CFCs, refrigerant recovery and collection is estimated at US $2 per ODP kg (and an additional US $3 per ODP kg for destruction) with foam blowing agent recovery an order of magnitude greater. It should be noted that these values increase further in the case of HCFC recovery (and destruction).

There is therefore clearly need for further research on more cost-effective destruction techniques (e.g. direct foam incineration). Where relevant, the cost of avoiding additional banks of ODSs and GHGs, by an accelerated ODS phase-out using appropriate alternative technologies, may be less than for collection and destruction. An alternative technology that increases the overall climate change impact of the application cannot be described as appropriate.

The relationship between halon, refrigerant and blowing agent options changes considerably if any credit is given for the greenhouse gas component of any recovery measure. This would need to be reflected in some fiscal incentive for destruction, possibly linked with existing emission trading options for greenhouse gases.

Finally, in Article 5(1) countries, the implication of collection and recovery costs are likely to be greater than in non-Article 5(1) countries owing to the lack of infra-structure. Indeed, end-of-life concepts are very different in Article 5(1) countries from the ones in non-Article 5(1) countries and the degree of re-use is generally much higher.

9 References

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10 Annexes

Detailed tables on demand, banks and emission data 2002-2015

The following tables show the data that were presented in the IPCC/TEAP Special Report on Ozone and Climate (SROC) (IPCC TEAP, 2005) and the assessed literature supporting this report (e.g. Ashford *et al.*, 2004).

Please note that the tables include corrected data on banks and emissions for halon-1211 in the fire protection sector and hence data for halons and fire protection differ from the data reported in the IPCC/TEAP Special Report. The 2002 halon-1211 emission data are changed from 17 to 8 product ktonnes per year, whereas 2015 Business-As-Usual projections are changed from 1.6 to 4.6 product ktonnes per year
(Verdonik, 2005).

The data on demand, banks and emissions expressed in global warming potential (GWP in $MtCO_2$-eq) and ozone depletion potential (ODP in ODP ktonnes) are calculated using the GWPs for direct radiative forcing for a 100-year time horizon and ODPs as reported in (IPCC TEAP, 2005).

For HFC-23 by-product emissions, non-medical aerosols and solvents no regional breakdown in demand, banks and emissions is available.

Key to the tables

'Demand' refers to the net use of fluorocarbons and their alternatives. Due to reuse, demand data may exceed annual production data.

'Banks' are the total amount of substances contained in existing equipment, chemical stockpiles, foams and other products not yet released to the atmosphere or destroyed in destruction facilities.

'Emissions' refer to direct emissions only. Indirect energy-related greenhouse gas emissions are not included in the tables.

BAU-2015:	Projections for 2015 in the Business-As-Usual Scenario
MIT-2015:	Projections for 2015 in the Mitigation Scenario
Red-2015:	Reduction potential in 2015: difference between the projections for the Business-As-Usual and the Mitigation Scenario.

Demand	**WORLD**											
Per group	**Product** ktonne yr^{-1}				**GWP_{SROC}** $MtCO_2$-eq yr^{-1}				**ODP_{SROC}** ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons	4				10				23			
CFCs	169	14	8	5	1,649	125	77	48	162	13	7	5
HCFCs	496	551	391	160	761	905	623	282	32	31	24	8
HFCs	207	663	466	197	449	1,323	889	434				
PFCs	0.11	0.02	0.02		1.0	0.2	0.2					
Total incl halons	**876**	**1,228**	**866**	**363**	**2,869**	**2,353**	**1,589**	**763**	**217**	**44**	**31**	**13**
Total excl halons	**872**	**1,228**	**866**	**363**	**2,859**	**2,353**	**1,589**	**763**	**194**	**44**	**31**	**13**

Per sector	**Product** ktonne yr^{-1}				**GWP_{SROC}** $MtCO_2$-eq yr^{-1}				**ODP_{SROC}** ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	337	578	396	182	1,390	1,335	867	467	85	23	17	7
Stationary Air Conditioning	202	300	212	88	407	512	354	158	19	9	5	4
Mobile Air Conditioning	155	192	142	50	740	296	222	74	56	3	2	0
Foams	150	123	80	43	204	119	69	50	25	6	6	
Medical Aerosols	12	15	15		75	40	26	14	8	2		2
Fire Protection	8	4	4		23	14	14		23	0	0	
HFC-23 by-product												
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**876**	**1,228**	**866**	**363**	**2,869**	**2,353**	**1,589**	**763**	**217**	**44**	**31**	**13**

Per subsector	**Product** ktonne yr^{-1}				**GWP_{SROC}** $MtCO_2$-eq yr^{-1}				**ODP_{SROC}** ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	15	22	8	14	83	38	17	21	7	1	1	0
Commercial Refrigeration	277	502	354	148	1,160	1,144	753	391	71	19	13	5
Transport Refrigeration	6	8	6	2	20	23	17	6	1	0	0	0
Industrial Refrigeration	39	46	28	17	127	129	79	50	6	4	3	1
Stationary Air Conditioning	202	300	212	88	407	512	354	158	19	9	5	4
Mobile Air Conditioning	155	192	142	50	740	296	222	74	56	3	2	0
Foams	150	123	80	43	204	119	69	50	25	6	6	
Medical Aerosols	12	15	15		75	40	26	14	8	2		2
Fire Protection	8	4	4		23	14	14		23	0	0	
HFC-23 by-product												
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**876**	**1,228**	**866**	**363**	**2,869**	**2,353**	**1,589**	**763**	**217**	**44**	**31**	**13**

Demand — WORLD

Halons	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	4				10				23			
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**4**				**10**				**23**			

CFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	82	6	4	2	840	53	38	15	76	5	3	1
Stationary Air Conditioning	11	3	2	2	86	26	14	12	11	3	2	2
Mobile Air Conditioning	56	3	2	0	598	28	25	4	56	3	2	0
Foams	11				56				11			
Medical Aerosols	8	2		2	69	17		17	8	2		2
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**169**	**14**	**8**	**5**	**1,649**	**125**	**77**	**48**	**162**	**13**	**7**	**5**

HCFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	188	378	269	109	332	671	478	194	9	19	13	5
Stationary Air Conditioning	165	106	55	51	281	185	97	88	8	5	3	3
Mobile Air Conditioning	3	1	1	0	5	2	2	0	0	0	0	0
Foams	128	50	50		136	37	37		14	6	6	
Medical Aerosols												
Fire Protection	0.5	0.3	0.3		0.6	0.1	0.1		0.02	0.01	0.01	
HFC-23 by-product												
Non-Medical Aerosols and Solvents	11	16	16		6	9	9		1	1	1	
Total	**496**	**551**	**391**	**160**	**761**	**905**	**623**	**282**	**32**	**31**	**24**	**8**

Demand — WORLD

HFCs	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	66	194	123	71	218	611	351	259				
Stationary Air Conditioning	25	190	155	35	40	301	243	58				
Mobile Air Conditioning	97	188	138	50	136	265	195	70				
Foams	11	73	30	43	11	82	32	50				
Medical Aerosols	4	13	15	-2	6	23	26	-4				
Fire Protection	3	4	4		12	14	14					
HFC-23 by-product												
Non-Medical Aerosols and Solvents	1	1	1		25	27	27					
Total	**207**	**663**	**466**	**197**	**449**	**1,323**	**889**	**434**				

PFCs	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.01	0.01	0.01		0.1	0.1	0.1					
HFC-23 by-product												
Non-Medical Aerosols and Solvents	0.10	0.01	0.01		0.9	0.1	0.1					
Total	**0.11**	**0.02**	**0.02**		**1.0**	**0.2**	**0.2**					

Demand — A. DEVELOPED COUNTRIES

Per group	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons												
CFCs	52	3	2	1	515	28	17	11	51	3	2	1
HCFCs	268	47	18	29	391	79	30	49	19	2	1	1
HFCs	188	505	326	179	392	1,002	607	395				
PFCs	0.01	0.01	0.01		0.1	0.1	0.1					
Total incl halons	**508**	**555**	**346**	**209**	**1,298**	**1,109**	**654**	**455**	**70**	**5**	**3**	**3**
Total excl halons	**508**	**555**	**346**	**209**	**1,298**	**1,109**	**654**	**455**	**70**	**5**	**3**	**3**

Per sector	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	113	146	85	61	329	497	260	237	6	2	2	1
Stationary Air Conditioning	138	185	124	61	261	307	203	105	11	3	1	2
Mobile Air Conditioning	126	137	92	45	507	193	130	63	35	0	0	0
Foams	118	73	30	43	132	82	32	50	11			
Medical Aerosols	9	11	11		58	19	19		6			
Fire Protection	3	3	3		10	9	9		0	0	0	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**508**	**555**	**346**	**209**	**1,298**	**1,109**	**654**	**455**	**70**	**5**	**3**	**3**

Per subsector	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	6	7	1	6	9	10	2	8	0	0	0	0
Commercial Refrigeration	81	110	67	43	234	396	204	192	2	1	0	0
Transport Refrigeration	4	6	4	2	13	19	14	5	0	0	0	0
Industrial Refrigeration	23	23	13	10	73	73	41	32	3	2	1	1
Stationary Air Conditioning	138	185	124	61	261	307	203	105	11	3	1	2
Mobile Air Conditioning	126	137	92	45	507	193	130	63	35	0	0	0
Foams	118	73	30	43	132	82	32	50	11			
Medical Aerosols	9	11	11		58	19	19		6			
Fire Protection	3	3	3		10	9	9		0	0	0	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**508**	**555**	**346**	**209**	**1,298**	**1,109**	**654**	**455**	**70**	**5**	**3**	**3**

Demand

A. DEVELOPED COUNTRIES

Halons	**Product** ktonne yr^{-1}				**GWP$_{SROC}$** MtCO$_2$-eq yr^{-1}				**ODP$_{SROC}$** ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total												

CFCs	**Product** ktonne yr^{-1}				**GWP$_{SROC}$** MtCO$_2$-eq yr^{-1}				**ODP$_{SROC}$** ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	4	2	1	1	41	16	11	5	4	1	1	0
Stationary Air Conditioning	6	2	1	1	43	12	6	6	6	2	1	1
Mobile Air Conditioning	35	0	0	0	379	0	0	0	35	0	0	0
Foams												
Medical Aerosols	6				52				6			
Fire Protection												
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**52**	**3**	**2**	**1**	**515**	**28**	**17**	**11**	**51**	**3**	**2**	**1**

HCFCs	**Product** ktonne yr^{-1}				**GWP$_{SROC}$** MtCO$_2$-eq yr^{-1}				**ODP$_{SROC}$** ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	49	19	12	7	84	32	20	12	2	1	1	0
Stationary Air Conditioning	111	28	6	22	185	46	9	37	5	1	0	1
Mobile Air Conditioning	1	0	0	0	1	0	0	0	0	0	0	0
Foams	107				121				11			
Medical Aerosols												
Fire Protection	0.5	0.2	0.2		0.5	0.1	0.1		0.02	0.01	0.01	
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**268**	**47**	**18**	**29**	**391**	**79**	**30**	**49**	**19**	**2**	**1**	**1**

Demand — A. DEVELOPED COUNTRIES

HFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	60	126	72	53	205	449	229	221				
Stationary Air Conditioning	21	156	118	38	33	249	187	62				
Mobile Air Conditioning	90	137	92	45	127	193	130	63				
Foams	11	73	30	43	11	82	32	50				
Medical Aerosols	3	11	11		6	19	19					
Fire Protection	3	3	3		10	9	9					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**188**	**505**	**326**	**179**	**392**	**1,002**	**607**	**395**				

PFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.01	0.01	0.01		0.1	0.1	0.1					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**0.01**	**0.01**	**0.01**		**0.1**	**0.1**	**0.1**					

Demand

B. DEVELOPING COUNTRIES

Per group	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons	4				10				23			
CFCs	117	10	6	4	1,134	97	60	37	111	10	6	4
HCFCs	217	489	358	131	364	817	584	233	12	28	21	7
HFCs	18	157	139	18	32	294	255	39				
PFCs	0.001	0.002	0.002		0.01	0.01	0.01					
Total incl halons	**356**	**656**	**503**	**153**	**1,539**	**1,207**	**899**	**308**	**147**	**37**	**27**	**10**
Total excl halons	**352**	**656**	**503**	**153**	**1,529**	**1,207**	**899**	**308**	**123**	**37**	**27**	**10**

Per sector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	224	431	310	121	1,060	837	608	230	79	21	15	6
Stationary Air Conditioning	64	114	88	26	146	205	151	54	8	6	3	2
Mobile Air Conditioning	29	55	49	6	232	102	91	11	21	3	2	0
Foams	32	50	50	0	72	37	37	0	14	6	6	
Medical Aerosols	2	4	4		17	21	7	14	2	2		2
Fire Protection	4	1	1		13	5	5		23	0	0	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**356**	**656**	**503**	**153**	**1,539**	**1,207**	**899**	**308**	**147**	**37**	**27**	**10**

Per subsector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	9	16	7	9	74	28	16	13	7	1	1	0
Commercial Refrigeration	197	391	287	105	926	748	549	199	69	18	13	5
Transport Refrigeration	1	2	1	0	7	4	3	1	0	0	0	0
Industrial Refrigeration	17	23	16	7	53	56	39	17	3	2	1	1
Stationary Air Conditioning	64	114	88	26	146	205	151	54	8	6	3	2
Mobile Air Conditioning	29	55	49	6	232	102	91	11	21	3	2	0
Foams	32	50	50	0	72	37	37	0	14	6	6	
Medical Aerosols	2	4	4		17	21	7	14	2	2		2
Fire Protection	4	1	1		13	5	5		23	0	0	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**356**	**656**	**503**	**153**	**1,539**	**1,207**	**899**	**308**	**147**	**37**	**27**	**10**

Demand

B. DEVELOPING COUNTRIES

Halons	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	4				10				23			
HFC-23 by-product		No regional breakdown available				No regional breakdown available				No regional breakdown available		
Non-Medical Aerosols and Solvents												
Total	**4**				**10**				**23**			

CFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	78	4	3	1	799	37	27	10	72	3	2	1
Stationary Air Conditioning	5	2	1	1	43	14	8	6	5	2	1	1
Mobile Air Conditioning	20	3	2	0	219	28	25	4	20	3	2	0
Foams	11				56				11			
Medical Aerosols	2	2		2	16	17		17	2	2		2
Fire Protection												
HFC-23 by-product		No regional breakdown available				No regional breakdown available				No regional breakdown available		
Non-Medical Aerosols and Solvents												
Total	**117**	**10**	**6**	**4**	**1,134**	**97**	**60**	**37**	**111**	**10**	**6**	**4**

HCFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	139	359	257	102	248	639	457	182	7	18	13	5
Stationary Air Conditioning	55	78	50	29	97	139	88	51	3	4	2	1
Mobile Air Conditioning	2	1	1	0	4	2	2	0	0	0	0	0
Foams	21	50	50		16	37	37		2	6	6	
Medical Aerosols												
Fire Protection	0.1	0.1	0.1		0.07	0.03	0.03		0.003	0.002	0.002	
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**217**	**489**	**358**	**131**	**364**	**817**	**584**	**233**	**12**	**28**	**21**	**7**

Demand

B. DEVELOPING COUNTRIES

HFCs	Product ktonne yr^{-1}				GWP$_{SROC}$ $MtCO_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	7	69	51	18	13	161	123	38				
Stationary Air Conditioning	4	34	37	-3	6	52	56	-4				
Mobile Air Conditioning	6	51	46	5	9	72	65	8				
Foams	0	0	0	0	0	0	0	0				
Medical Aerosols	0	2	4	-2	0	4	7	-4				
Fire Protection	1	1	1		3	5	5					
HFC-23 by-product		No regional breakdown available				No regional breakdown available				No regional breakdown available		
Non-Medical Aerosols and Solvents												
Total	**18**	**157**	**139**	**18**	**32**	**294**	**255**	**39**				

PFCs	Product ktonne yr^{-1}				GWP$_{SROC}$ $MtCO_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.001	0.002	0.002		0.01	0.01	0.01					
HFC-23 by-product		No regional breakdown available				No regional breakdown available				No regional breakdown available		
Non-Medical Aerosols and Solvents												
Total	**0.001**	**0.002**	**0.002**		**0.01**	**0.01**	**0.01**					

Demand

O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

Per group	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons												
CFCs												
HCFCs	11	16	16		6	9	9		1	1	1	
HFCs	1	1	1		25	27	27					
PFCs	0.10	0.01	0.01		0.9	0.1	0.1					
Total incl halons	**12**	**17**	**17**		**32**	**37**	**37**		**1**	**1**	**1**	
Total excl halons	**12**	**17**	**17**		**32**	**37**	**37**		**1**	**1**	**1**	

Per sector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**12**	**17**	**17**		**32**	**37**	**37**		**1**	**1**	**1**	

Per subsector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration												
Commercial Refrigeration												
Transport Refrigeration												
Industrial Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**12**	**17**	**17**		**32**	**37**	**37**		**1**	**1**	**1**	

Demand

O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

Halons	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total												

CFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total												

HCFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	11	16	16		6	9	9		1	1	1	
Total	**11**	**16**	**16**		**6**	**9**	**9**		**1**	**1**	**1**	

Demand

O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

HFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	1	1	1		25	27	27					
Total	**1**	**1**	**1**		**25**	**27**	**27**					

PFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	0.10	0.01	0.01		0.9	0.1	0.1					
Total	**0.10**	**0.01**	**0.01**		**0.9**	**0.1**	**0.1**					

Banks — WORLD

Per group	Product (ktonne)				GWP_{SROC} ($MtCO_2$-eq)				ODP_{SROC} (ktonne ODP)			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons	168	55	55		531	229	229		1,173	457	457	
CFCs	2,430	1,411	1,407	4	15,749	8,302	8,258	43	2,412	1,406	1,402	4
HCFCs	2,651	3,317	3,017	300	3,841	4,871	4,352	520	194	247	232	15
HFCs	544	2,950	2,613	337	1,103	5,227	4,527	700				
PFCs	1	1	1		5	4	4					
Total incl halons	**5,793**	**7,735**	**7,093**	**641**	**21,229**	**18,633**	**17,370**	**1,263**	**3,779**	**2,110**	**2,091**	**19**
Total excl halons	**5,625**	**7,679**	**7,038**	**641**	**20,698**	**18,404**	**17,141**	**1,263**	**2,606**	**1,653**	**1,634**	**19**

Per sector	Product (ktonne)				GWP_{SROC} ($MtCO_2$-eq)				ODP_{SROC} (ktonne ODP)			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	971	1,675	1,455	221	4,751	4,157	3,548	609	335	103	98	6
Stationary Air Conditioning	1,192	1,856	1,689	166	2,509	3,232	2,928	304	134	70	59	11
Mobile Air Conditioning	418	671	541	131	1,987	1,076	891	185	150	14	14	0
Foams	2,996	3,374	3,250	123	11,270	9,626	9,475	151	1,977	1,462	1,462	
Medical Aerosols	12	15	15		75	40	26	14	8	2		2
Fire Protection	191	126	126		606	465	465		1,174	457	457	
HFC-23 by-product												
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**5,793**	**7,735**	**7,093**	**641**	**21,229**	**18,633**	**17,370**	**1,263**	**3,779**	**2,110**	**2,091**	**19**

Per subsector	Product (ktonne)				GWP_{SROC} ($MtCO_2$-eq)				ODP_{SROC} (ktonne ODP)			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	157	226	140	87	1,218	664	523	141	107	37	35	2
Commercial Refrigeration	606	1,193	1,087	107	2,863	2,746	2,355	391	194	44	41	3
Transport Refrigeration	16	23	23		57	72	72		2	0	0	
Industrial Refrigeration	192	233	205	28	613	676	598	77	33	22	22	0
Stationary Air Conditioning	1,192	1,856	1,689	166	2,509	3,232	2,928	304	134	70	59	11
Mobile Air Conditioning	418	671	541	131	1,987	1,076	891	185	150	14	14	0
Foams	2,996	3,374	3,250	123	11,270	9,626	9,475	151	1,977	1,462	1,462	
Medical Aerosols	12	15	15		75	40	26	14	8	2		2
Fire Protection	191	126	126		606	465	465		1,174	457	457	
HFC-23 by-product												
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**5,793**	**7,735**	**7,093**	**641**	**21,229**	**18,633**	**17,370**	**1,263**	**3,779**	**2,110**	**2,091**	**19**

Banks — WORLD

Halons	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	168	55	55		531	229	229		1,173	457	457	
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**168**	**55**	**55**		**531**	**229**	**229**		**1,173**	**457**	**457**	

CFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	330	64	62	2	3,423	653	627	26	313	59	57	2
Stationary Air Conditioning	84	27	27	0	631	208	208	0	84	27	27	0
Mobile Air Conditioning	149	13	13	0	1,600	138	138	0	149	13	13	0
Foams	1,858	1,305	1,305		10,026	7,286	7,286		1,858	1,305	1,305	
Medical Aerosols	8	2		2	69	17		17	8	2		2
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**2,430**	**1,411**	**1,407**	**4**	**15,749**	**8,302**	**8,258**	**43**	**2,412**	**1,406**	**1,402**	**4**

HCFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	461	891	825	66	810	1,582	1,466	117	23	44	41	3
Stationary Air Conditioning	1,028	878	644	233	1,755	1,536	1,134	402	50	43	32	11
Mobile Air Conditioning	20	23	23	0	36	42	41	1	1	1	1	0
Foams	1,126	1,502	1,502		1,229	1,696	1,696		119	157	157	
Medical Aerosols												
Fire Protection	4	6	6		5	6	6		0	0	0	
HFC-23 by-product												
Non-Medical Aerosols and Solvents	11	16	16		6	9	9		1	1	1	
Total	**2,651**	**3,317**	**3,017**	**300**	**3,841**	**4,871**	**4,352**	**520**	**194**	**247**	**232**	**15**

Banks — WORLD

HFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	180	720	568	153	518	1,922	1,455	467				
Stationary Air Conditioning	81	951	1,018	-67	123	1,488	1,586	-99				
Mobile Air Conditioning	249	635	505	131	350	896	712	184				
Foams	12	566	443	123	16	644	494	151				
Medical Aerosols	4	13	15	-2	6	23	26	-4				
Fire Protection	19	64	64		65	226	226					
HFC-23 by-product												
Non-Medical Aerosols and Solvents	1	1	1		25	27	27					
Total	**544**	**2,950**	**2,613**	**337**	**1,103**	**5,227**	**4,527**	**700**				

PFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.5	0.5	0.5		4.1	4.3	4.3					
HFC-23 by-product												
Non-Medical Aerosols and Solvents	0.1	0.01	0.01		0.9	0.1	0.1					
Total	**0.6**	**0.5**	**0.5**		**5**	**4**	**4**					

Banks — A. DEVELOPED COUNTRIES

Per group	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons	80	40	40		330	181	181		659	349	349	
CFCs	1,669	1,132	1,132	0	10,235	6,535	6,535	0	1,665	1,130	1,130	0
HCFCs	1,997	1,479	1,299	180	2,773	2,161	1,852	308	156	119	111	9
HFCs	494	2,327	2,015	312	992	4,089	3,435	655				
PFCs	0.4	0.5	0.5		4	4	4					
Total incl halons	**4,241**	**4,978**	**4,486**	**493**	**14,334**	**12,970**	**12,007**	**963**	**2,480**	**1,598**	**1,589**	**9**
Total excl halons	**4,161**	**4,939**	**4,446**	**493**	**14,004**	**12,789**	**11,826**	**963**	**1,821**	**1,249**	**1,240**	**9**

Per sector	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	406	508	415	94	1,423	1,559	1,185	374	66	12	12	0
Stationary Air Conditioning	868	1,220	1,075	146	1,721	2,060	1,805	254	86	34	25	9
Mobile Air Conditioning	352	492	361	130	1,500	695	511	184	108	0	0	0
Foams	2,507	2,660	2,536	123	9,241	8,298	8,147	151	1,555	1,203	1,203	
Medical Aerosols	9	11	11		58	19	19		6			
Fire Protection	99	87	87		390	339	339		659	349	349	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**4,241**	**4,978**	**4,486**	**493**	**14,334**	**12,970**	**12,007**	**963**	**2,480**	**1,598**	**1,589**	**9**

Per subsector	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	80	79	42	37	467	114	62	52	38	0	0	0
Commercial Refrigeration	200	285	249	36	548	990	731	258	8	2	1	0
Transport Refrigeration	12	18	18		38	58	58		0	0	0	
Industrial Refrigeration	115	127	106	20	370	398	334	64	20	10	10	0
Stationary Air Conditioning	868	1,220	1,075	146	1,721	2,060	1,805	254	86	34	25	9
Mobile Air Conditioning	352	492	361	130	1,500	695	511	184	108	0	0	0
Foams	2,507	2,660	2,536	123	9,241	8,298	8,147	151	1,555	1,203	1,203	
Medical Aerosols	9	11	11		58	19	19		6			
Fire Protection	99	87	87		390	339	339		659	349	349	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**4,241**	**4,978**	**4,486**	**493**	**14,334**	**12,970**	**12,007**	**963**	**2,480**	**1,598**	**1,589**	**9**

Banks — A. DEVELOPED COUNTRIES

Halons	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	80	40	40		330	181	181		659	349	349	
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**80**	**40**	**40**		**330**	**181**	**181**		**659**	**349**	**349**	

CFCs	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	61	10	10	0	622	95	95	0	57	8	8	0
Stationary Air Conditioning	50	14	14	0	354	98	98	0	50	14	14	0
Mobile Air Conditioning	108	0	0	0	1,153	1	0	0	108	0	0	0
Foams	1,445	1,108	1,108		8,054	6,341	6,341		1,445	1,108	1,108	
Medical Aerosols	6				52				6			
Fire Protection												
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**1,669**	**1,132**	**1,132**	**0**	**10,235**	**6,535**	**6,535**	**0**	**1,665**	**1,130**	**1,130**	**0**

HCFCs	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	183	79	76	3	315	138	132	6	9	4	4	0
Stationary Air Conditioning	751	405	228	177	1,265	699	397	302	36	20	11	9
Mobile Air Conditioning	9	4	3	0	16	6	6	1	0	0	0	0
Foams	1,050	986	986		1,172	1,313	1,313		110	95	95	
Medical Aerosols												
Fire Protection	4	5	5		5	5	5		0	0	0	
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**1,997**	**1,479**	**1,299**	**180**	**2,773**	**2,161**	**1,852**	**308**	**156**	**119**	**111**	**9**

Banks

A. DEVELOPED COUNTRIES

HFCs	Product ktonne				GWP$_{SROC}$ MtCO2-eq				ODP$_{SROC}$ ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	163	418	328	90	486	1,326	958	369				
Stationary Air Conditioning	67	801	833	-31	102	1,262	1,310	-48				
Mobile Air Conditioning	235	488	358	130	331	689	505	183				
Foams	12	566	443	123	16	644	494	151				
Medical Aerosols	3	11	11		6	19	19					
Fire Protection	15	42	42		51	149	149					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**494**	**2,327**	**2,015**	**312**	**992**	**4,089**	**3,435**	**655**				

PFCs	Product ktonne				GWP$_{SROC}$ MtCO2-eq				ODP$_{SROC}$ ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.4	0.5	0.5		4	4	4					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**0.4**	**0.5**	**0.5**		**4**	**4**	**4**					

Banks

B. DEVELOPING COUNTRIES

Per group	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons	88	16	16		201	48	48		514	108	108	
CFCs	760	280	275	4	5,514	1,767	1,724	43	747	276	272	4
HCFCs	643	1,822	1,703	119	1,062	2,701	2,490	211	37	126	121	6
HFCs	49	622	597	25	86	1,110	1,065	45				
PFCs	0	0	0		0	0	0					
Total incl halons	**1,540**	**2,740**	**2,591**	**149**	**6,864**	**5,626**	**5,326**	**300**	**1,299**	**510**	**500**	**10**
Total excl halons	**1,452**	**2,724**	**2,575**	**149**	**6,663**	**5,578**	**5,279**	**300**	**784**	**403**	**392**	**10**

Per sector	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	565	1,167	1,040	127	3,328	2,598	2,363	235	270	91	86	6
Stationary Air Conditioning	325	635	615	21	787	1,172	1,123	50	48	37	34	3
Mobile Air Conditioning	67	180	179	1	487	380	379	1	42	14	14	0
Foams	490	714	714	0	2,029	1,328	1,328	0	423	259	259	
Medical Aerosols	2	4	4		17	21	7	14	2	2		2
Fire Protection	92	39	39		216	126	126		514	108	108	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**1,540**	**2,740**	**2,591**	**149**	**6,864**	**5,626**	**5,326**	**300**	**1,299**	**510**	**500**	**10**

Per subsector	Product ktonne				GWP_{SROC} $MtCO_2$-eq				ODP_{SROC} ktonne ODP			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	77	148	98	50	751	550	461	89	69	37	35	2
Commercial Refrigeration	406	908	838	70	2,316	1,757	1,624	133	186	42	39	3
Transport Refrigeration	4	6	6		19	14	14		1	0	0	
Industrial Refrigeration	78	106	99	7	243	278	264	14	14	12	12	0
Stationary Air Conditioning	325	635	615	21	787	1,172	1,123	50	48	37	34	3
Mobile Air Conditioning	67	180	179	1	487	380	379	1	42	14	14	0
Foams	490	714	714	0	2,029	1,328	1,328	0	423	259	259	
Medical Aerosols	2	4	4		17	21	7	14	2	2		2
Fire Protection	92	39	39		216	126	126		514	108	108	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**1,540**	**2,740**	**2,591**	**149**	**6,864**	**5,626**	**5,326**	**300**	**1,299**	**510**	**500**	**10**

Banks

B. DEVELOPING COUNTRIES

Halons	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	88	16	16		201	48	48		514	108	108	
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**88**	**16**	**16**		**201**	**48**	**48**		**514**	**108**	**108**	

CFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	269	54	52	2	2,801	558	532	26	256	51	48	2
Stationary Air Conditioning	34	13	13	0	277	109	109	0	34	13	13	0
Mobile Air Conditioning	42	13	13	0	448	137	137	0	42	13	13	0
Foams	414	198	198		1,972	945	945		414	198	198	
Medical Aerosols	2	2		2	16	17		17	2	2		2
Fire Protection												
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**760**	**280**	**275**	**4**	**5,514**	**1,767**	**1,724**	**43**	**747**	**276**	**272**	**4**

HCFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	278	812	749	62	495	1,444	1,333	111	14	41	37	3
Stationary Air Conditioning	276	473	416	57	489	837	737	100	14	24	21	3
Mobile Air Conditioning	11	20	20	0	20	35	35	0	1	1	1	0
Foams	76	516	516		57	383	383		9	61	61	
Medical Aerosols												
Fire Protection	1	1	1		1	1	1		0	0	0	
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**643**	**1,822**	**1,703**	**119**	**1,062**	**2,701**	**2,490**	**211**	**37**	**126**	**121**	**6**

Banks

B. DEVELOPING COUNTRIES

HFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	17	302	239	62	32	596	498	98				
Stationary Air Conditioning	14	149	185	-36	21	226	276	-51				
Mobile Air Conditioning	14	147	147	1	19	208	207	1				
Foams		0	0	0		0	0	0				
Medical Aerosols	0	2	4	-2	0	4	7	-4				
Fire Protection	4	22	22		14	77	77					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**49**	**622**	**597**	**25**	**86**	**1,110**	**1,065**	**45**				

PFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.04	0.05	0.05		0.3	0.4	0.4					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**0.04**	**0.05**	**0.05**		**0.3**	**0.4**	**0.4**					

Banks — O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

Per group	Product (ktonne)				GWP_{SROC} ($MtCO_2$-eq)				ODP_{SROC} (ktonne ODP)			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons												
CFCs												
HCFCs	11	16	16		6	9	9		1	1	1	
HFCs	1	1	1		25	27	27					
PFCs	0.10	0.01	0.01		0.9	0.1	0.1					
Total incl halons	**12**	**17**	**17**		**32**	**37**	**37**		**1**	**1**	**1**	
Total excl halons	**12**	**17**	**17**		**32**	**37**	**37**		**1**	**1**	**1**	

Per sector	Product (ktonne)				GWP_{SROC} ($MtCO_2$-eq)				ODP_{SROC} (ktonne ODP)			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**12**	**17**	**17**		**32**	**37**	**37**		**1**	**1**	**1**	

Per subsector	Product (ktonne)				GWP_{SROC} ($MtCO_2$-eq)				ODP_{SROC} (ktonne ODP)			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration												
Commercial Refrigeration												
Transport Refrigeration												
Industrial Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**12**	**17**	**17**		**32**	**37**	**37**		**1**	**1**	**1**	

Banks

O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

Halons	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total												

CFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total												

HCFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	11	16	16		6	9	9		1	1	1	
Total	**11**	**16**	**16**		**6**	**9**	**9**		**1**	**1**	**1**	

Banks

O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

HFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	1	1	1		25	27	27					
Total	**1**	**1**	**1**		**25**	**27**	**27**					

PFCs	Product ktonne				GWP_{SROC} MtCO2-eq				ODP_{SROC} ktonne ODP			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	0.1	0.01	0.01		0.9	0.1	0.1					
Total	**0.1**	**0.01**	**0.01**		**0.9**	**0.1**	**0.1**					

Emissions — WORLD

Per group	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons	10	6	6		30	18	18		68	40	40	
CFCs	174	43	30	13	1,652	338	221	117	168	42	29	13
HCFCs	271	492	292	200	448	828	484	344	15	26	16	10
HFCs	124	415	184	231	434	1,153	416	737				
PFCs	0.11	0.02	0.02		1.0	0.2	0.2					
Total incl halons	**580**	**956**	**512**	**444**	**2,565**	**2,337**	**1,139**	**1,198**	**252**	**107**	**85**	**23**
Total excl halons	**570**	**950**	**506**	**444**	**2,535**	**2,319**	**1,121**	**1,198**	**183**	**68**	**45**	**23**

Per sector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	232	450	263	187	1,061	1,097	607	490	72	28	18	11
Stationary Air Conditioning	115	198	91	108	271	370	170	200	18	13	6	7
Mobile Air Conditioning	134	190	75	115	749	315	136	179	60	5	3	2
Foams	51	55	42	13	152	124	107	17	24	18	17	1
Medical Aerosols	12	15	15		75	40	26	14	8	2		2
Fire Protection	11	7	7		31	22	22		68	40	40	
HFC-23 by-product	14	23	2	21	195	332	33	299				
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**580**	**956**	**512**	**444**	**2,565**	**2,337**	**1,139**	**1,198**	**252**	**107**	**85**	**23**

Per subsector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	9	13	6	7	91	65	35	30	8	5	3	2
Commercial Refrigeration	185	393	230	162	837	902	494	409	56	19	12	7
Transport Refrigeration	6	9	5	3	23	26	15	10	1	0	0	0
Industrial Refrigeration	32	35	21	14	110	104	63	41	6	4	3	1
Stationary Air Conditioning	115	198	91	108	271	370	170	200	18	13	6	7
Mobile Air Conditioning	134	190	75	115	749	315	136	179	60	5	3	2
Foams	51	55	42	13	152	124	107	17	24	18	17	1
Medical Aerosols	12	15	15		75	40	26	14	8	2		2
Fire Protection	11	7	7		31	22	22		68	40	40	
HFC-23 by-product	14	23	2	21	195	332	33	299				
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**580**	**956**	**512**	**444**	**2,565**	**2,337**	**1,139**	**1,198**	**252**	**107**	**85**	**23**

Emissions — WORLD

Halons	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	10	6	6		30	18	18		68	40	40	
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**10**	**6**	**6**		**30**	**18**	**18**		**68**	**40**	**40**	

CFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	71	13	8	5	727	136	84	53	65	12	8	5
Stationary Air Conditioning	13	7	3	3	99	50	24	26	13	7	3	3
Mobile Air Conditioning	60	5	3	2	641	49	32	17	60	5	3	2
Foams	22	16	15	1	117	85	81	4	22	16	15	1
Medical Aerosols	8	2		2	69	17		17	8	2		2
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**174**	**43**	**30**	**13**	**1,652**	**338**	**221**	**117**	**168**	**42**	**29**	**13**

HCFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	132	321	202	119	232	570	359	210	7	16	10	6
Stationary Air Conditioning	96	124	50	74	164	210	86	124	5	6	2	4
Mobile Air Conditioning	8	11	7	4	15	19	12	7	0	1	0	0
Foams	24	21	17	4	32	20	17	3	2	2	2	0
Medical Aerosols												
Fire Protection	0.1	0.2	0.2		0.1	0.1	0.1		0.00	0.01	0.01	
HFC-23 by-product												
Non-Medical Aerosols and Solvents	11	16	16		6	9	9		1	1	1	
Total	**271**	**492**	**292**	**200**	**448**	**828**	**484**	**344**	**15**	**26**	**16**	**10**

Emissions	**WORLD**											
HFCs	**Product** ktonne yr^{-1}				**GWP_{SROC}** $MtCO_2$-eq yr^{-1}				**ODP_{SROC}** ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	29	115	52	63	102	391	164	227				
Stationary Air Conditioning	6	68	38	30	9	109	60	49				
Mobile Air Conditioning	66	175	65	110	93	247	92	155				
Foams	5	18	9	9	3	18	9	10				
Medical Aerosols	4	13	15	-2	6	23	26	-4				
Fire Protection	0.3	1	1		1	4	4					
HFC-23 by-product	14	23	2	21	195	332	33	299				
Non-Medical Aerosols and Solvents	1	1	1		25	27	27					
Total	**124**	**415**	**184**	**231**	**434**	**1,153**	**416**	**737**				

PFCs	**Product** ktonne yr^{-1}				**GWP_{SROC}** $MtCO_2$-eq yr^{-1}				**ODP_{SROC}** ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.01	0.01	0.01		0.1	0.1	0.1					
HFC-23 by-product												
Non-Medical Aerosols and Solvents	0.10	0.01	0.01		0.9	0.1	0.1					
Total	**0.11**	**0.02**	**0.02**		**1.0**	**0.2**	**0.2**					

Emissions

A. DEVELOPED COUNTRIES

Per group	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons	5	2	2		16	8	8		35	16	16	
CFCs	88	17	15	2	814	103	88	16	87	16	15	2
HCFCs	133	96	38	58	218	152	59	93	7	5	2	3
HFCs	103	305	126	179	204	627	250	376				
PFCs	0.01	0.01	0.01		0.1	0.1	0.1					
Total incl halons	**329**	**419**	**181**	**238**	**1,253**	**890**	**405**	**485**	**129**	**38**	**33**	**5**
Total excl halons	**324**	**417**	**179**	**238**	**1,236**	**882**	**397**	**485**	**94**	**22**	**17**	**5**

Per sector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	85	106	45	61	293	355	141	214	13	2	1	1
Stationary Air Conditioning	75	123	49	74	165	219	87	132	10	6	2	4
Mobile Air Conditioning	113	134	41	93	603	191	59	132	48	0	0	0
Foams	42	42	32	10	116	96	88	8	18	13	13	-1
Medical Aerosols	9	11	11		58	19	19		6			
Fire Protection	5	3	3		17	11	11		35	16	16	
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total incl halons	**329**	**419**	**181**	**238**	**1,253**	**890**	**405**	**485**	**129**	**38**	**33**	**5**

Per subsector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	5	5	1	4	52	7	2	5	5	0	0	0
Commercial Refrigeration	56	77	30	47	162	272	96	176	4	1	0	0
Transport Refrigeration	4	6	3	3	13	20	11	9	0	0	0	0
Industrial Refrigeration	19	18	10	8	66	56	32	24	4	2	1	1
Stationary Air Conditioning	75	123	49	74	165	219	87	132	10	6	2	4
Mobile Air Conditioning	113	134	41	93	603	191	59	132	48	0	0	0
Foams	42	42	32	10	116	96	88	8	18	13	13	-1
Medical Aerosols	9	11	11		58	19	19		6			
Fire Protection	5	3	3		17	11	11		35	16	16	
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total incl halons	**329**	**419**	**181**	**238**	**1,253**	**890**	**405**	**485**	**129**	**38**	**33**	**5**

Emissions — A. DEVELOPED COUNTRIES

Halons	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	5	2	2		16	8	8		35	16	16	
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**5**	**2**	**2**		**16**	**8**	**8**		**35**	**16**	**16**	

CFCs	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	12	2	1	1	117	15	11	5	11	1	1	0
Stationary Air Conditioning	7	3	1	2	53	24	10	15	7	3	1	2
Mobile Air Conditioning	47	0	0	0	508	0	0	0	47	0	0	0
Foams	16	12	12	-1	84	64	67	-4	16	12	12	-1
Medical Aerosols	6				52				6			
Fire Protection												
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**88**	**17**	**15**	**2**	**814**	**103**	**88**	**16**	**87**	**16**	**15**	**2**

HCFCs	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	45	18	9	9	78	31	16	15	2	1	0	0
Stationary Air Conditioning	63	63	18	45	105	104	30	74	3	3	1	2
Mobile Air Conditioning	4	2	1	1	7	3	1	2	0	0	0	0
Foams	21	12	10	3	29	14	12	2	2	1	1	0
Medical Aerosols												
Fire Protection	0.1	0.1	0.1		0.1	0.1	0.1		0.003	0.004	0.004	
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**133**	**96**	**38**	**58**	**218**	**152**	**59**	**93**	**7**	**5**	**2**	**3**

Emissions

A. DEVELOPED COUNTRIES

HFCs	Product ktonne yr^{-1}				GWP$_{SROC}$ $MtCO_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	28	86	35	52	99	308	114	194				
Stationary Air Conditioning	5	56	30	26	7	91	48	43				
Mobile Air Conditioning	62	133	41	92	88	187	57	130				
Foams	5	18	9	9	3	18	9	10				
Medical Aerosols	3	11	11		6	19	19					
Fire Protection	0.3	1	1		1	3	3					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**103**	**305**	**126**	**179**	**204**	**627**	**250**	**376**				

PFCs	Product ktonne yr^{-1}				GWP$_{SROC}$ $MtCO_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.01	0.01	0.01		0.1	0.1	0.1					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**0.01**	**0.01**	**0.01**		**0.1**	**0.1**	**0.1**					

Emissions — B. DEVELOPING COUNTRIES

Per group	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons	6	4	4		13	9	9		34	24	24	
CFCs	86	26	15	11	838	234	133	101	81	25	14	11
HCFCs	128	380	238	142	223	667	416	251	7	20	12	7
HFCs	6	86	55	32	11	167	105	61				
PFCs	0.001	0.001	0.001		0.01	0.01	0.01					
Total incl halons	**226**	**496**	**311**	**185**	**1,086**	**1,078**	**664**	**414**	**122**	**69**	**50**	**18**
Total excl halons	**220**	**492**	**307**	**185**	**1,072**	**1,068**	**654**	**414**	**88**	**45**	**26**	**18**

Per sector	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	148	343	218	126	768	743	467	276	59	26	16	10
Stationary Air Conditioning	40	76	42	34	107	151	83	68	7	6	3	3
Mobile Air Conditioning	21	56	34	22	146	124	77	47	13	5	3	2
Foams	10	13	10	3	35	28	19	9	7	5	4	2
Medical Aerosols	2	4	4		17	21	7	14	2	2		2
Fire Protection	6	4	4		14	11	11		34	24	24	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**226**	**496**	**311**	**185**	**1,086**	**1,078**	**664**	**414**	**122**	**69**	**50**	**18**

Per subsector	Product ktonne yr^{-1}				GWP$_{SROC}$ MtCO$_2$-eq yr^{-1}				ODP$_{SROC}$ ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration	4	8	4	4	39	58	33	25	4	5	3	2
Commercial Refrigeration	129	316	200	115	675	631	398	233	52	19	12	7
Transport Refrigeration	2	3	2	1	10	6	5	2	1	0	0	0
Industrial Refrigeration	13	17	11	6	44	47	31	16	3	2	1	1
Stationary Air Conditioning	40	76	42	34	107	151	83	68	7	6	3	3
Mobile Air Conditioning	21	56	34	22	146	124	77	47	13	5	3	2
Foams	10	13	10	3	35	28	19	9	7	5	4	2
Medical Aerosols	2	4	4		17	21	7	14	2	2		2
Fire Protection	6	4	4		14	11	11		34	24	24	
HFC-23 by-product Non-Medical Aerosols and Solvents	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Total incl halons	**226**	**496**	**311**	**185**	**1,086**	**1,078**	**664**	**414**	**122**	**69**	**50**	**18**

Emissions

B. DEVELOPING COUNTRIES

Halons	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	6	4	4		13	9	9		34	24	24	
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**6**	**4**	**4**		**13**	**9**	**9**		**34**	**24**	**24**	

CFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	60	12	7	5	610	121	73	48	55	11	7	4
Stationary Air Conditioning	6	3	2	1	46	26	14	12	6	3	2	1
Mobile Air Conditioning	12	5	3	2	133	49	32	17	12	5	3	2
Foams	6	4	3	2	33	22	14	8	6	4	3	2
Medical Aerosols	2	2		2	16	17		17	2	2		2
Fire Protection												
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**86**	**26**	**15**	**11**	**838**	**234**	**133**	**101**	**81**	**25**	**14**	**11**

HCFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	87	302	193	109	154	538	343	195	4	15	10	5
Stationary Air Conditioning	33	60	32	29	59	107	56	50	2	3	2	1
Mobile Air Conditioning	4	9	6	3	8	16	11	5	0	0	0	0
Foams	3	8	7	1	2	6	5	1	0	1	1	0
Medical Aerosols												
Fire Protection	0.01	0.04	0.04		0.01	0.03	0.03		0.001	0.001	0.001	
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total	**128**	**380**	**238**	**142**	**223**	**667**	**416**	**251**	**7**	**20**	**12**	**7**

Emissions

B. DEVELOPING COUNTRIES

HFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration	1	29	17	12	3	84	50	33				
Stationary Air Conditioning	1	12	8	4	2	18	12	6				
Mobile Air Conditioning	4	42	25	18	5	60	35	25				
Foams	0	0	0	0	0	0	0	0				
Medical Aerosols	0	2	4	-2	0	4	7	-4				
Fire Protection	0.1	0.4	0.4		0.3	1	1					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**6**	**86**	**55**	**32**	**11**	**167**	**105**	**61**				

PFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection	0.001	0.001	0.001		0.01	0.01	0.01					
HFC-23 by-product	No regional breakdown available				No regional breakdown available				No regional breakdown available			
Non-Medical Aerosols and Solvents												
Total	**0.001**	**0.001**	**0.001**		**0.01**	**0.01**	**0.01**					

Emissions — O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

Per group	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Halons												
CFCs												
HCFCs	11	16	16		6	9	9		1	1	1	
HFCs	15	24	3	21	220	359	60	299				
PFCs	0.10	0.01	0.01		0.9	0.1	0.1					
Total incl halons	**26**	**40**	**19**	**21**	**226**	**369**	**70**	**299**	**1**	**1**	**1**	
Total excl halons	**26**	**40**	**19**	**21**	**226**	**369**	**70**	**299**	**1**	**1**	**1**	

Per sector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product	14	23	2	21	195	332	33	299				
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**26**	**40**	**19**	**21**	**226**	**369**	**70**	**299**	**1**	**1**	**1**	

Per subsector	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
	2002	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Domestic Refrigeration												
Commercial Refrigeration												
Transport Refrigeration												
Industrial Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product	14	23	2	21	195	332	33	299				
Non-Medical Aerosols and Solvents	12	17	17		32	37	37		1	1	1	
Total incl halons	**26**	**40**	**19**	**21**	**226**	**369**	**70**	**299**	**1**	**1**	**1**	

Emissions — O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

Halons	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total												

CFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents												
Total												

HCFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	11	16	16		6	9	9		1	1	1	
Total	**11**	**16**	**16**		**6**	**9**	**9**		**1**	**1**	**1**	

Emissions — O. NO REGIONAL BREAKDOWN SPECIFIED (World Total)

HFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product	14	23	2	21	195	332	33	299				
Non-Medical Aerosols and Solvents	1	1	1		25	27	27					
Total	**15**	**24**	**3**	**21**	**220**	**359**	**60**	**299**				

PFCs	Product ktonne yr^{-1}				GWP_{SROC} $MtCO_2$-eq yr^{-1}				ODP_{SROC} ktonne ODP yr^{-1}			
per sector	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**	**2002**	**BAU-2015**	**MIT-2015**	**Red-2015**
Refrigeration												
Stationary Air Conditioning												
Mobile Air Conditioning												
Foams												
Medical Aerosols												
Fire Protection												
HFC-23 by-product												
Non-Medical Aerosols and Solvents	0.10	0.01	0.01		0.9	0.1	0.1					
Total	**0.10**	**0.01**	**0.01**		**0.9**	**0.1**	**0.1**					

Graphs on demand, banks and emission data 2002-2015

The following graphs are based on the tables presented in the previous section. See the introduction of section 10.1 for some general remarks regarding the underlying data.

Legend

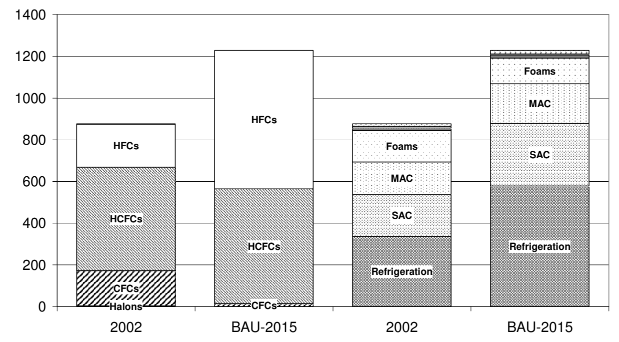
- Non-Medical Aerosols and Solvents
- HFC-23 by-product
- Fire Protection
- Medical Aerosols
- Foams
- Mobile Air Conditioning
- Stationary Air Conditioning
- Refrigeration

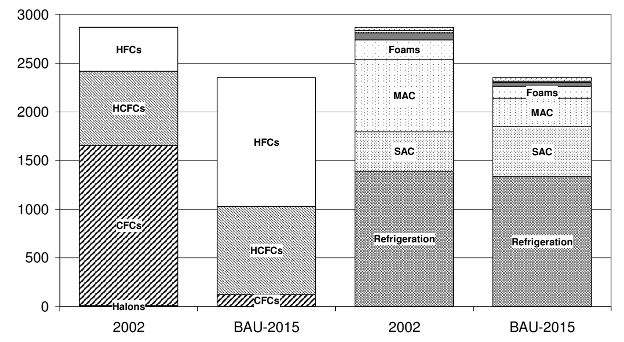
- PFCs
- HFCs
- HCFCs
- CFCs
- Halons

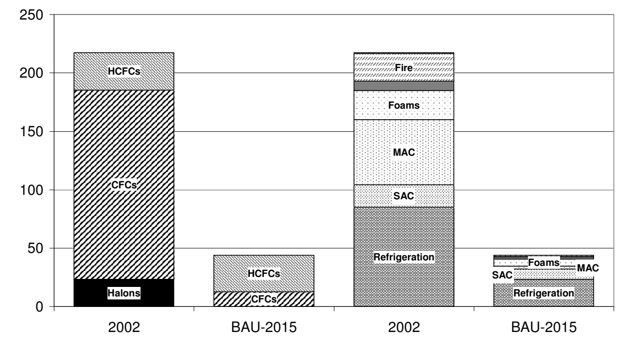
DEMAND - 2002 and 2015 Business As Usual

	Product (in kt product)	GWP (in Mt CO_2-eq.)	ODP (in kt ODP)

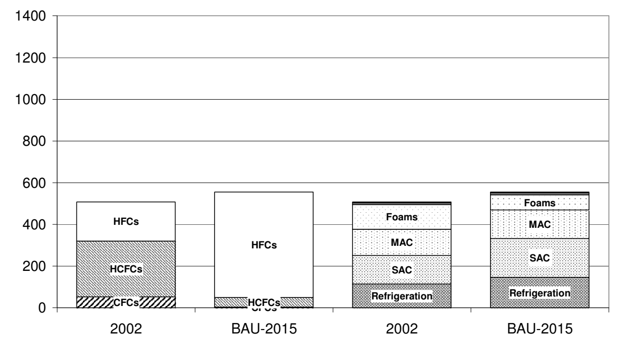
World Total

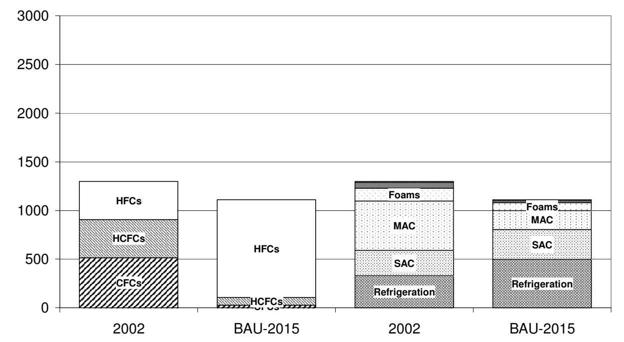


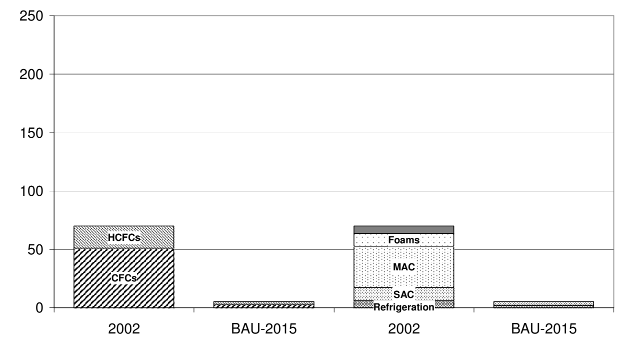




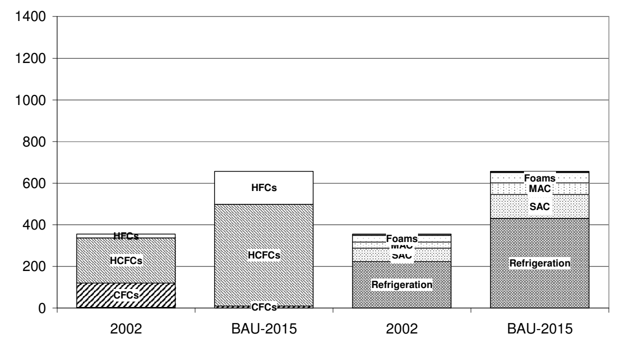
Developed Countries

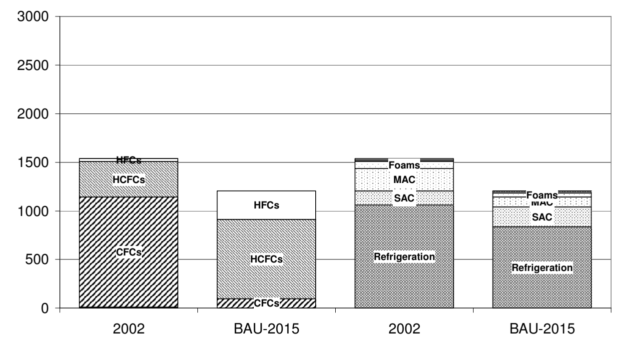


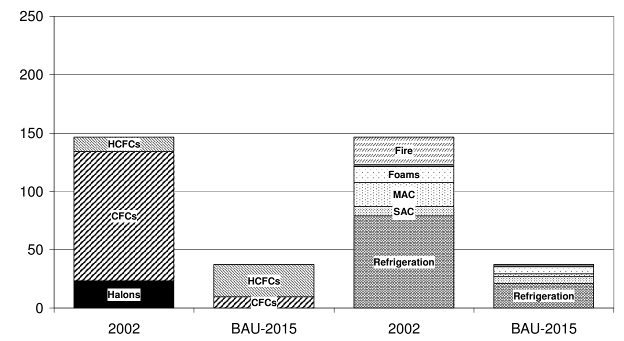




Developing Countries



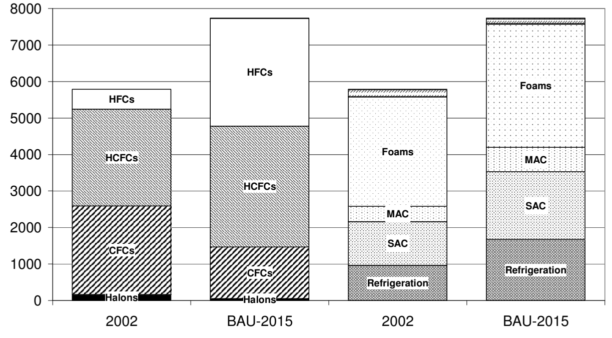


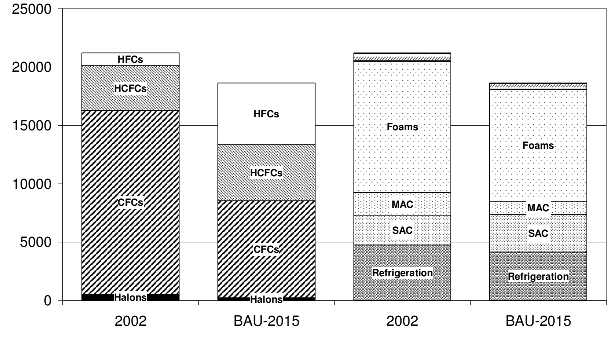


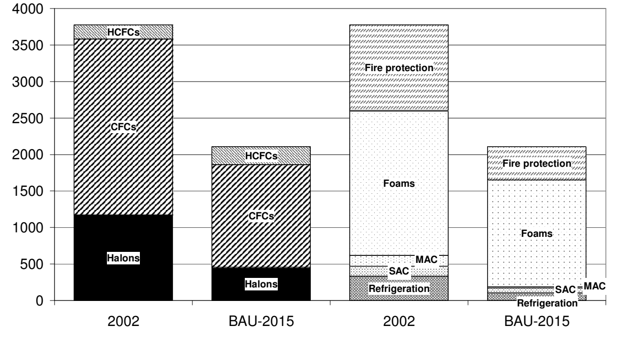
BANKS - 2002 and 2015 Business As Usual

Product (in kt product) | GWP (in Mt CO_2-eq.) | ODP (in kt ODP)

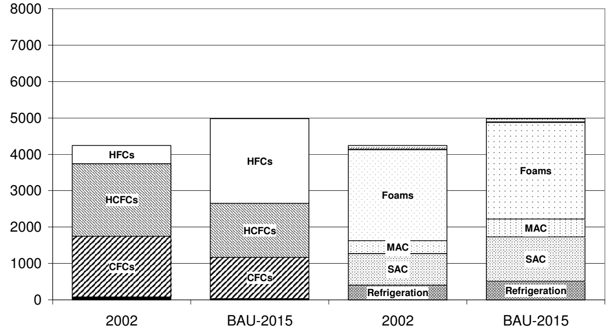
World Total

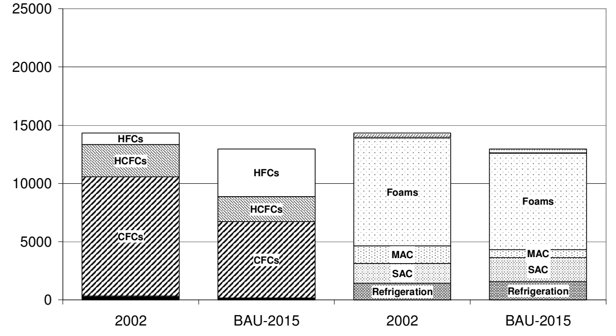


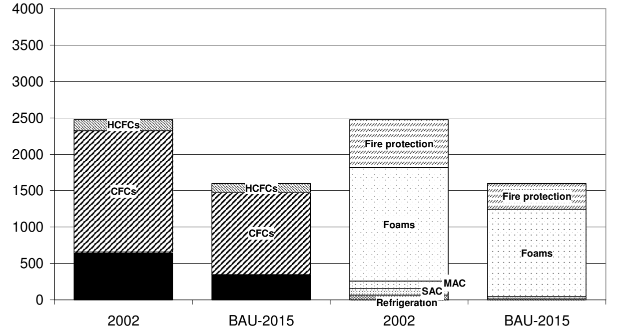




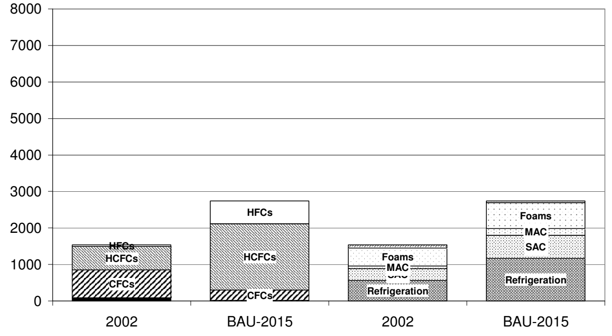
Developed Countries

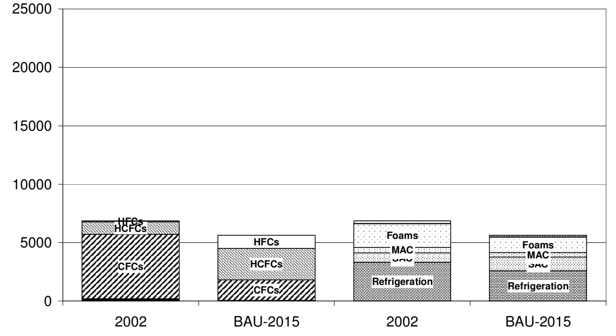


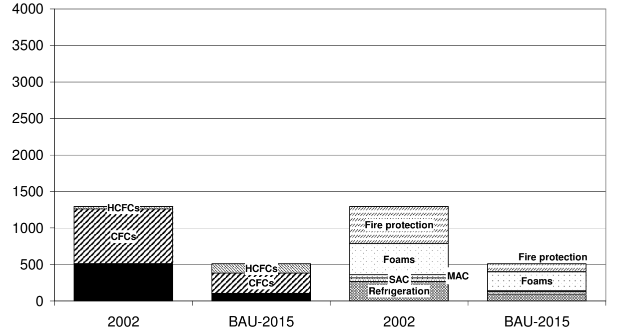




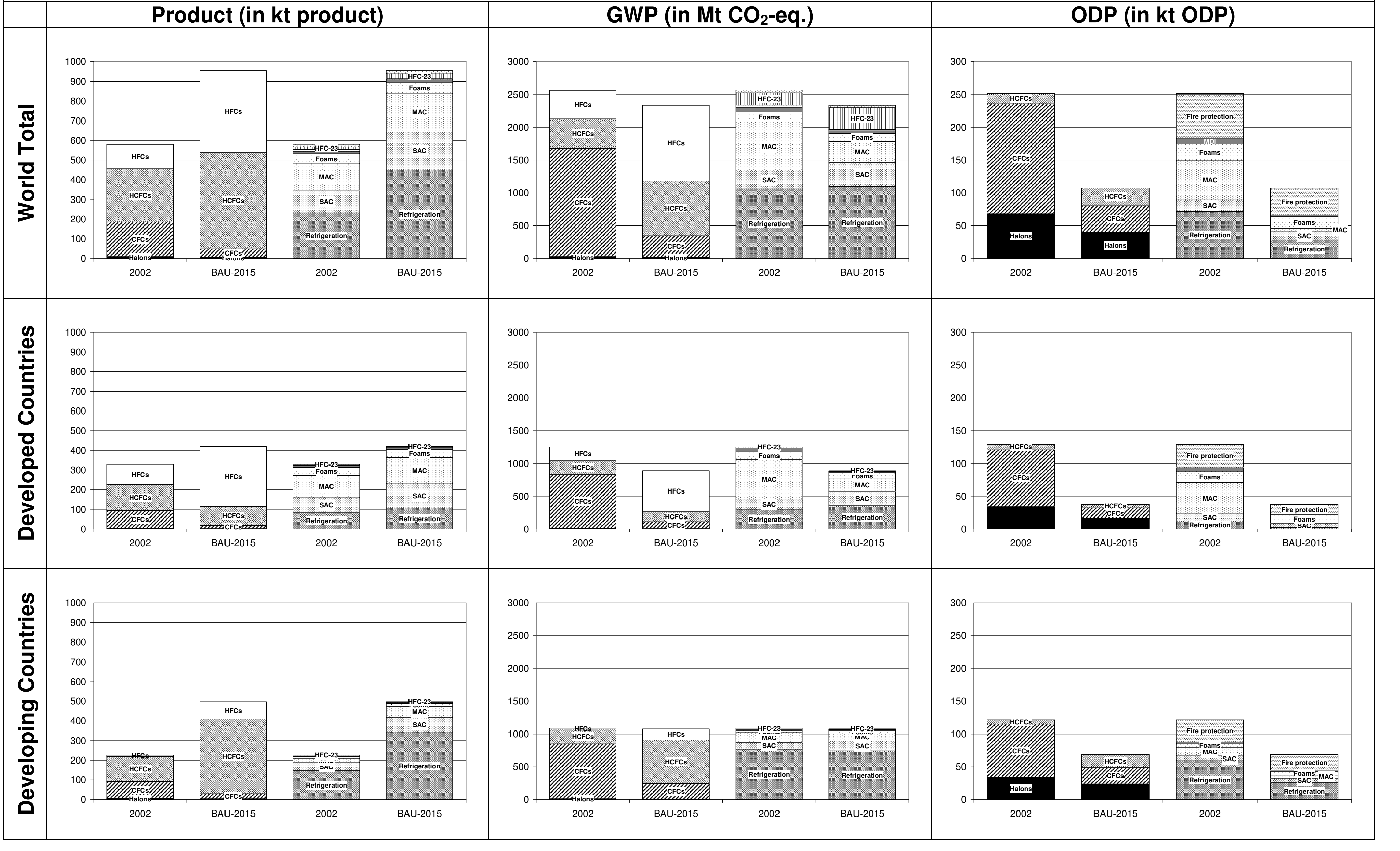
Developing Countries







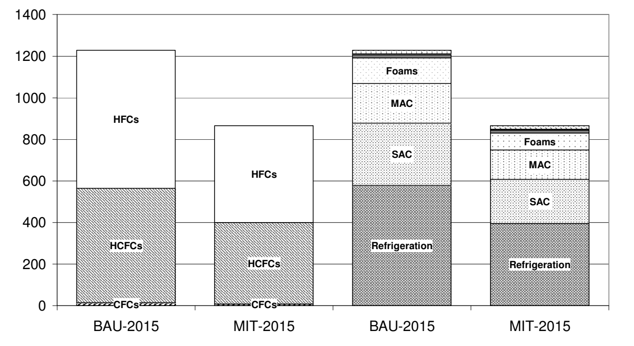
EMISSIONS - 2002 and 2015 Business As Usual

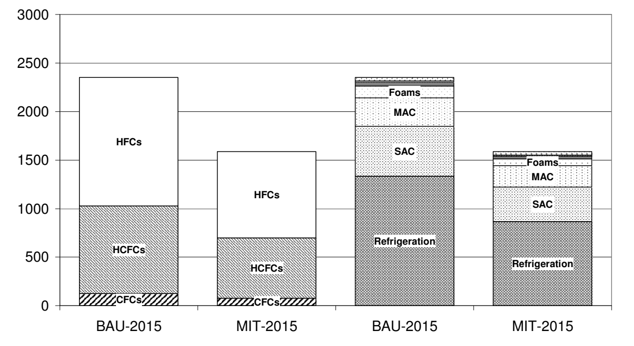


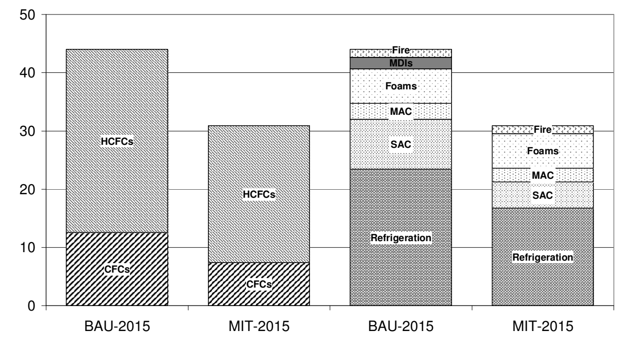
DEMAND - 2015 Business As Usual (BAU) and Mitigation (MIT) Scenario

	Product (in kt product)	GWP (in Mt CO_2-eq.)	ODP (in kt ODP)

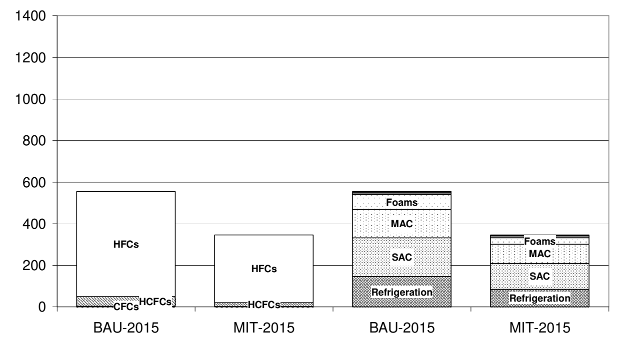
World Total

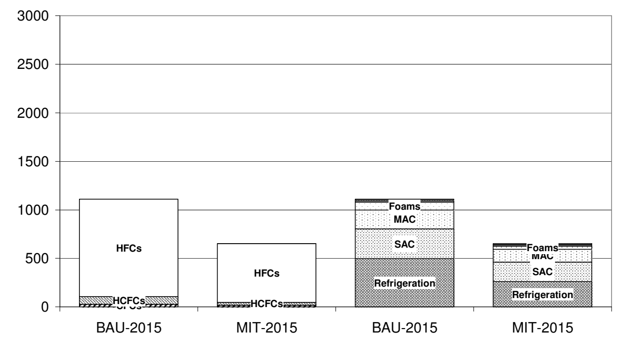


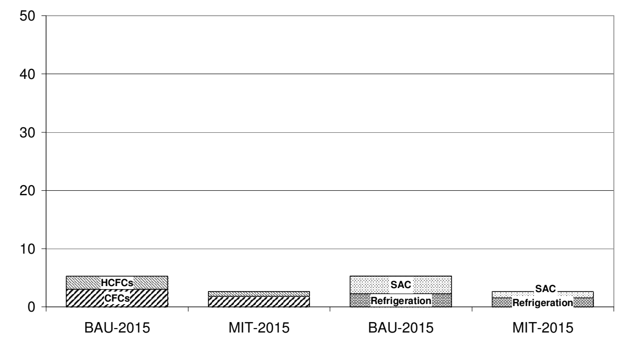




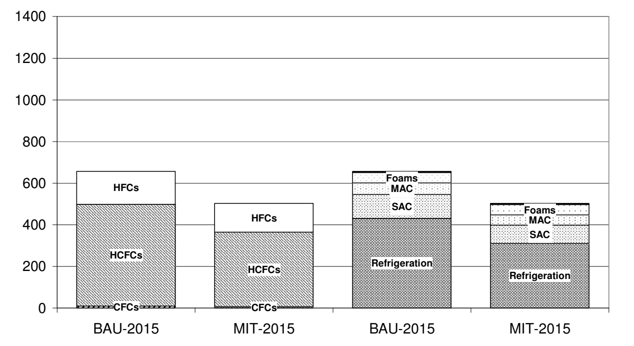
Developed Countries

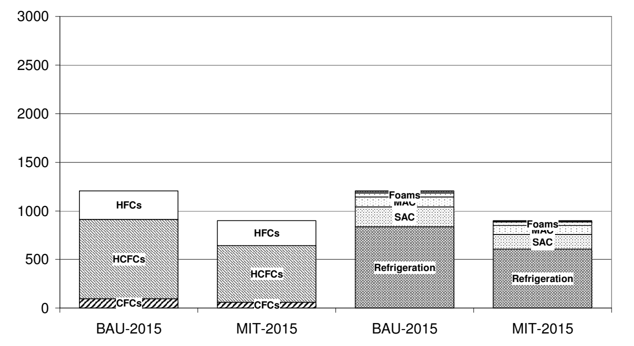


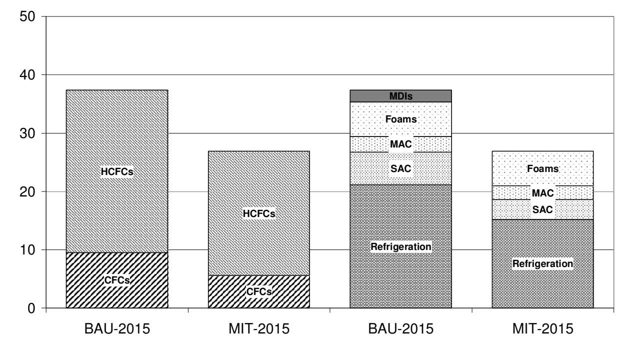




Developing Countries



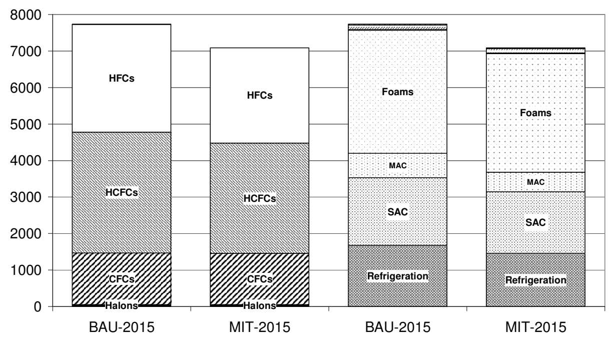




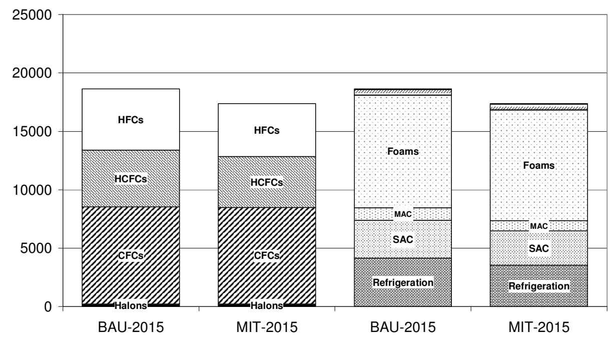
BANKS - 2015 Business As Usual (BAU) and Mitigation (MIT) Scenario

World Total

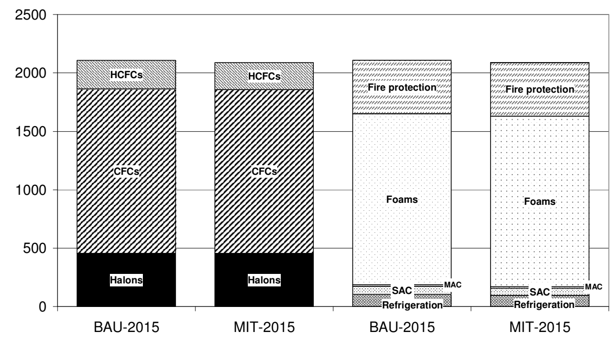
Product (in kt product)



GWP (in Mt CO_2-eq.)

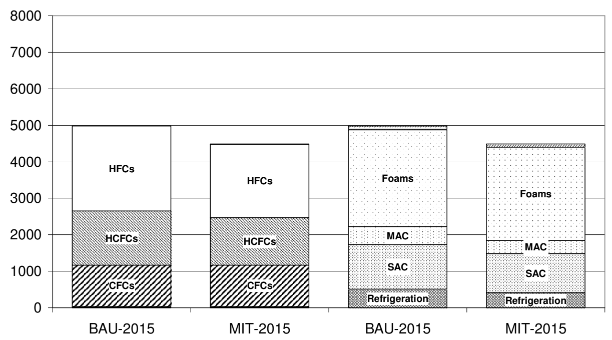


ODP (in kt ODP)

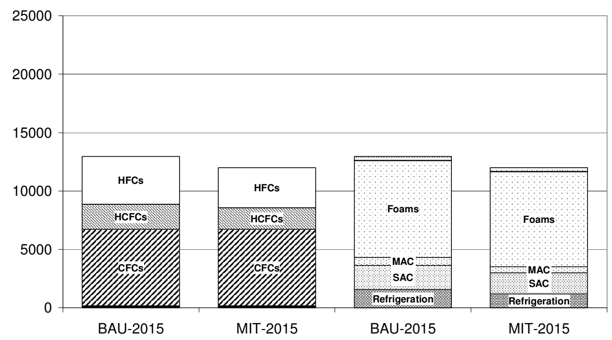


Developed Countries

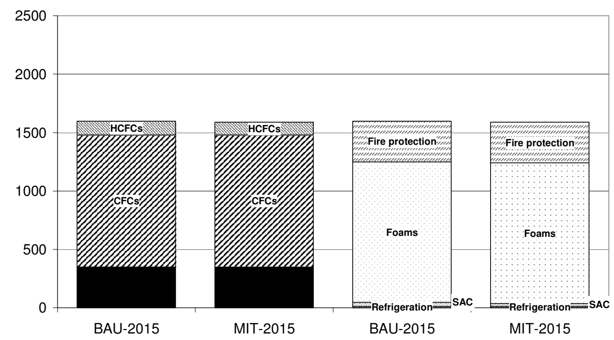
Product (in kt product)



GWP (in Mt CO_2-eq.)

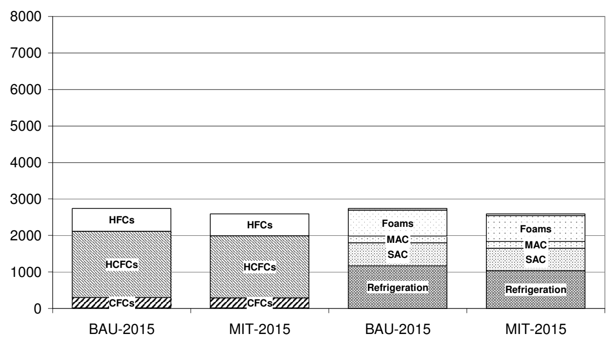


ODP (in kt ODP)

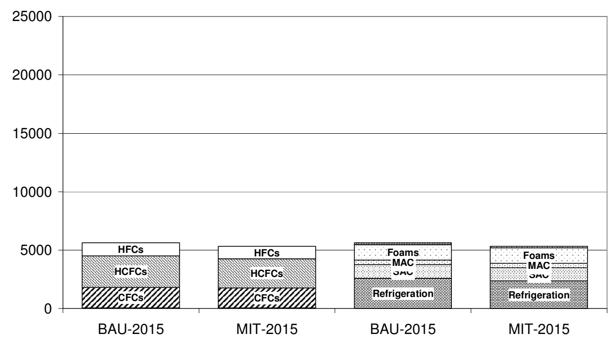


Developing Countries

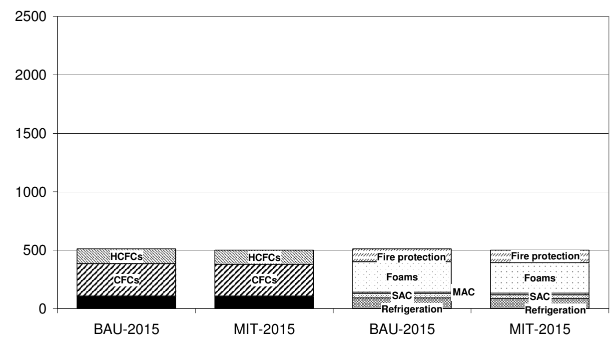
Product (in kt product)



GWP (in Mt CO_2-eq.)



ODP (in kt ODP)



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<tr><th></th><th>Product (in kt product)</th><th>GWP (in Mt CO_2-eq.)</th><th>ODP (in kt ODP)</th></tr>
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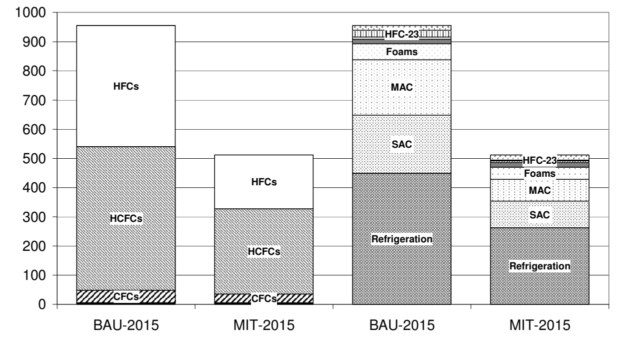
<td>
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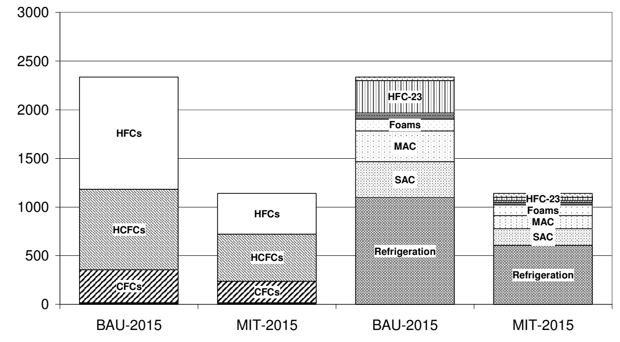
<td>
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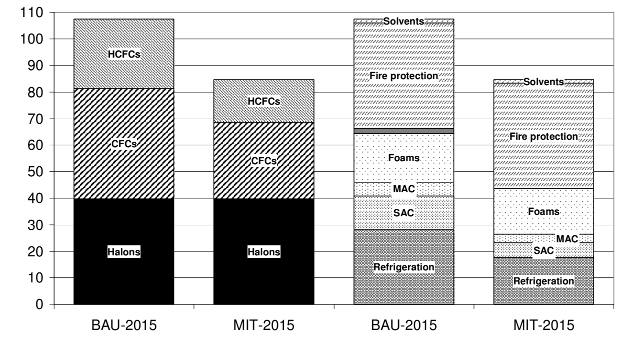
<td>
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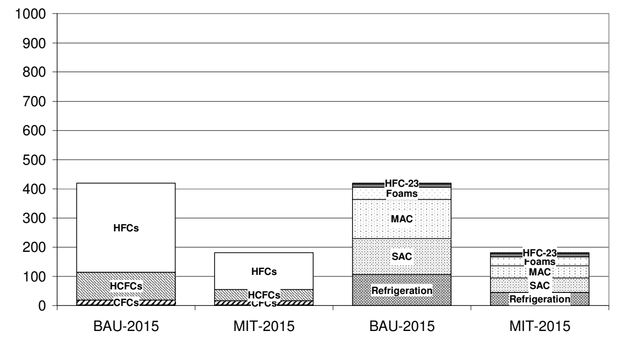
<td>
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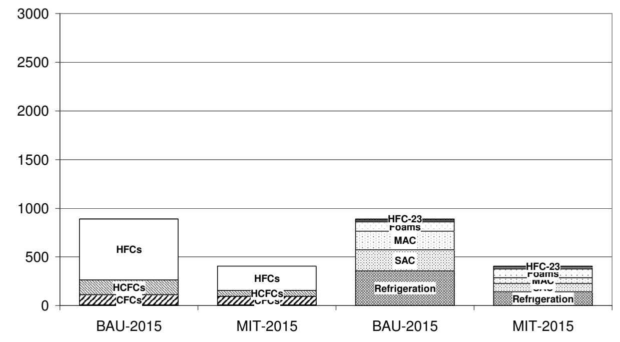
<td>
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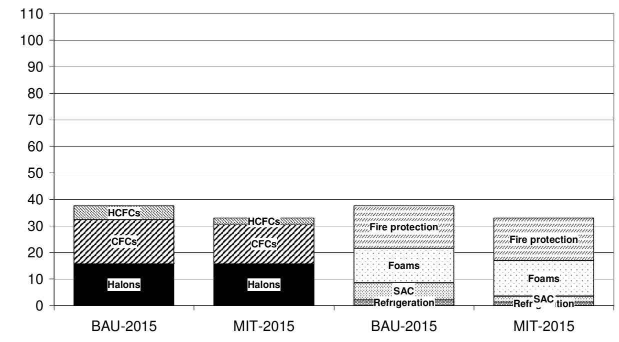
<td>
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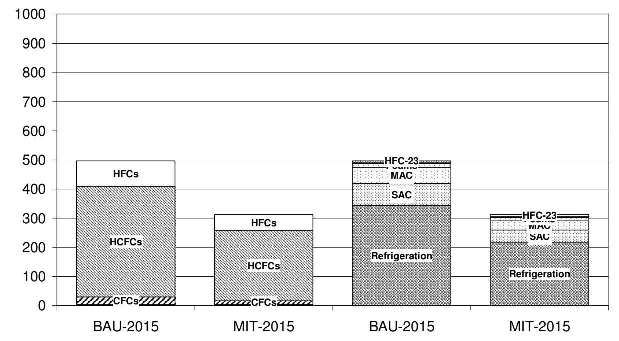
<td>
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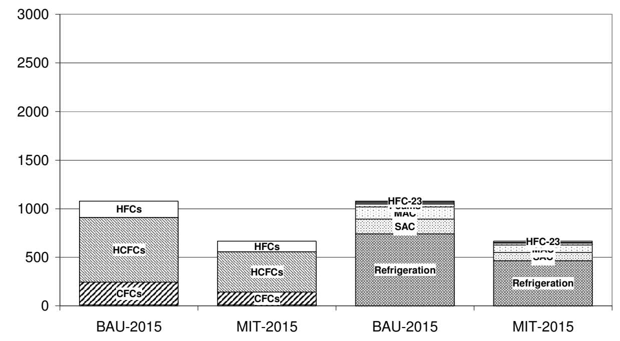
<td>
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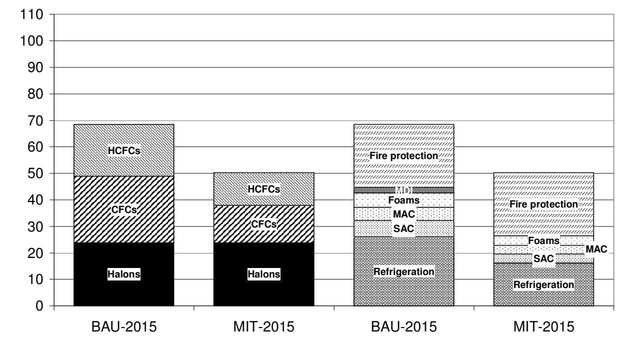
<td>
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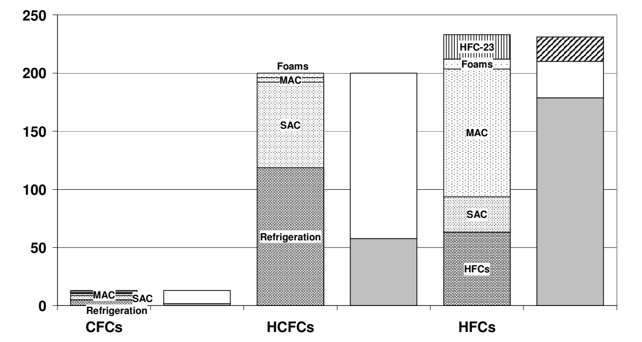
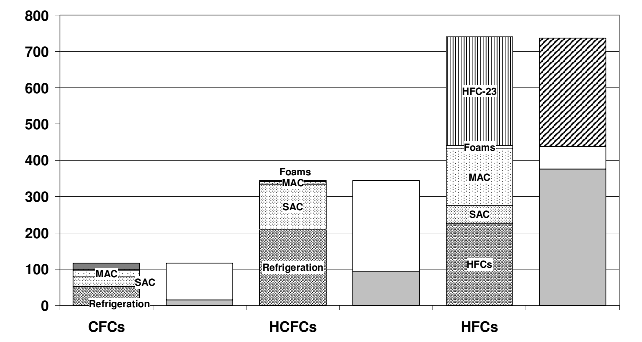
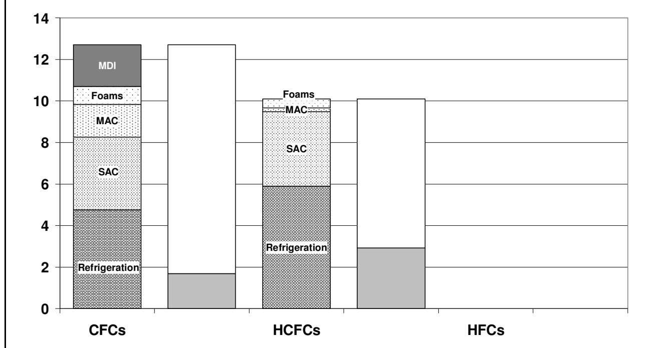
2015 Emission Reduction Potential as compared to Business As Usual

	Product (in kt product)	GWP (in Mt CO_2-eq.)	ODP (in kt ODP)
Emission Reduction			

Legend

- No regional breakdown
- Developing
- Developed

- Non-Medical Aerosols and Solvents
- HFC-23 by-product
- Fire Protection
- Medical Aerosols
- Foams
- Mobile Air Conditioning
- Stationary Air Conditioning
- Refrigeration