

**MONTREAL PROTOCOL  
ON SUBSTANCES THAT DEplete  
THE OZONE LAYER**



**UNEP**

**REPORT OF THE  
TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL**

**MAY 2005  
PROGRESS REPORT**



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On Substances that Deplete the Ozone Layer**

Report of the  
UNEP Technology and Economic Assessment Panel

May 2005

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Co-ordination: **Technology and Economic Assessment Panel**

Composition of the report: Lambert Kuijpers

Layout: Dawn Lindon, Eindhoven, Netherlands  
Ozone Secretariat, UNEP

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## Foreword

### The May 2005 TEAP Report

The May 2005 TEAP Report consists of three volumes:

*Volume 1:* May 2005 TEAP Progress Report

*Volume 2:* May 2005 TEAP Replenishment Task Force Report

*Volume 3:* May 2005 TEAP Foams End-of-Life Task Force Report

### Volume 1

Volume 1 contains an Executive Summary of all TEAP Progress Report topics, as well as the Executive Summary of Volume 2 and 3. Volume 1 contains the essential use report, progress reports, the CTOC report, the MB QPS report, the MB CUN report, and TEAP member biographies and membership lists.

### Volume 2

Volume 2 is the Assessment Report of the TEAP Replenishment Task Force of the Funding Requirement for the Replenishment of the Multilateral Fund during 2006-2008, in response to Decision XVI/35.

### Volume 3

Volume 3 is the Foams End-of- Life Task Force Report according to Decision XV/10.

The UNEP Technology and Economic Assessment Panel:

<i>Stephen O. Andersen, co-chair</i>	USA	<i>Thomas Morehouse</i>	USA
<i>Jose I. Pons, co-chair</i>	VEN	<i>Ian Porter (convenor)</i>	AUS
<i>Lambert Kuijpers, co-chair</i>	NL	<i>Miguel Quintero</i>	COL
<i>Radhey Agarwal</i>	IND	<i>Ian Rae (interim)</i>	AUS
<i>Paul Ashford</i>	UK	<i>K. Madhava Sarma</i>	IND
<i>Jonathan Banks</i>	AUS	<i>Helen Tope</i>	AUS
<i>David Catchpole (interim)</i>	UK	<i>Dan Verdonik (interim)</i>	USA
<i>Tamás Lotz</i>	H	<i>Ashley Woodcock</i>	UK
<i>Nahum Marban Mendoza</i>	MEX	<i>Masaaki Yamabe</i>	J
<i>Michelle Marcotte (convenor)</i>	CDN	<i>Shiqiu Zhang</i>	PRC



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## EXECUTIVE SUMMARY PROGRESS REPORT

### Review of Essential Use Nominations for Metered Dose Inhalers (MDIs)

The following table summarises TEAP and its Medical Technical Options Committee (MTOC) recommendations on nominations for essential use production exemptions for metered dose inhalers (MDIs).

	<b>European Community</b>	<b>Russian Federation</b>	<b>United States</b>
<b>2006</b>	Recommend, 539 tonnes, including 181 tonnes for salbutamol CFC MDIs for export to non-A5(1) Parties	Recommend upward revised quantity of 400 tonnes	Recommend downward revised quantity of 1,242 tonnes for 2006, minus any available pre-1996 stockpile that satisfies US regulatory requirements sold into the US market for use in MDIs, plus up to 180 tonnes if salbutamol CFC MDIs are not imported from the EC in 2006.
<b>2007</b>		Unable to recommend	Unable to recommend

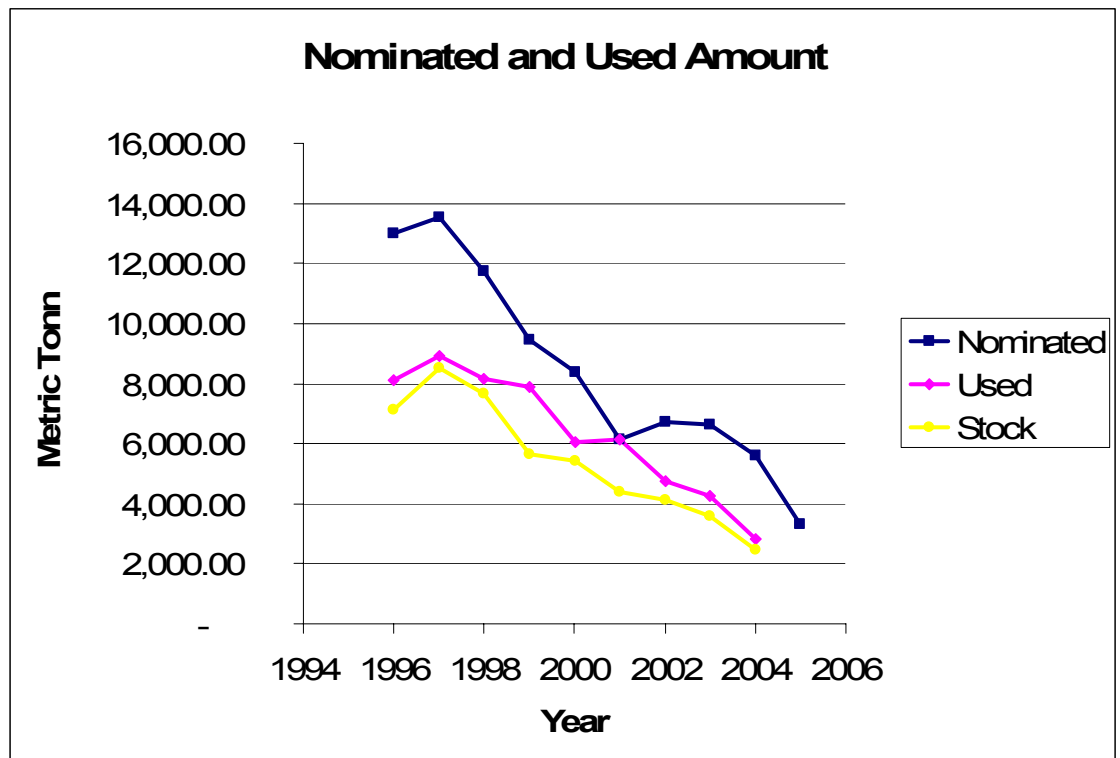
### Update of the Handbook on Essential Use Nominations

Decision XV/5(9) requests the TEAP to “*modify the Handbook on Essential Use Nominations to reflect the present decision.*” TEAP has provided an updated Handbook on Essential Use Nominations.

### Medical TOC Technical Progress

The figure below shows the use of CFCs for the production of MDIs for asthma and chronic obstructive pulmonary disease (COPD) in non-Article 5(1) countries. In 2004, 2,841 tonnes of CFCs were used in the manufacture of MDIs under essential use exemptions, as reported through accounting frameworks. The downward trend in CFC use for MDIs continues and is roughly parallel to the decrease in stocks.

*Quantities relating to the use of CFCs for the production of MDIs*



Technically satisfactory HFC alternatives to CFC MDIs are available for short-acting beta-agonists and other therapeutic categories for asthma and COPD. The availability of CFC stocks coupled with these alternatives assures patient safety during the transition.

The management of stockpiles at this last stage of the phase-out will be extremely important to avoid unnecessary production of essential use CFCs. Parties may wish to remind CFC MDI producers that any CFCs obtained under essential use exemptions must be used for the essential uses (including through a transfer), transferred to an Article 5(1) country for basic domestic need, or destroyed. MTOC is concerned that some users may try to circumvent this rule by claiming that their remaining stockpiles are pre-1996.

### **Foams TOC Technical Progress**

#### CFC Transition Issues (Developing Countries)

Virtually all individually funded MLF foam projects are technically complete, but some CFC-11 phase-out under National Plans is still on-going. Nevertheless, the transition out of CFC-11 has virtually been achieved (remaining usage <5%). CFC-11 prices have increased during the last year in line with the removal of key manufacturing capacity. Prices are now at, or

above, the levels of HCFC-141b, except in those regions where a combination of local production and poor distribution control still exists. In some countries, further expansions in foam manufacturing capacity at SMEs are taking place using HCFC-based technologies for cost reasons, even where the original MLF funded projects were based on hydrocarbons.

#### HCFC Transition Issues (Developed Countries)

HCFC-141b phase-out in the foam sector has been delayed in some countries by the use of stockpiled materials through 2004. However, stocks are now virtually exhausted. The reliance on limited manufacturing sites for the supply of key HFC alternatives (e.g. HFC-365mfc) is continuing to cause difficulties in foam markets and, in some regions, has been challenging the transition out of HCFCs. In other cases, such as that of HFC-245fa, regional patent restrictions have shown the potential to compound the problem further. Even for products manufactured at multiple sites (e.g. HFC-134a), recent shortages have served to highlight the on-going vulnerability of the foam industry both in developed and developing countries. Future transitions from ozone depleting substances are likely to become more challenging unless further capacity is installed in the interim. The investment climate is currently being affected by uncertainties over the form of regulation being adopted on HFCs in some regions of the world.

The use of blends continues to proliferate in order to make best use of the available HFC supply and to limit the impact on foam formulation costs. There has been heightened international attention on the adoption of responsible use criteria for HFCs in foams during 2004. Nonetheless, political pressure to control the use of HFCs is increasing in some regions.

#### Other product and market issues

Foam market growth is well in excess of growth in GDP for several foam sectors as insulation levels increase to save energy and the efficiency of foams becomes more widely recognised in spite of blowing agent transition. In domestic refrigerators and freezers, product design improvements have more than compensated for deficiencies in the basic thermal insulation performance of some of the alternative blowing agents.

The focus on foam end-of-life issues continues as consideration is given to the management of blowing agent banks. However, practicality and economic viability of recovery and destruction of ozone depleting substances varies across foam sectors and regions.

Choices in technology remain limited in flexible box foam applications. In many countries, the use of methylene chloride remains the only viable option. Other technologies are either limited in regional availability, complicated in processing or economically non-viable. Other blowing agent options continue

to emerge, amongst which Ecomate (a proprietary formulation based on methyl formate) and trans-1,2-dichloroethylene are the latest. The incremental value of these new options continues to be evaluated.

### **Halon TOC Technical Progress**

The HTOC met on March 7-9, 2005 in Eschborn, Germany to update the status of the transition from halons for all sectors of use.

As reported at the 16<sup>th</sup> meeting of the Parties, and in accordance with Decision XV/11, a plan of action has been developed with ICAO to help accelerate the introduction of halon alternatives in new aircraft designs.

HTOC was encouraged to learn that Lufthansa has 8-10 Airbus A340-600 aircraft using the HFC-236fa lavatory waste receptacle extinguishing system, and subsequently learned that this has become standard equipment on new Airbus A318/A319/A320/A321/A340 series of aircraft (and will shortly be certified for deliveries of the A380 as well).

The HTOC has recently reviewed existing data on halon supplies and emissions. This review revealed that atmospheric concentrations of halon 1211 between 1999 and 2002 are about 50% lower than the HTOC model predicts, and atmospheric concentrations for halon 1301 in the same time frame are fairly close to the HTOC model's emissions predictions. However, the bank of halon 1301 in at least one country is significantly larger than predicted by the HTOC model, suggesting a significantly lower emission rate than used in the HTOC model. In light of the new evidence, the HTOC bank model for halons 1301 and 1211 needs to be updated, and also needs to include halon 2402.

The HTOC discussed the progress and challenges in the transition away from halons among Article 5(1) countries and the implementation of halon projects. The HTOC noted that some countries are experiencing difficulties in operating and maintaining recycling centres for some MLF projects. The equipment needed to properly recycle halon is expensive, often leaving inadequate resources for the recruitment, retention, and training of qualified staff in the host country to operate the recycling centre and maintain the equipment. The HTOC also noted that contaminated halon is a serious issue in Africa, and there is currently a lack of independent laboratories able to assess and certify the purity of recycled halons.

The HTOC discussed the growing importance of ensuring the option to safely and effectively destroy halons, as well as other ozone-depleting substances, to prevent emissions from surplus or contaminated supplies. Two plasma arc facilities exist world-wide, one in Australia and one in the United Kingdom, where halons have been destroyed. In addition, small quantities of halons have been destroyed in hazardous waste incineration facilities in Europe. As



part of its work to complete the 2006 Assessment Report, the HTOC will include a new chapter on the issues related to halon destruction.

### **Refrigeration, AC and Heat Pumps TOC Technical Progress**

HFCs continue to be the main alternatives to CFCs and HCFCs in most refrigeration, air conditioning and heat pump sub-sectors. However, the use of hydrocarbons, ammonia, carbon dioxide and fluorochemicals with lower GWPs has increased further. There is also an increasing trend to use indirect refrigeration systems using heat transfer fluids (HTFs) in secondary-loop delivery (distribution) systems to reduce refrigerant charge and likely emissions.

In *domestic refrigerator applications*, no new alternatives have surfaced that are superior in energy-efficiency or cost competitiveness compared to conventional vapour-compression refrigeration. HFC-134a or HC-600a continue as the dominant refrigerant options for application in products. Conversion of the service demand for CFC-12 refrigerant is more sluggish. Approximately one-half of the approximately 1500 million domestic refrigerators in service originally contained CFC-12 refrigerant. This percentage is even higher in Article 5(1) countries. In *commercial refrigeration*, the following issues need to be mentioned. For commercial freezers installed by companies operating globally, the replacement of HFC-134a by isobutane in freezers is significant, about 50% of the new installed systems. The lifetime of the equipment is about 10 years. In the USA, the use of HCFC-22 is still quite significant and the blends R-404A and R-507A are now applied in about 50% of the new equipment. In developing countries, HCFC-22 is the refrigerant of choice, while HFC-134a and R-404A are now used in some applications. In centralised commercial refrigeration systems, the choice of refrigerants shows a similar trend as in condensing units. In *large size industrial*, cold storage and food processing refrigeration systems, the current state of technical options has continued to change since the publication of the 2002 Assessment Report particularly in low temperature applications with CO<sub>2</sub> as the heat transfer fluid and refrigerant. In the case of ammonia systems there is any increased tendency to reduce the refrigerant charge. *Transport refrigeration* accounted for about 1% of all refrigerants used in 2002. The market share of HFCs used in transport refrigeration systems was 2% of all HFCs used in 2002, the market share of CFCs was 0.5% and that of HCFCs was 0.3%. These figures show that the transport refrigeration sector has already shifted more towards HFCs than the other industry sectors.

In *unitary air conditioning*, the current state of the technical options has experienced only incremental change since the publication of the RTOC 2002 Assessment Report. The primary changes have been the continued penetration of HFC technologies into the markets of the developed countries

and the significant growth in HCFC-22 usage in China. In *chiller air conditioning*, centrifugal chillers using CFC refrigerants are gradually being replaced by new chillers using HCFC or HFC refrigerants. Conversion of existing chillers to use non-CFC refrigerants (HCFC-123 for CFC-11 or HFC-134a for CFC-12) has nearly ended because most good candidates for conversion have already been converted in markets where there are regulatory and financial incentives. For *water-heating heat pumps*, markets continue to grow. Heating-only space-heating heat pumps are available in sizes ranging from 1 kW heating capacity for single-room units to 50-1000 kW for commercial/institutional applications. HCFC-22 still is used as one of the main refrigerants in heat pumps but manufacturers are introducing models using HFC-134a, R-407C, R-404A, or in smaller systems, hydrocarbons as refrigerants. When hydrocarbons are used, the refrigerant circuit is located outdoors using ambient air, earth, or ground water sources, and is connected to hydronic floor heating systems. Carbon dioxide is being introduced in Japan and Norway as a refrigerant for heat pumps, particularly those with a domestic hot water heating function.

In *vehicle air conditioning*, HFC-134a has replaced CFC-12 as the globally accepted mobile A/C (MAC) refrigerant and the industry is busy expanding global production to meet the increasing demand. By 2008, almost all vehicles on the road are expected to be using HFC-134a. Due to the fact that HFC-134a is considered a potent greenhouse gas and also due to concerns about emissions of HFC-134a from MAC systems, vehicle makers and their suppliers are reducing their system leakage and improving energy efficiency. This joint activity is an industry-wide co-operative effort known as I-MAC (Improved Mobile Air Conditioning). Targeted improvements include a 50% or greater reduction in refrigerant emissions and a 30% or greater reduction in energy use. Currently, it is not clear whether improved HFC-134a, HFC-152a, or CO<sub>2</sub> systems will achieve the highest life-cycle climate performance, particularly in the hottest climates where air conditioning is most needed.

### **Chemicals TOC Technical Progress**

The CTOC is responsible for annual progress updates on Solvents, Feedstocks, Laboratory and Analytical Uses, Non-Medical Aerosols and Miscellaneous Uses, and also for completing assessments on Process Agents, Carbon Tetrachloride (CTC), Destruction Technologies, and on new chemicals such as n-Propyl Bromide (n-PB).

#### ***Process Agents***

The 16th Meeting of the Parties received the Report of the Process Agents Task Force, which concluded that the processes reviewed met the criteria defined by the Process Agents Task Force in its 1997 Report. Parties did not include in Table A any of the nominations placed before the 16th MOP, and requested clarification on the initial dates for each Process Agent use. These

dates were mentioned explicitly for the nominations made by the DPR of Korea, although the nomination for radiolabelled cyanocobalamin reported use of CTC from 1995 onwards.

The USA resubmitted its request for CFC-113 to produce High Modulus Polyethylene Fibre as a Process Agent. This process commenced operation in 1985 and output has grown steadily with plant expansions in the same site, where more spinning capacity was installed. This expansion was accompanied by substantial reductions in emissions of CFC-113.

The interaction of the spinning solvent with the fibre plays an important role in the unusual strength of the end product. Therefore, the CTOC reaffirms its finding that the use of CFC-113 for this purpose satisfies the technical criteria as a Process Agent Use.

The CTOC considers that there is ambiguity in the meaning of 'new plant' as it is used in *Decision X/14*. 'New plant' could involve construction of a new facility, separate from any facility that might have existed before 1 January 1999. An alternative interpretation would be that an increase in the production capacity of an existing facility would constitute 'new plant'.

If Parties decide that expanded production requires classification of the expanded production as an Essential Use rather than a Process Agent Use, it will be necessary to allow time for nomination, review, and manufacturing response. However, the expiry at the end of 2005 of the temporary allowance granted by Parties in 2004, leaves no time for such an application to be considered.

An Emergency Request by the EU to the Ozone Secretariat to authorise the use of 8 litres CTC required for the manufacture of radiolabelled cyanocobalamin was recommended by the TEAP and CTOC co-chairs. Parties may wish to consider granting a long-term exemption. Conversely, Parties may also wish to consider whether there should be any limit to the continued renewal of an Emergency Exemption.

The Republic of Turkey submitted a nomination for the use of bromochloromethane (BCM) in the production of Sultamillicine, an antibiotic whose production started there in 1991. In this application BCM is being consumed as feedstock and so it cannot be accepted as a Process Agent Use.

A Guidance Note with Pro-forma has been prepared by the CTOC to help Parties provide all necessary information when making nominations for Process Agents, and is included in an Appendix to the CTOC Progress Report.

### ***Feedstocks***

CTC, CFCs and HCFCs can be major feedstocks either by being fed directly into the process as a raw material stream or they can be produced as intermediates in the synthesis of another product. Fugitive leakage when CTC, HFCs and HCFCs are directly fed is likely to be somewhat lower since losses can occur, if transport is involved, and transfers.

Given that emissions will vary according to a number of variables, which include plant location, technology used, plant size, availability and transport of ODS, and local regulations; it seems appropriate to consider ranges of emissions. If one accepts that 0.5-4% is an appropriate guidance level for products transported and used as raw materials, while 0.2-2% is an accepted leakage rate for intermediates with no interplant transport, calculations from 2002 production data suggest that total emissions from feedstock use are on the order of 2,000-18,000 tonnes or 612-6,000 ODP tonnes per year.

### ***Laboratory and Analytical Uses***

The search for “carbon tetrachloride” found over one thousand active standards, of which 52 of them are ASTM “Standards Test Methods” and 22 of them are ASTM “Standard Practices” which are likely to require use of CTC for laboratory and analytical uses.

A workshop on the elimination of controlled substances in laboratory and analytical uses would assist Parties to phase-out of the uses as defined under Decision XI/15. The workshop could also identify remaining uses of controlled substances and their potential substitutes. This could expedite the incorporation of new analytical methods into national and international standards.

The CTOC will appreciate any information that Parties may supply on new ODS-free testing methods that come to their attention.

Parties may wish to consider extending the laboratory and analytical use exemption to allow the use of methyl bromide in laboratory and analytical uses as an exempted use with appropriate standards of purity, special packaging and other strategies to avoid unauthorised use.

### ***Aerosol products, Non-medical***

The TEAP Report of April 2000 indicated that there were no technical barriers for the transition to alternatives for aerosol products other than MDIs. Some residual uses of CFCs still remain in the aerosol sector of some Article 5(1) countries:

- technical aerosol products that need to be non-flammable;

- cans that contain CFC refrigerant only; and
- products made by SMEs that cannot use Hydrocarbon Aerosol Propellants (HAPs).

In the technical aerosol products the conversion from CFCs to HFCs will not occur unless specifically mandated in Article 5(1) countries due to the big price difference between CFCs and HFCs.

### ***Carbon Tetrachloride (CTC) Emissions and Opportunities for Reduction***

The production of CTC in non-Article 5(1) countries in 2002 could be assumed to be approximately as follows: EU 60,000 tonnes; USA 20,000 tonnes, Russia 10,000 tonnes, and Japan 10,000 tonnes for a total of 100,000 tonnes.

Among Article 5(1) countries, the two major countries that produce CTC are China and India, the first with 60,000 tonnes, and the second with 20,000 tonnes. Both are assumed to have used the majority of their production and import to produce CFCs. Solvents uses as cleaning agent are known in Article 5(1) countries and the 2002 STOC Report gave an estimate for 2000 at around 14,000 tonnes, of which 5,000 to 6,000 tonnes were assumed to be used as Process Agents. More recently, China has reported Process Agent Uses of about 10,000 tonnes and 1,000 tonnes for solvent uses.

Other Article 5(1) countries that may be producing CTC are Brazil, South Korea and North Korea, but their usages are unknown. No new statistical numbers are available. From the numbers given above, total world-wide production of CTC can be estimated at less than 200,000 tonnes in 2002.

CTC emissions among USA, Japan and some EU countries have been studied. US Fugitive atmospheric emission records on CTC are made public for the years 2000, 2001 and 2002 at 32.6 tonnes, 30.4 tonnes and 115.4 tonnes, respectively. Japan reports fugitive atmospheric emission for the years 2001, 2002 and 2003 at 71.9 tonnes, 65.7 tonnes and 45.9 tonnes, respectively. Among EU countries, UK reports its atmospheric releases of CTC for the years from 1998 through 2003 at 30.1 tonnes, 31.7 tonnes, 26.4 tonnes, 15.0 tonnes, 5.0 tonnes and 8.7 tonnes, respectively.

Article 5(1) countries currently do not report CTC emissions, so no data are available neither on the volume emitted nor the sources that may be making emissions. If emissions from all feedstock uses are assumed to be 2,500 ODP tonnes, emissions of Process Agent Uses are estimated at 15,000 ODP tonnes and emissions from solvent cleaning and laboratory and analytical uses are calculated at 3,000 ODP tonnes, total emissions of CTC should be around 20,000 ODP tonnes per year.

CTOC is aware of different studies that estimate CTC emissions from *in situ* atmospheric abundances (that is, AGAGE). Estimated emissions derived from tropospheric CTC measurements show a decline in the value of emissions, but still remain two to three times higher than the estimated emissions of around 20,000 tonnes. CTOC will study these discrepancies and report its findings next year.

It is difficult to identify potential solutions for the reduction of emissions, as there are no accurate numbers that relate directly the emissions to specific operations. Tightening of emissions from venting and increasing recovery rates are potential methods to reduce emissions. Production of CTC should decrease with reduced use as feedstock for CFCs.

A full report will be provided to the Parties in 2006.

### **Solvents**

Since the last STOC report in 2002 no new alternative solvents have been developed and it is unlikely that there will be new solvent alternative breakthroughs. Thus far only the HFCs, and HFEs are leading the field in halogenated solvent replacements.

Use of n-propyl bromide (n-PB) continues (in spite of toxicity concerns and pending proposals to reduce exposure guidelines) due to its good solvency and relatively low cost. Its current use estimates range from 2,200 MT to 9,100 MT per year. This substance has an ODP that ranges from 0.013 to 0.1 depending on where it is emitted (higher at lower latitudes).

Long term (chronic) testing of n-PB in animals has shown toxicity to the reproductive systems of both male and female. n-PB also has significant neurotoxicity to animals and humans. The animal study showed significant neurological effects on animals at various dose levels. The Environmental Protection Agency (EPA) of the USA has suggested an exposure limit of 25 ppm. The American Conference of Government Industrial Hygienists recommends an exposure limit of 10 ppm.

An update on the Essential Use Exemption for 1,1,1-Trichloroethane (Methyl Chloroform) Used in Aerospace Applications is provided. NASA and their contractors are currently working to re-qualify the Space Shuttle for return to flight status, following the February 2003 accident when the Space Shuttle Columbia was lost during re-entry into earth's atmosphere.

NASA/Thiokol estimates that the remaining quantity of 1,1,1-trichloroethane granted under the existing EUE is sufficient for anticipated Shuttle flights and for the transition to the next-generation space vehicles. There has been some progress in reducing use and emissions of 1,1,1-trichloroethane, but alternatives are not yet available for some critical applications.

TEAP concurs with the NASA/Thiokol technical assessment confirming the importance of the continuing use of 1,1,1-trichloroethane for their critical aerospace applications and reaffirms its recommendation for the already-granted EUE.

### ***Destruction Technologies***

The 2002 Task Force on Destruction Technologies identified 45 technologies of which the Task Force recommended 12 technologies now being operated in commercial-scale. In April 2001, Japan mandated the component recovery and recycling law from domestic appliances, which include the refrigerants from the compressor. As a result, the recovery of refrigerants increased from 136 tonnes in the period between April 2001 and March 2002 to 287 tonnes between April 2003 and March 2004. Since the law enforced recovery of the blowing agents from domestic appliances from April 2004, the amount of ODS for destruction is expected to increase. Similar destruction plants in the EU are found in UK and Germany.

No appreciable advance has been reported for the 29 emerging technologies.

The application of criteria such as destruction and removal efficiency (DRE) for dilute sources (foams) cannot be done without considering the several steps that might constitute a “destruction technology”. This issue is covered in the Foams End of Life Chapter of the 2005 TEAP Report.

### **Methyl Bromide TOC Progress Report**

This section on methyl bromide (MB) updates trends in MB production and consumption, and gives progress in the development and adoption of alternatives. Preliminary information is also given on the registration status of various alternatives in part fulfilment of Decisions Ex.I/4(9i) and Ex.I/4(9j).

Non-Article 5(1) countries reduced controlled production of methyl bromide from about 66,000 tonnes in 1991 (baseline) to less than 24,580 tonnes in 2003, while Article 5(1) countries reduced their controlled production from a peak of more than 2,380 tonnes in 1998 to approximately 960 tonnes in 2003. In non-Article 5(1) regions, controlled MB consumption was reduced from 56,043 tonnes in 1991 to 14,478 tonnes in 2003. MB consumption in Article 5(1) regions peaked at about 18,140 tonnes in 1998 and fell to about 11,858 tonnes in 2003.

Many sectors have eliminated or much reduced use of methyl bromide as a soil fumigant. Key in-kind alternatives include various formulations of 1,3-dichloropropene, chloropicrin and metham sodium, applied alone or in some combinations. To a lesser extent, users have adopted combinations of chemical and non-chemical measures, such as use of grafted plants and use of substrates. There is renewed interest in combining alternative fumigants with

low permeability barrier films (VIF, or equivalent) to improve efficiency of treatments at lower rates of application. An increasing number of research studies are showing that new or modified formulations of various fumigants, often with modified application methods, are producing yields similar to methyl bromide in diverse situations.

There are several potential in-kind alternatives to methyl bromide as a soil fumigant at an advanced stage of development, currently under evaluation for registration in some regions. These include methyl iodide, cyanogen, propylene oxide, azides and dimethyldisulphide.

Recent progress in development of methyl bromide alternatives for soil fumigation is summarised by crop.

There have been some recent registrations of alternatives, including sulphuryl fluoride and ethyl formate, in some regions for postharvest/structural use. Recapture/destruction technology is in limited use in this sector.

Article 5(1) Parties, in aggregate, have reduced their methyl bromide consumption substantially in recent years, using alternatives in general the same as available for non-Article 5(1) Parties. From experience with methyl bromide phase-out in Article 5(1) countries, it has been found that alternatives work best when used within an IPM framework and training in this respect is essential, the capability to adapt to local conditions is important to the success of any alternative, and alternatives can be introduced within periods of 2-3 years. Demonstration projects have led larger or more technically prepared growers to adopt alternatives on their own initiative.

### **MBTOC CUN Report**

MBTOC assessed 62 new or additional critical use nominations for 2006 and 27 nominations for 2007 totalling 324.68 and 8088.32 metric tonnes respectively. MBTOC was unable to assess 26 of these nominations. Some of the larger and more complex nominations were in this category. It did not recommend two nominations. Recommendations totalled 269.61 tonnes for 2006 and 873.19 tonnes for 2007. Evaluations were carried out in the light of Decision IX/6 and in conformity with recent guidance from Parties given in the Annex referred to in Decision XVI/4.

MBTOC set out the standard presumptions it used in its evaluations. These were taken to be applicable unless there was explicit reason to the contrary. In particular MBTOC assumed that use of Virtually Impervious Films (VIF) or equivalent barrier films for critical uses, with associated low dosages of fumigant and reduced emissions, unless there were specific indications to the contrary, in fulfilment of Decision IX/6(1,b,i).



## **Methyl Bromide QPS Task Force Report**

A Task Force has been set up in response to Decision XVI/10 to evaluate the technical and economic feasibility of alternative treatments and procedures that could replace methyl bromide for quarantine and pre-shipment (QPS) treatment and to estimate the volume of methyl bromide that would be replaced by the implementation of technically and economically feasible alternatives for quarantine and pre-shipment treatment, reported by commodity and/or application.

Forty two Parties responded to a survey on QPS uses and alternatives seeking data for 2002. The quantity of methyl bromide used for QPS reported by the respondents totalled 1,611.062 metric tonnes. This represents approximately 15% of the QPS usage that was estimated for 2000 by MBTOC in its 2002 Assessment Report. As of 1 April 2005, ten Parties had responded to paras 2 and 3 of Decision XVI/10 with further data on QPS usage.

Preliminary results indicate that, as expected, development of methyl bromide alternatives for QPS applications continues to be a difficult process, often coping with diverse situations with small quantities of MB (<1 tonne annually) consumed for particular uses. A variety of technologies are potentially suitable as replacements, but their actual use is constrained many factors, including the need for a very high level of effectiveness against target pests in the supply chain in which the measures are applied.

## **EXECUTIVE SUMMARY REPLENISHMENT TASK FORCE REPORT**

The Replenishment Task Force has estimated the total funding for the 2006-2008 replenishment to enable the Article 5(1) Parties to comply with all relevant control schedules under the Montreal Protocol control schedules under the Montreal Protocol to be **US \$419.4 million**.

The larger part of this funding requirement is for forward commitments for already approved multi-year agreements in the consumption and production sectors (about US \$206 million), and for standard recurring costs such as Institutional Strengthening, UNEP's Compliance Assistance Programme, the budget of the MLF Secretariat and Executive Committee meetings, the Treasurer's fees and the Implementing Agencies core funding (US \$78 million). This implies that about US \$284 million of the US \$419.4 million (68%) can be considered as already committed.

### *MANDATE AND CONSULTATIONS*

#### *Mandate from the Parties to TEAP; Decision XVI/35*

The Sixteenth Meeting of the Parties requested the TEAP to prepare a replenishment report and present it to the Open-ended Working Group at its 25th Meeting to enable the Parties to decide at their Seventeenth Meeting on the appropriate level of the 2006-2008 replenishment of the Multilateral Fund (Decision XVI/35).

#### *TEAP Response; Replenishment Task Force*

The TEAP constituted a Task Force of six TEAP/ TOC members from Belgium, China, Hungary, India, The Netherlands, and Venezuela, as well as an advisor from Egypt to prepare the report.

#### *Technical and Financial Consultations*

The Task Force carried out consultations with a wide range of financial and technical experts. Interviews were conducted during the 45th Meeting of the Executive Committee held in Montreal, April 2005. The Task Force extensively consulted the MLF Secretariat, The Regional Network Coordinators, the Ozone Secretariat and the Implementing Agencies.

A small group of experts, selected by the Task Force, in consultation with the TEAP, reviewed the drafts of this report. The final review was carried out by the TEAP at its April 2005 meeting.

## *DATA AND METHODOLOGY*

The following reduction schedules apply:

- ❑ CFC: 85% reduction in 2007, and complete phase-out by 2010;
- ❑ Halons: phase-out by 2010;
- ❑ CTC: complete phase-out by 2010;
- ❑ TCA: 70% reduction step in 2010 and complete phase-out by 2015;
- ❑ MB: complete phase-out by 2015.

### ***Data***

The Replenishment Task Force used the MLF Secretariat data on the remaining eligible consumption for CFCs, particularly for countries with no fixed multi-year agreements, as well as data on forward financial commitments. It also used the data for the consumption and production of all ODS in all Article 5(1) countries (that will apply for funding) as reported to the Ozone Secretariat; it included the most recent reports for the year 2003 (some for 2004).

More data on CTC, TCA and methyl bromide were available for this study than for the previous replenishment study in 2002.

The Task Force sought and received data on technology from industry.

### ***Cost Elements and Methodology to Address the Costs***

This report provides estimates for all the cost elements of the funding requirement for the 2006-2008 replenishment of the Multilateral Fund. Seven cost elements have been addressed in this report, which includes the cost related to investment projects to completely phase out consumption and production (including bilateral programs), non-investment activities, administrative costs, project preparation costs, core units funding for Implementing Agencies, operating costs of the MLF Secretariat and for holding meetings of the Executive Committee, as well as Treasurer's fees.

Each category of the cost elements and the estimation are described below.

#### ***1. Investment Projects for the Consumption Sector***

This cost category refers to the funding requirements for the investment projects to completely phase out the consumption of CFCs, carbon tetrachloride (CTC) and halons by 1 January 2010, and 1,1,1 trichloroethane (TCA), and methyl bromide by 1 January 2015 or earlier, as pertinent.

For the CFC consumption sector, Article 5(1) countries were sub-divided into three groups. The first group consists of non-LVC countries (i.e., countries with a CFC consumption baseline above 360 ODP tonnes) with existing multi-year agreements where the funding during the triennium 2006-2008 has already been determined in the agreements. The second group consists of a few countries that have so far no approved multi-year agreements. It is expected that most of these countries will submit National Phase-out Plans that are expected to be approved by the Executive Committee in 2005 or 2006, and funded during 2006-2008. The third group consists of LVC countries, for which an approach to deal with the total phase-out has been taken as given in the Executive Committee decision 45/54; this would imply funding additional to the funding already received for Refrigerant Management Plans (RMPs).

For the CFC consumption sector, a total funding requirement of US \$115 million was determined (excluding agency support costs, as in all the following cost statements).

In the case of CTC, in particular, the majority of the funding is in multi-year agreements. A lumped approach was used to determine the funding requirement for reductions necessary in the halon sector, and for addressing low consumption of CTC and TCA, larger than 2.0 ODP tonnes (for lower levels technical assistance would be appropriate, according to the relevant Executive Committee Decision 45/14). The total amount of funding involved in CTC agreements and projects amounts to US \$53 million, in the TCA sector it amounts to US \$0.4 million.

Small amounts are assumed to be needed for the halon consumption sector and for phasing out bromochloromethane in the process agent sector.

In the case of MB, two scenarios have been investigated. The first scenario consists of the existing agreements, the funding required for two Parties, which have so far been exempted (Decision XV/12), and for a few new multi-year projects which have been considered in business planning for the year 2005 and beyond (mainly for maintaining momentum and accelerated phase-out). The funding requirement for MB projects is then determined as US \$24 million.

A second scenario (submitted by the European Community) has been investigated (as it was included in the Terms of Reference, Decision XVI/35), which assumes reduction steps in MB consumption in 2008, 2010 and 2012, with a 60% reduction in the year 2010. This scenario would add US \$10.580 million to the above estimate.

## ***2. Investment Projects in the Production Sector***

This refers to the investment projects to phase out the production of controlled substances, particularly CFCs, halons and CTC by 1 January 2010, and 1,1,1 trichloroethane (TCA) and methyl bromide by 1 January 2015 or earlier.

Estimates were based on the costs for phase-out projects already agreed with virtually all ODS producing countries (this excludes one Party with a small CTC/ MB/ CFC production capacity, still to be addressed, i.e., Romania having CTC/ MB/ CFC production capacity and China having MB production (see paragraph below)).

The amount involved in the phase-out of production of CFC, halon, CTC and TCA producing plants equals US \$102 million. For the phase-out of MB capacity in one country US \$3.0 million is assumed in the next triennium.

## ***3. Non-investment Activities***

The non-investment activities refer to the activities related to UNEP's Compliance Assistance Programme (CAP), institutional strengthening, training, refrigerant management plans (RMPs), halon banking, technical assistance, country programme preparation and updating, and preparation of MDI transition strategies;

In many cases, cost information for these activities, which support investment projects in phasing out ODS consumption and production, were received by the Replenishment Task Force. They are based on the Business Plans of the Implementing Agencies, in particular UNEP, and on information from the MLF Secretariat. In other cases, estimates were made by the Task Force based on extrapolation from data in the existing databases towards the future replenishment 2006-2008. For all Article 5(1) countries, institutional strengthening funding has been taken into account, with a funding pattern that yields similar amounts every two years. The total for non-investment activities is estimated at US \$55.5 million.

## ***4. Administrative Costs of the Implementing Agencies***

Different charges in implementing agencies support costs were applied to all types of project approvals. These charges were individually agreed by the Executive Committee or according to guidelines decided by the Executive Committee. In the few cases where no direct support cost information was available, estimates of the agency support costs were made on the basis of experience with similar types of projects. By adding all cost components, the total funding for this element is estimated to be US \$28.67 million.

### **5. *Project Preparation***

Project preparation costs for the triennium 2006-2008 were estimated from the average of the project preparation costs per year during the period 2003-2004, and from the project preparation requirements for new TPMP plans for LVC countries (Decision 45/54); it amounts to US \$3.02 million.

### **6. *Core Unit Funding***

Costs for the Implementing Agencies Core Unit funding (which does not apply to UNEP) were determined on the basis of the relevant Executive Committee decision 38/68 (regarding the current administrative cost regime), and amount to US \$13.5 million for the triennium 2006-2008.

### **7. *Operating Costs of the MLF Secretariat and the costs for holding meetings of the Executive Committee, and for the Treasurer***

These costs were determined on the basis of planned expenditure on current operations for the Executive Committee and the MLF Secretariat, including the monitoring and evaluation part, as well as for the Treasurer's fees. It amounts to a total of US \$14.325 million.

### ***FUNDING REQUIREMENT FOR THE 2006-2008 REPLENISHMENT OF THE MULTILATERAL FUND***

The RTF estimates and concludes that a total of US \$419.44 million will be needed for enabling the Article 5(1) Parties to comply with the control schedules under the Montreal Protocol, with the cost elements as set out in the summary table below.

<b>Funding Requirement Elements for the Replenishment:</b>	<b>US \$Million</b>
CFC Consumption Sector Projects non-LVCs	63.205
CFC Consumption LVC Activities – TPMPs, others	32.113
CFC MDI and pharmaceutical aerosols	19.786
MB Consumption Sector Projects	24.022
Halon Consumption Sector Projects	0.954
CTC Consumption Sector Projects	58.904
TCA Consumption Sector Projects	0.413
BCM Consumption Sector Projects	0.700
Investments: Production Sector	
1- CFC	83.345
2- Halon	0.800
3- CTC	17.188
4- TCA	0.700
5- MB	3.000
Non-investment Activities; Supporting Activities	55.524
Administrative Costs of Implementing Agencies	27.939
Project Preparation Cost	3.020
MLF Secretariat/ ExCom Operation/ Treasurer's fees	14.325
Core Unit Funding	13.500
<b>Total</b>	<b>419.44</b>

In the total estimate of the funding requirement, the already agreed commitments have become more important than the new projects, activities and new multi-year agreements proposed. For consumption and production an amount of about US \$206 million is already committed in multi-year agreements. For new projects and agreements, mainly in the consumption sector, about US \$127 million is proposed in this report. US \$78 million of the remainder of the funding requirement (about US \$87 million) has already been committed (US \$78 million) to agreed non investment activities and is for the budgeted costs of the Executive Committee, the MLF Secretariat, the Treasurer's fees and the Core Units costs for the Implementing Agencies.

This implies that a total of about US \$284 million of the total funding requirement (or 68% of the total recommended) can be considered as committed.

The scenario with gradual MB reduction steps in 2008/2010/2012, as mentioned in the Terms of Reference, would have the implication that an amount of **US \$10.580 million** (including agency support costs) would have to be added to the total amount given above.

## **EXECUTIVE SUMMARY FOAM END-OF-LIFE ISSUES TASK FORCE REPORT**

This report responds to Decision XV/10 of the Parties of the Montreal Protocol, which sought feedback from the TEAP on two issues:

1. The provision of useful information on the handling and destruction of ODS contained in thermal insulation foams with particular focus on economic and technological aspects of those contained in buildings;
2. The clarification of the distinction between destruction efficiencies achieved when blowing agents are extracted from foams prior to destruction (re-concentrated sources) and those achieved when foams themselves are destroyed directly (dilute sources).

Although the report touches on the uptake of various destruction technologies in the foam sector, it was not the prime purpose of this report to investigate the success of implementation of end-of-life management strategies (i.e. the efficacy and efficiency of collection). The main focus of the report is to describe the technical and economic aspects of blowing agent recovery and destruction from appliance and building insulation foams.

There have been considerable advances in the understanding and application of end-of-life management strategies for foams over the three years since the TEAP last reported on this issue within the Task Force Report on Collection, Recovery & Storage of ODS. There are two prime categories of destruction option available to the sector. These are:

- Mechanical blowing agent separation techniques followed by the destruction of re-concentrated blowing agent
- Direct destruction of the foam including its blowing agent using techniques such as direct incineration (e.g. co-incineration in power plants or cement kilns)

### Efficiency issues

During the finalisation of the report of the TEAP Task Force on Destruction Technologies in 2002, there had been some confusion about how to express efficiencies for these two types of processes. The favoured method for expressing all destruction efficiencies was by use of the term Destruction and Recovery Efficiency (DRE) which focused only on the efficiency of destruction within the incineration 'stack' of the destruction facility. Even the wider scope of the term Destruction Efficiency (DE) was not sufficient to take into account the real situation with foams, since this only dealt with handling efficiencies at the destruction facility itself. It was clear, therefore, that any



meaningful statement on the efficiency of destruction of blowing agents within foams needed to consider all steps along the recovery and destruction handling chain including those practised prior to the foam ever reaching a destruction facility.

Three main steps involving potential losses of efficiency have been identified. These are:

1. Losses on the segregation of the foam from other waste streams
2. Losses during other pre-incineration steps, particularly where mechanical recovery and re-concentration of blowing agent is practised
3. Losses during final incineration of the re-concentrated or dilute blowing agent source

The Task Force was able to evaluate these steps for all major end-of-life management options being operated or researched at this time. Table FES-1 summarises these findings based on recent research and evaluations:

<i>Product Type</i>	<i>Recovery Method</i>	<i>Losses in segregation</i>	<i>Losses in other pre-incineration steps</i>	<i>Losses in incineration</i>	<i>Recovery &amp; Destruction Efficiency (RDE)</i>
General Building Foam	Mechanical Recovery	2-8%	0.5%	<0.1%	>90%
General Building Foam	Direct Incineration	2-8%	Not Applicable	<0.1%	>90%
Sandwich Panels	Mechanical Recovery	Not Applicable	<5%	<0.1%	>94%
Sandwich Panels	Direct Incineration	Not Applicable	Not Applicable	<0.1%	>99%
Appliance Foam	Mechanical Recovery	Not Applicable	<5%	<0.1%	>94%
Appliance Foam	Direct Incineration	0.5-4%	Not Applicable	<0.1%	>95%
Appliance Foam	Auto-shredder + managed attenuation	8-40%	<40%	Not Applicable	>20%

*Table FES-1 Typical losses experienced in currently considered end-of-life strategies*

In seeking to find a means of expressing this combined efficiency, the Task Force decided to introduce a new term entitled Recovery and Destruction Efficiency (RDE) to express the composite efficiency of these three steps. This parameter identifies the proportion of the ‘banked’ blowing agent, which is recovered in the overall end-of-life management step. It does not, therefore, cover losses in blowing agent, which may have occurred during the production and in-use phases of the product’s lifecycle.

$$RDE (\%) = \frac{\text{Blowing Agent in foam immediately prior to Decommissioning} - [\text{Losses in Segregation and/or Mechanical Recovery and/or Incineration}]}{\text{Blowing Agent in foam immediately prior to decommissioning}}$$

It can be seen from Table FES-1 that in all but the final end-of-life management option listed (auto shredder + managed attenuation), the potential exists to achieve RDEs of greater than 90%, albeit based on a limited level of

information in the buildings sector. The opportunity therefore exists to introduce this, or a slightly lower, minimum value to identify Approved Technologies under the Montreal Protocol in future.

Although not likely to become an Approved Technology, managed attenuation could still prove to be an important technology to minimise emissions from foam already landfilled and building foam that is not segregated. Further work must be done to determine the technology's capacity and efficacy in mitigating emissions.

#### Appropriateness of available technologies

Although few genuinely new technological options have emerged for end-of-life management in the period since the last review (TF CRS: 2002), there has been considerable progress in the characterisation and optimisation of existing processes. It would not have been possible to assemble a table similar to Table FES-1 for the earlier report.

There are two key waste streams yielding foams with potential for end-of-life management. These are the appliance sector and the buildings sector.

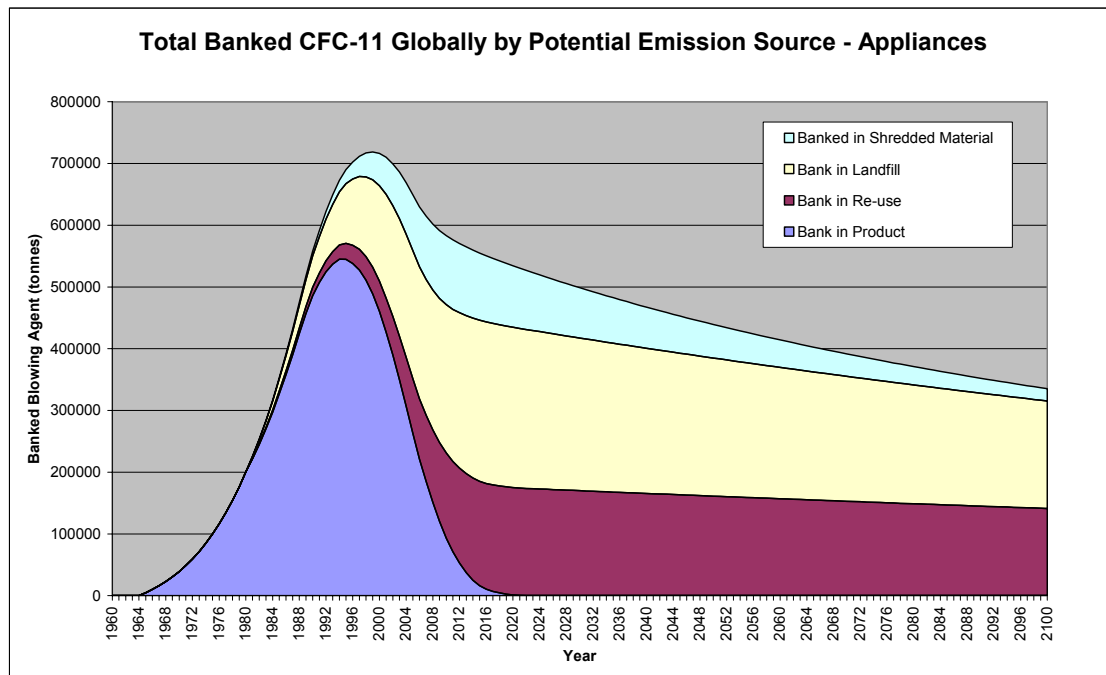
#### Appliances

It is estimated that upward of 1 billion domestic refrigerators and freezers are in use globally at this time. Many of these still contain foams blown with CFC-11, although the bank is already in decline. The appliance sector is characterised by the fact that the average global lifetime for such units is around 15 years (range 10-25 years). This distinguishes it from the building sector where, with the exception of a few building services applications, product lifetimes are much longer (50 years plus). These distinctive lifetimes have effects on both the character of waste streams and the processes required to manage them.

There are four key phases in which banks of blowing agent can reside:

- Within products during their normal service life
- Within products during an extended service life (often referred to as re-use)
- Within foams already landfilled without special treatment
- Within landfilled foams which have been segregated, shredded or otherwise treated

Figure FES-1 shows the predicted shift of CFC-11 from the original appliances into the various categories of re-use, normal landfill and shredded landfill, based on the consumption and emissions data used in the IPCC/TEAP Special Report.



*Figure FES-1 Predicted trends in the location of CFC-11 banks from appliances*

Several factors emerge from this graph. The first is that total banks of CFC-11 from the appliance sector probably peaked in around 2003 and are now beginning to decline as emissions from banks, coupled with managed recovery and destruction, outstrip any new consumption. The impact of the end-of-life regulation in both Europe and Japan (mostly through mechanical recovery and destruction) can be seen in the period from 2004 -2012 through the overall decline in the bank size.

In contrast, it is also important to note that at least 30% of the world's appliances that contained CFC-11 had been decommissioned by 2003 and much of the resulting foam had found its way into landfill. This is a particularly important factor in the developed countries where the proportion of appliances that had already reached the end of their service lives in 2003 were believed to be greater than 60% (Europe 73%; North America 63%; Japan 73%). This point highlights the need for prompt actions in this area if recovery of CFC-11 is to be further enhanced. It also implies that much of the CFC-11 in these regions had already reached landfill before regulatory provisions for end-of-life recovery were in place.

The situation for HCFC-141b and other more recent CFC-substitutes is different. In most cases HCFC-141b was only introduced in the early 1990s and waste streams are only now beginning to see signs of the first decommissioned units coming through. Accordingly, virtually the whole

'bank' of HCFC-141b contained in appliances (in excess of 200,000 tonnes) is still fully available for end-of-life management.

### Buildings

For buildings, the situation is very different. Taking the average lifetime of insulated building products as 50 years, it is not even expected that products containing CFC-11 will reach the waste stream in significant quantities until after 2010. This provides some further time to research appropriate end-of-life management options. However, achieving significant recovery and destruction is still likely to be a daunting task, since the foamed products were often installed with no thought to the fact that the foam might need to be reclaimed at end-of-life. One of the biggest challenges for this sector will be how to segregate foams from other demolition waste. At present, only manual methods exist and these make the economics of recovery and destruction very marginal, particularly in developed countries where labour rates are relatively high and the bulk of building insulation is situated.

Figure FES-2 gives an example of the trends in CFC-11 bank development expected in the building sector. In this instance, the graph addresses the situation for PU Boardstock.

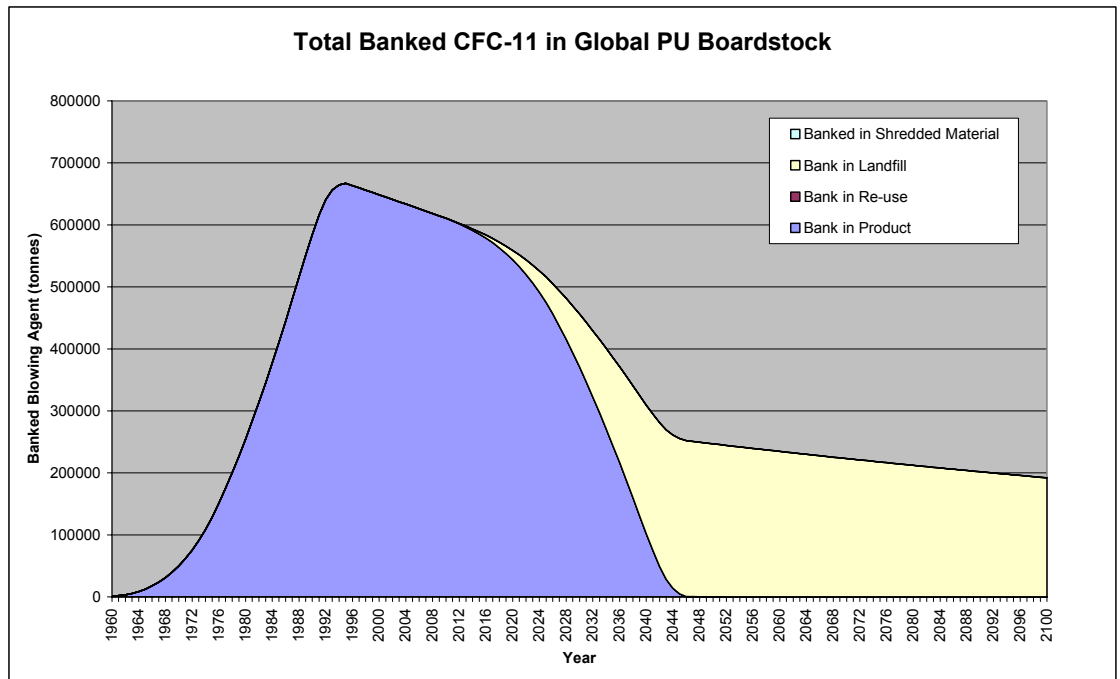


Figure FES-2 Predicted trends in the location of CFC-11 banks from PU Boardstock

For the reasons outlined above, it has been estimated for modelling purposes that 20% or less of the currently installed building insulation will be available for recovery and destruction through technically and economically viable means. The one exception to this is the case of steel faced sandwich panels where deconstruction of the building may be easier and there would be no subsequent requirement for segregation. Trials are already in progress to establish the costs of recovery and destruction of the blowing agent in such panels, and there is expectation that there will be no fundamental technical or economic barriers to either mechanical recovery or direct incineration methods.

#### Economic and Logistical issues

Although there are significant variations in approach between the various proposed methods of end-of-life management, Table FES-1 illustrates that, when well-practised, most end-of-life methods can be effective in achieving satisfactory recovery levels (i.e. >90%).

However, when it comes to economic viability the range of performance is much greater. The prime reason for this has already been mentioned – namely the potential need for waste segregation. One of the difficulties that the Task Force had in compiling this report was that there is little experience, as yet, in recovery and destruction of blowing agents from buildings on a commercial scale, primarily because most such foams are still in use. One of the challenges for end-of-life management in the building sector will be to provide sufficient incentive for the research and development of segregation methods ahead of the time when significant commercial opportunity exists. The key to optimising recovery and destruction in this sector is likely to be the successful co-ordination of technical feasibility, economic viability and regulatory versatility.

For appliances and steel faced sandwich panels, the situation is far more straight-forward. Infra-structure is already established in key areas of the world and commercial evidence suggests that recovery at \$25-40/kg of blowing agent is already an achievable goal. The challenge has been to keep capacity investment (mostly in mechanical recovery) and demand in balance in a fast-moving market environment. Where regulation has been used to encourage the development of such markets, enforcement remains a challenge. Currently, typical efficiencies of collection are believed to be in the 50-65% range although they are generally still improving.

One of the barriers to wider success of such programmes is the quality of infrastructure available for collection and transport. The location of recovery and destruction plants is important, with proximity to large urban populations advantageous. The introduction of mobile recovery units is also likely to assist in reaching less densely populated areas and may have particular

advantages in cutting down transport impacts from large building demolition sites.

The issue of logistics is particularly acute for developing countries and the existence of a reliable infra-structure is a pre-requisite for investment in any recovery and destruction facility.

#### Are there possibilities for dealing with foams already in landfills?

From the previous commentary on both appliances and buildings, it is clear that there has been, and will continue to be, substantial amounts of CFC-11 reaching landfills. Accordingly, methods of containing or otherwise attenuating emissions are of significant interest.

Preliminary laboratory work by the Danish Technical University (and others) has indicated that CFC-11 can breakdown under anaerobic conditions (exclusion of air). The breakdown products include initially HCFC-21 and HCFC-31, but these are then converted on to HFC-41. It appears that the microbes are unable to deal with the carbon-fluorine bond and there is no further breakdown of HFC-41 as currently observed. However, it is not clear why this is.

Another unknown is whether this breakdown mechanism occurs in all landfills to a limited extent or whether it only occurs where conditions are optimised by the 'seeding' of appropriate microbes in a controlled anaerobic setting.

Finally, it should be noted that the breakdown mechanism cited above does not offer a full mass balance and other breakdown products are suspected. It is important that further work be done to identify these breakdown products, not only to establish whether managed attenuation in landfills, if practicable, should be encouraged but to determine whether harmful products are already being generated from CFC-11 breakdown in landfills on a more widespread basis.

With recorded CFC-11 breakdown levels in the range of 60-100% in the laboratory, there is significant emission reduction potential if this technology can be transposed to the landfill environment. However, there is still much to learn about this mechanism and the technologies that could derive from it. Scale-up work would be required to investigate this option further if the breakdown products are seen to be relatively benign.

#### Emission Reduction Potential and dependence on Economics

Work carried out for the IPCC/TEAP Special Report on HFC & PFC related issues, identified a cumulative emission reduction potential from foam end-of-life measures in excess of 150,000 ODP tonnes based on the assumption that

20% of the blowing agent currently situated in existing buildings can be recovered and destroyed economically.

The sensitivity of this assessment of recovery potential to economic drivers remains a key factor. There are examples in the appliance sector where 'bounty programmes' have made manual segregation possible both technically and economically because the benefit has been associated with another parameter (in this case energy savings and reduced costs). The Task Force believes that much of the opportunity to recover ODSs will depend on the ability to link recovery and destruction to other drivers, such as the POPs treaty or emissions trading schemes, in order to achieve economies of scale on the one hand or full environmental value for the end-of-life management step. In this context, it should be noted that much of the ODS recovery and destruction in the appliance sector has been supported (and sometimes initiated) by parallel recycling targets.

### Conclusions

This review of foam end-of-life issues has led to the following key conclusions:

#### Technical Feasibility

- The increasing focus on the potential for emission reduction through end-of-life measures has led to a greater study of technical options in the past three years and more information is now available.
- A review of the Montreal Protocol technology approval process for blowing agent recovery and destruction suggests that a new parameter, Recovery & Destruction Efficiency (RDE) would be valuable to accommodate the whole recovery and destruction chain and overcome the limitations of both DRE and DE in respect of foams. Parties may wish to consider whether this would make an appropriate basis for re-defining Approved Technologies for foams.
- All currently practised recovery and destruction processes have the potential to reach an RDE of greater than 90% and a level of this order (e.g. 85%) could be considered as a new minimum standard for determining Approved Technologies in the foams sector.
- Laboratory evidence continues to emerge for anaerobic degradation of ODSs, which could be applicable in the landfill environment. However, it is not clear whether the process occurs to any extent in normal landfills or whether it would require specific landfill management techniques (managed attenuation).
- Optimisation of anaerobic conditions in the laboratory can create high levels of degradation. However, further work would be required on the



identification of breakdown products to confirm that no new health or environmental impact are likely to be created inadvertently.

- In view of the nature of landfilling processes, there is unlikely to be any circumstance in which the managed attenuation would become an Approved Technology. However, the technology could be highly beneficial in dealing with foamed products already in landfills and those for which no economically viable Approved Technology exists.

#### Economic Considerations

- The economics of recovery and destruction are greatly affected by the need to manually segregate foams from other components. The most cost-effective options are those mechanical recovery and direct incineration processes which avoid the need to segregate.
- The most demanding requirements for segregation (e.g. traditional building demolition wastes) occur in developed countries where the costs of labour are likely to be at their highest.
- In general, manual segregation can only be avoided where metals or plastics are the other primary component. This is the case for domestic appliances and steel faced panels. Mixed demolition waste will virtually always need to be segregated.
- The most cost-effective of all processes is the incineration of steel faced panels in steel-making furnaces where the steel is immediately recycled and the foam provides energy. Recent work with plastisol-coated steel suggests that emissions from this process can be managed without problem. However, the breadth of application of this approach depends on the geographic availability of such furnaces. Steel plants remain very sensitive to high chlorine feed concentrations and these need to be managed.
- Direct incineration using other technologies (e.g. Municipal Solid Waste Incinerators) will normally require segregation of foams unless the feedstock is sufficiently diluted to avoid build-up of incineration residues. Care also needs to be taken to ensure that emissions of halogenated bi-products do not exceed concentration limits.
- Mechanical recovery methods work well with appliances and steel faced panels. Blowing agents can currently be recovered from appliances at a net cost of US \$25-40/kg. However, work is on-going to establish the full costs of recovery from steel-faced panels.
- The costs of transport can also be a significant factor in the recovery of blowing agents. Indeed, in developing countries, the lack of appropriate supporting infra-structure (e.g. road networks) can negate the value of otherwise viable investments in recovery and destruction facilities. Even in developed countries, cost of transport to recovery and destruction

facilities is a factor because of the wide distribution of use and low density of building foams.

- The Montreal Protocol is not alone in seeking to manage the end-of-life recovery and destruction of chemicals. There are similar drivers in both the POPs Treaty and the Kyoto Protocol. An opportunity therefore exists to explore possible cost-sharing mechanisms and other shared drivers.

#### Environmental Potential

- Existing banks of CFCs and HCFCs are estimated to be in excess of 1.5 million and 0.75 million tonnes respectively. Efforts to corroborate these estimates from bottom-up analysis (e.g. JTCCM and others) have confirmed broad agreement at country-level.
- Emission factors from banks continue to be under review. This is an ongoing process requiring the identification of other emissive sources in order to align with observed atmospheric concentrations. In general, foams are among the slowest emitting product groups. This means that opportunities for bank management are maximised, but, if unmanaged, emissions are spread over a very long period.
- Several of the banks are already situated in landfills. In developed countries, over 60% of the domestic refrigerators using CFC-11 were already disposed of by 2003. Accordingly, managed attenuation of blowing agents in landfills would be the only available emission reduction option in many cases.
- Managed attenuation in landfills may also be the only practical option available for many foams currently in buildings unless segregation methods can be improved. Experience with the management of foams in buildings is currently limited, partly because of the longevity of many foam products, which have yet to reach end-of-life.
- Published assessments carried out for the IPCC/TEAP Special Report on the inter-relationship between ozone depletion and climate change suggested that cumulative ODS emission reductions in excess of 190,000 ODP tonnes could be achieved by 2100 using appropriate end-of-life management techniques. This does not take into account potential contributions from managed attenuation.
- In the foam sector, there could be incremental environmental benefits accruing from reductions in HFC emissions at end-of-life, through the continued use of equipment originally deployed to manage ODSs at end-of-life.

## **TEAP PROGRESS REPORT**



# **1 Essential Uses**

## **1.1 Essential Use Nominations for Metered Dose Inhalers (MDIs)**

### *1.1.1 Criteria for Review of Essential Use Nominations for MDIs*

Decision IV/25 of the 4th Meeting and subsequent Decisions V/18, VII/28, VIII/9, VIII/10, XII/2, XIV/5, XV/5 and XVI/12 have set the criteria and the process for the assessment of essential use nominations for metered dose inhalers (MDIs). Decision XVI/12 authorised levels of production and consumption for the European Community and the United States, subject to a second review of 2006 levels in accordance with Decisions VII/28 and XV/5, also with a request for TEAP to review the Russian Federation nomination for 2006.

### *1.1.2 Review of Nominations*

The review of essential use nominations by the Medical Technical Options Committee (MTOC) was conducted as follows.

Three members of the MTOC independently reviewed each nomination, each preparing an assessment. Further information was requested where necessary. The MTOC considered the assessments, made recommendation decisions and prepared a consensus report.

Nominations were assessed according to the guidelines for essential use contained within the *Handbook on Essential Use Nominations* (TEAP, 2001) and subsequent Decisions of the Parties.

Concurrent with the evaluation undertaken by the MTOC, copies of all nominations are provided to the Technology and Economic Assessment Panel (TEAP). The TEAP can consult with other individuals or organisations to assist in the review and to prepare TEAP recommendations for the Parties. MTOC received comments from the International Pharmaceutical Aerosol Consortium and the US Stakeholders Group on MDI Transition and letters from GlaxoSmithKline (GSK) and 3M Drug Delivery Systems Division. MTOC co-Chairs received correspondence from the Russian Federation and the United States at the time of the TEAP meeting, 25-29 April 2005.

### *1.1.3 Summary of Parties' Essential Use Nominations and Review of Quantities*

The Russian Federation nominated for an essential use exemption for MDIs for 2006 and 2007, which MTOC assessed during its meeting of 13-15 April 2005. Additional information from the Russian Federation was subsequently received during the TEAP meeting, 25-29 April 2005. This contained information that TEAP was able to use to make a recommendation.

With respect to the United States, at its meeting MTOC reviewed the authorised quantity (1,900 tonnes) of CFCs for 2006, in response to Decision XVI/12, and assessed the United States' essential use nomination for 2007 (submitted in 2005). Subsequently, a letter was received during the TEAP meeting in which the United States provided additional information and revised its essential use quantity for 2006, reducing its previously authorised quantity to 1,702 tonnes. Thus TEAP made its own recommendations based on new information not available to MTOC.

In early 2005, the European Community submitted a revised essential use quantity for 2006, reducing its previously authorised quantity from 550 to 539 tonnes.

*Essential Use Nominations and Quantities for 2006 and 2007 (in tonnes)*

	<b>European Community</b>	<b>United States</b>	<b>Russian Federation</b>
<b>2006</b>	539	1,702	286
<b>2007</b>		1,493	243

1.1.4 *Observations on nominations*

1.1.4.1 Surplus CFCs and stockpile issues

Decision IV/25 states, in paragraph 1(b)(ii), that an essential use exemption can be given only if "*the controlled substance is not available in sufficient quantity and quality from existing stocks of banked or recycled controlled substances, also bearing in mind the developing countries' need for controlled substances.*" MTOC understands that the Protocol has not put any restrictions on pre-1996 stockpiles. However, Decision IV/25 implies that when a Party applies for an essential use exemption, it qualifies only for the amount that cannot be supplied from available stockpiles. In the context of Decision IV/25 and XVI/12, Parties may choose to deduct available pre-1996 stockpiles from essential use nominations and deduct an equivalent amount from allocations to companies holding pre-1996 stockpiles, prompting companies to exhaust pre-1996 stockpiles before seeking CFCs under the essential use exemption. Parties are requested to report in any future nomination the availability, quality and quantity of any pre-1996 stockpile.

MTOC is concerned that substantial amounts of unreported pre-1996 stocks appear at this final stage of the CFC MDI phase-out, and that one company has reported this information directly to MTOC rather than to the relevant nominating Party. One company wrote to MTOC explaining that 605 tonnes of pharmaceutical-grade CFCs was held in excess of quantities necessary for its essential use in CFC MDIs. That company stated that this material was

produced before the 1996 phase-out and was available for sale for essential use by other companies or qualifying Article 5(1) countries.

TEAP and its TOC understand that there are three options to resolve post-1996 surplus:

1. Transfer to an essential use authorised by Parties;
2. Transfer to an Article 5(1) country for basic domestic needs (with prior consent and accounting); and
3. Destruction in processes approved by the Montreal Protocol.

In this instance, TEAP and its TOCs query the significance that the quantity was produced prior to the 1996 phase-out. TEAP and its TOCs presume that any company that had received an essential use would have been required to use existing pre-1996 stock first. TEAP and its MTOC believes that if a company used an essential use quantity while in possession of pre-1996 material, then any pre-1996 surplus remaining at the end of a company's production of MDIs under essential use exemption should be treated as having been produced post-1996. If Parties adopted this interpretation, the deployment of the pre-1996 surplus in these circumstances would need to abide by the provisions of the Montreal Protocol that apply to post-1996 surplus (as outlined above).

MTOC believes that it is critical during the final stages of the phase-out of CFC MDIs that stockpiles of CFCs meeting quality requirements are utilised in preference to the production of newly produced CFCs. Thus, Parties may wish to consider flexible use of existing stock, and MDI manufacturers may wish to operate to ensure stockpiles are fully depleted at the time of phase-out.

#### 1.1.4.2 Maintaining flexibility for essential use exemptions and stockpile reductions

While considering this year's essential uses, MTOC wishes to bring to the attention of the Parties an unintended consequence of Decision XV/5, under which essential use recommendations and allocations are split between CFCs intended for use in salbutamol MDIs and CFCs intended for use in MDIs containing other active ingredients. This approach may have an unforeseen and detrimental effect during the phase-out of CFC MDIs, as it could deprive Parties of flexibility to manage essential use allocations and stockpile reduction. Parties may wish to consider the advantages of retaining the flexibility to transfer allocations and stockpiles between MDI manufacturers and between different active ingredients in order to minimise the requests for new CFC production.

### 1.1.5 *Committee Evaluation and Recommendations*

Quantities are expressed in metric tonnes.

#### 1.1.5.1 European Community

ODS/Year	Quantity
2006	539 tonnes*

\*The original exemption and quantity of 550 tonnes authorised by Parties in 2004, and subject to review, was revised to 539 tonnes in a new nomination submitted by the European Community in 2005.

*Specific Use:* MDIs for asthma and COPD

*TEAP and MTOC Recommendation:*

Recommend exemption for 539 tonnes.

*Comments*

Decision XVI/12 instructed MTOC to review quantities authorised under the essential use exemption for the European Community for 2006. Under a new nomination for 2006 from the European Community, the nominated quantity has been reduced from the previously authorised 550 tonnes to 539 tonnes, due to a revised estimate of needs. This compares with actual use of 1,188.5 tonnes reported for 2004 and is consistent with a continuing downward trend in CFCs used for MDIs manufactured in the European Community. The nomination includes 180 tonnes for the production of salbutamol CFC MDIs for export to the United States, and a further one tonne for export to other non-Article 5(1) countries.

The stockpile of 733 tonnes at the end of 2004 appears to be substantially higher than the projected need for 2006, noting that the European Community has reduced stocks in past years. Continued reduction in the stockpile is to be expected, noting the European Community's policy of maintaining no more than six to nine months' operational supply. The European Community has reported that its accounting framework records combined stockpile for pre- and post-1996 material.

MTOC also notes the details of the "*European Community Plan of Action to Phase-out CFC Salbutamol MDIs*" submitted to the Ozone Secretariat by the European Community on 15 February 2005. This document states that salbutamol is not considered an essential use of CFCs in all 25 European Union member states. However, there is a discrepancy between the plan of action and the 2006 nomination. The plan of action states that for 2006 forward, European Community nominations would contain requests for salbutamol solely for Article 5(1) countries, while the European Community's essential use nomination contradicted the plan by including a nomination for



181 tonnes for non-Article 5(1) countries, mainly for the United States' market. The European Community may wish to clarify this discrepancy prior to the OEWG meeting.

MTOC believes that the European Community might be able to provide the additional 181 tonnes intended for export from its available existing stockpile. Export from the European Community supplies about 18 percent of salbutamol CFC MDI use in the United States. MTOC recognises that if this were no longer available from the European Community, the shortfall would have to be made up either by imported HFC MDIs or by the manufacture of MDIs (HFC and/or CFC) in the United States.

The European Community has chosen not to submit a nomination for 2007 at this time, given the uncertainties in the transition two years hence. Given the uncertainties in the late stages of the transition, submitting nominations in the prior year, rather than two years prior, is appropriate.

In the context of Decision IV/25 and XVI/12, Parties may choose to deduct available pre-1996 stockpiles from essential use nominations and deduct an equivalent amount from allocations to companies holding pre-1996 stockpiles, prompting companies to exhaust pre-1996 stockpiles before seeking CFCs under the essential use exemption. Parties are requested to report in any future nomination the availability, quality and quantity of any pre-1996 stockpile. If the European Community chooses to make a nomination for essential uses for 2007 in 2006, MTOC requests that the nomination include the results of the European Community's survey along with information on stockpiles.

#### 1.1.5.2 Russian Federation

ODS/Year	Quantity
2006	286 tonnes
2007	243 tonnes

*Specific Usage:* MDIs for asthma and COPD

*TEAP Recommendation:*

Recommend upward revised exemption for 400 tonnes for 2006.

Unable to recommend exemption for 2007 at this time, with an assessment in 2006 if a nomination for 2007 is submitted by the Russian Federation.

*Comments*

MTOC was unable to comment as it had not received a response to its request to the Russian Federation for additional information in time for its meeting of

13-15 April 2005. However, during the TEAP meeting of 25-29 April 2005, additional information for the phase-out of salbutamol CFC MDIs was received which responded to this request. The Russian Federation reported on its plan of action, which was finalised in late 2004, and which will continue to be refined during 2005 and resubmitted to the Ozone Secretariat.

The Russian Federation reported actual use of CFCs in MDIs for 2003 and 2004 to be stable at about 330 tonnes, with only 98 tonnes in stockpile at the end of 2004. The nomination for 2006 is a significant reduction on the quantity exempted for 2004, and is about 15 percent below actual use in 2004. Stockpiles may be insufficient to guarantee adequate supply of MDIs and represent only four months operational supply in 2004. TEAP and MTOC are concerned that an adequate supply of medication must be available to patients in the Russian Federation.

TEAP therefore recommends an upward revised essential use exemption of up to 400 tonnes for 2006 to guarantee an adequate supply of CFCs. This would provide for one year's actual use, and augment the stockpile to about six months' operational supply.

Given the rapidly changing technical and economic environment in these final stages of transition, TEAP believes it would be better able to make its technical assessment in accordance with essential use Decisions if it could consider a nomination for 2007 in 2006. Therefore, TEAP is unable to recommend an exemption for 2007 at this time, with an assessment in 2006 if a nomination for 2007 is submitted by the Russian Federation.

#### 1.1.5.3 United States

ODS/Year	Quantity
2006	1,702 tonnes*
2007	1,493 tonnes

\*The original quantity of 1,900 tonnes authorised by Parties in 2004, and subject to review, was revised to 1,702 tonnes in a letter from the USEPA dated 25 April 2005 and received by TEAP during its meeting.

Specific Usage: MDIs for asthma and COPD

*TEAP Recommendation:*

Recommend downward revised quantity of 1,242 tonnes for 2006, minus any available pre-1996 stockpile that satisfies US regulatory requirements sold into the US market for use in MDIs, plus up to 180 tonnes if salbutamol CFC MDIs are not imported from the European Community in 2006.

Unable to recommend exemption for 2007 at this time, with an assessment in 2006 if a nomination for 2007 is submitted by the United States.

### *Summary of TEAP Findings*

Decision XVI/12 instructed TEAP to review the quantity authorised under the essential use exemption for the United States for 2006. During the TEAP meeting, the United States submitted a revised quantity of 1,702 tonnes, which reduced its previously authorised quantity for 2006 (1,900 tonnes). Also in 2005, the United States made a nomination for 2007 (1,493 tonnes).

In April 2005, the US Federal Drug Administration (FDA) issued its plan of action through its Rule on the Removal of Essential Use Designation for Salbutamol (Albuterol) MDIs, which sets an effective date for the removal of the essential use designation for salbutamol CFC MDIs on 31 December 2008.

The original 2006 and the 2007 nominations were submitted prior to the completion of the FDA Rule, and therefore assumed business-as-usual.

In its Rule, the United States indicates that it does not anticipate making an essential use nomination for CFCs for salbutamol MDIs in 2008.

The nominated quantity for 2006 (1,702 tonnes) is in excess of reported actual CFC use in 2004 (1,242 tonnes), which had been continuing a downward trend in use in recent years. TEAP concludes that actual CFC use in 2006 is not expected to exceed 1,242 tonnes, provided that 180 tonnes for salbutamol MDIs that is included in the European Community allocation is manufactured and exported to the United States. Export from the European Community currently supplies about 18 percent of salbutamol CFC MDI use in the United States. TEAP recognises that if this were no longer available from the European Community, the shortfall would have to be made up either by imported HFC MDIs or by the manufacture of MDIs (HFC and/or CFC) in the United States.

Four alternative salbutamol HFC MDIs are approved in the United States with one being available for over ten years. It may require 18 months for HFC MDI manufacturers to have production ramped up to meet the requirements of the United States' MDI market. If manufacturers took the immediate decision to transition production, the majority of CFC use for salbutamol CFC MDIs in the United States could be phased-out by the end of 2006.

Decision IV/25 states in paragraph 1(b)(ii) that the essential use exemption can be permitted only if "*the controlled substance is not available in sufficient quality and quantity from existing stocks of banked or recycled controlled substances, also bearing in mind the developing countries need for controlled substances*".

The United States has reported its CFC stockpile in its accounting framework to be 1,521 tonnes at the end of 2004. This figure does not include pre-1996 stockpile. The United States has allocated an amount of 1,766 tonnes for use

in 2005. Assuming actual use would be the same in 2005 as in 2004, and assuming the full allocated amount would be acquired, the projected stock at the end of 2005/start of year 2006 would be 2,045 tonnes (about 20 months use). For 2006, if the United States were authorised and acquired an essential use allocation of 1,242 tonnes, then its stockpile at the end of 2006 would remain at 2,045 tonnes. In 2007, if actual use were assumed to be the same, even with no allocation, the end of year stockpile would be about 800 tonnes. This stockpile should be adequate to complete salbutamol CFC MDI phase-out in 2008 and provide an adequate operational supply for remaining non-salbutamol CFC MDIs, even if no pre-1996 stockpile is taken into account. This assumes that 180 tonnes for salbutamol MDIs would be included in the European Community allocation, manufactured and exported to the United States. Export from the European Community currently supplies about 18 percent of salbutamol CFC MDI use in the United States. If this were no longer available from the European Community, the shortfall would have to be made up either by imported HFC MDIs or by the manufacture of MDIs (HFC and/or CFC) in the United States.

*Scenario of projected quantities of CFC use and stockpile in the United States 2005-2007*

<b>Year (1 Jan)</b>	<b>Stockpile (A)</b>	<b>Allocated amount (B)</b>	<b>Total available (C)=(A+B)</b>	<b>Projected Use (D)</b>	<b>Projected Stock at year end (C-D)</b>
2005	1,521	1,766	3,287	1,242	2,045
2006	2,045	1,242	3,287	1,242	2,045
2007	2,045	0	2,045	1,242	803

In response to a TEAP request, the United States reported in 2004 and 2005, separate to its accounting framework, an additional 400 tonnes of pre-1996 stockpile. During the MTOC meeting, one company provided a letter reporting an additional 605 tonnes of pre-1996 stockpile. In a letter to TEAP dated 25 April 2005, subsequent to the MTOC meeting, the United States confirmed that it had been aware that the company reporting a surplus was in possession of inventory, though not the precise amount or whether it would be available to manufacture MDIs needed by United States' patients.

Although TEAP understands that there may be some uncertainty regarding the availability and quality of this pre-1996 stockpile, it believes that the existence of more than 1,000 additional tonnes of CFCs provides further assurance that nominations need not exceed the amount actually used in 2004. In the context of Decision IV/25 and XVI/12, Parties may choose to deduct available pre-1996 stockpiles from essential use nominations and deduct an equivalent amount from allocations to companies holding pre-1996 stockpiles, prompting companies to exhaust pre-1996 stockpiles before seeking CFCs under the

essential use exemption. Parties are requested to report in any future nomination the availability, quality and quantity of any pre-1996 stockpile.

Certain additional safeguards provide further assurance regarding a recommendation for an essential use allowance not exceeding actual use in 2004:

- The United States can make a nomination for 2007 in 2006 if needed; and
- CFC MDI use in 2006 and 2007 is likely to be less than actual use in 2004.

This approach provides flexibility and more than adequate CFCs to allow a safe transition towards the United States' phase-out date of the end of 2008 for salbutamol CFC MDIs.

Given the rapidly changing technical and economic environment in these final stages of transition, TEAP believes it would be better able to make its technical assessment in accordance with essential use Decisions if it could consider a nomination for 2007 in 2006. Therefore, TEAP is unable to recommend an exemption for 2007 at this time, with an assessment in 2006 if a nomination for 2007 is submitted by the United States.

#### *MTOC Comments*

#### *United States Rule on Essential-Use Designation for Salbutamol (Albuterol) MDIs*

The US Food and Drug Administration (FDA) issued its Rule on the Removal of Essential-Use Designation for Salbutamol (Albuterol) MDIs in April 2005. Under United States' law and regulations, the FDA determines essentiality of CFC use for medical products for the United States. Consistent with the expectations of the Montreal Protocol under Decision XV/5(5) to provide to the Ozone Secretariat a salbutamol plan of action, the FDA, on 4 April 2005, published a final rule on the removal of the essential use designation for CFC salbutamol MDIs (Federal Register Vol. 70 No. 63 April 4, 2005). The final rule sets an effective date for the removal of the essential use designation for salbutamol CFC MDIs on 31 December 2008. FDA based its choice of this effective date on its conclusion that a period of time until that date is needed to ensure adequate production capacity for salbutamol HFC MDIs, considering that this date is the last day that salbutamol CFC MDIs can be legally sold in the United States.

Below is a summary of the key issues:

- The FDA final rule on the essential use designation applies to salbutamol CFC MDIs, which account for 70 percent of the total CFC use for MDIs in

the United States. The rule noted that there were two salbutamol non-CFC MDIs that had been marketed in the United States for more than three years and one product was approved in 2004. In addition, a fourth product was recently approved. However, under the particulars of the United States' rulemaking process, only the first two products were considered as acceptable alternatives to salbutamol CFC MDIs, as there is not sufficient United States post-marketing data on the products approved more recently.

- Oral and written statements by GlaxoSmithKline, Ivax and Schering-Plough/3M during the rule-making process stipulated that adequate HFC MDI production would be available by the end of 2005. The December 2005 date proposed by the companies was a projected date. The FDA noted in its decision that no specific time lines, construction and installation schedules were provided. Therefore the FDA chose December 2008 as the effective date for the rule with the expectation that this production capacity would be in place by that date (page 17173).
- The final rule contains an extensive analysis of potential impact on patients and concluded that patients would be adequately served by available salbutamol CFC-free alternatives.
- The FDA final rule does not regulate the process by which the companies will reduce salbutamol CFC MDI production, but only sets the final phase-out date. The rule further indicated that due to possible inventory the United States does not anticipate making an essential use application for salbutamol in 2008 (page 17186).

MTOC considers the FDA final rule to be a positive step towards a complete phase-out of CFC-containing MDIs and anticipates a rapid, safe transition within the projected time period.

#### *Dynamics in the United States salbutamol market*

Two companies (Schering Plough (~61 percent) and IVAX (~28 percent)) dominate the salbutamol CFC MDI market in the United States (IPAC 2005). Schering Plough (SP) has had a marketing agreement with 3M to sell salbutamol HFC MDIs since the mid 1990s. SP markets in parallel both branded salbutamol CFC MDIs (Proventil) and branded salbutamol HFC MDIs (Proventil HFA, launched in 1996), and also through its subsidiary Warrick, generic salbutamol CFC MDIs.

IVAX has manufactured salbutamol CFC MDIs in Ireland for sale in the United States, with CFCs obtained under the European Community's essential use exemption. IVAX also received approval in 2004 for a salbutamol HFC MDI, which is now on sale in the United States.

CFCs for the United States' MDI market have been produced from the Honeywell plant in Weert, Holland, which is scheduled to close at the end of 2005. Honeywell has announced its intention to start production of CFC-11

and -12 at a plant in the United States that currently produces only CFC-113 and -114. MTOC believes that there are likely to be sufficient stockpiles of pharmaceutical-grade CFC available to make unnecessary the new production of CFC-11 and -12 at the facility in the United States.

If SP and IVAX took the immediate decision to transition their production, this would result in an approximate 90 percent reduction in CFC volumes for salbutamol MDI use in the United States (equivalent to ~900 tonnes of CFC). Eighteen months may be required for HFC MDI manufacturers to have their production capacities ramped up to meet the requirements of the United States' MDI market. Thus, both companies could achieve complete cessation of salbutamol CFC MDI manufacture by the end of 2006. The declining salbutamol CFC MDI production in 2006 could be managed from existing stockpiles. This would accelerate the phase-out of CFCs for salbutamol MDIs in the United States during 2006.

MTOC remains very concerned that companies continue to request essential use quantities for CFCs when they also manufacture HFC MDI alternatives for salbutamol. This contrasts with the approach followed by GSK, which ceased production and distribution of its salbutamol CFC MDI after launching its salbutamol HFC MDI alternative.

*MTOC comments on the review of authorised essential use quantities and nomination for the United States for 2006 and 2007*

Under its new Rule, the United States is regulating sales and not production, which means that from 31 December 2008 any unsold salbutamol CFC MDIs would have to be destroyed. Any excess essential use CFCs for MDI production remaining at the end of 2008 would either have to be transferred to another Party with remaining essential uses, or to an Article 5(1) country to offset production for basic domestic needs, or be destroyed.

The United States, as all other nominating Parties, has consistently requested an amount of CFCs that is in excess of its actual needs. Parties have their own internal mechanisms to allocate only the actual CFC requirements between MDI manufacturers.

Nevertheless, the quantity of CFCs authorised for essential use in the United States for 2006 and subject to review (1,900 tonnes) is well in excess of the actual use documented in the accounting framework of 2004 (1,242 tonnes). It is significant that this quantity was authorised before the final FDA rule for salbutamol MDIs was issued in April 2005 and assumes a business-as-usual scenario (no change from the amount requested for the year 2005).

The MTOC considered a range of options regarding the quantities under review for 2006 and the 2007 nomination for the United States. Given the rapidly changing technical and economic environment in these final stages of

transition, MTOC believes it would be better able to make its technical assessment in accordance with essential use Decisions if it could consider a nomination for 2007 in 2006. The United States can make a revised nomination for 2007, if needed, in 2006.

Serious consideration was given to the option of revising the essential use quantity in 2006 to zero tonnes. MTOC believes that this option could be achieved in the context of a phase-out of salbutamol CFC MDIs in the United States following the FDA rule, which prohibits sales of salbutamol CFC MDIs after 31 December 2008. However, there are a number of factors and uncertainties that reduce the flexibility that will be required for a smooth phase-out of salbutamol CFC MDIs in the United States. In particular, there is uncertainty in the size, quality, and availability of the stockpile, including a significant quantity of recently reported pre-1996 stockpiles. Furthermore, currently it is difficult to project the trajectory of the phase-out of salbutamol CFC MDIs in the United States over the next two years, prior to the cessation of sales in 31 December 2008.

Due consideration was given to the option of recommending no change to the original authorised quantity for 2006 (1,900 metric tonnes). However MTOC finds that at this final stage in the phase-out there is no technical or economic justification to grant essential use nominations higher than actual use in 2004 (1,242 tonnes). Furthermore, the company reporting surplus CFCs has indicated a willingness to sell its pre-1996 stockpile of 605 metric tonnes for use by other MDI manufacturers (under certain commercial conditions). MTOC took into account available information on the inventory of surplus CFCs in determining essential use volumes, to keep with Decisions IV/25 and XVI/12, par 3.

In addition to the recently reported 605 tonnes of pre-1996 material, the United States has reported to MTOC an additional 400 tonnes of pre-1996 material. Parties are requested to report in any future nomination the quantity, quality and availability of any pre-1996 stockpiled material that has not been included in the accounting framework. This information will allow future MTOC evaluations to abide by the provisions of the essential use exemption.

Below are some scenarios considered by MTOC. Scenarios were used as a modelling tool by MTOC to consider a range of possibilities as part of its technical assessment. The scenarios used available information on reported use and stockpiles (as provided in accounting frameworks), pre-1996 stockpiles (as reported by the United States and one company) and the licensed allocation of CFCs in the United States for 2005 (publicly available information). By using different assumptions for each scenario, different possible outcomes were considered for coming years, and assisted MTOC to assess certain technical parameters and variables in accordance with Decisions IV/25 and XVI/12, par. 3.



*Scenario 1: Essential Use Allocation revised to 0 tonnes for 2006*

<b>Year (1 Jan)</b>	<b>Stockpile (A)</b>	<b>Allocated amount (B)</b>	<b>Total available (C)=(A+B)</b>	<b>Projected Use (D)</b>	<b>Projected Stock at year end (C-D)</b>
2005	1,521 + 605	1,766	3,892	1,242	2,650
2006	2,650	0	2,650	1,242	1,408
2007	1,408	0	1,408	1,242	166

Assumptions:

- Includes 605 tonnes of pre-1996 material in the stockpile calculations;
- Does not include additional 400 tonnes of pre-96 material;
- Assumes full allocations are taken by companies in 2005;
- Assumes United States' use will not increase (i.e. some salbutamol CFC MDI still imported from Europe in 2006/2007), but will not decrease (i.e. worst case);
- Zero tonnes approved for 2006 and 2007; and
- No nomination for salbutamol CFC MDIs in 2008.

In scenario 1, no allocations are made for 2006 and 2007. This scenario assumes that the stockpile of 605 tonnes of CFCs reported to the MTOC will be available in its entirety to United States' patients. It can be seen that there would be an adequate stockpile at the end of 2006 but not at the end of 2007. In addition, zero allocation may not provide the flexibility required for companies that have no allocation and inadequate stockpiles. This might jeopardise the availability of CFC MDIs to patients during the transition.

*Scenario 2: Essential Use Allocation revised to 637 tonnes for 2006 (1,242 tonnes actual use minus 605 tonnes)*

<b>Year (1 Jan)</b>	<b>Stockpile (A)</b>	<b>Allocated amount (B)</b>	<b>Total available (C)=(A+B)</b>	<b>Projected Use (D)</b>	<b>Projected Stock at year end (C-D)</b>
2005	1,521 + 605	1,766	3,892	1,242	2,650
2006	2,650	637	3,287	1,242	2,045
2007	2,045	0	2,045	1,242	803

Assumptions:

- Same as Scenario 1 except 637 tonnes approved for 2006.

In scenario 2, a revised allocation of 637 tonnes in 2006 and zero tonnes in 2007 appears to provide adequate stockpiles to the end of 2008. The stockpile

at the end of 2007 would provide more than one year's operational supply for non-salbutamol CFC MDIs should they still be essential at that time. This scenario assumes that the stockpile of 605 tonnes of CFCs will be available in its entirety to United States' patients.

*Scenario 3: Essential Use Allocation revised to 1,242 tonnes for 2006*

Year (1 Jan)	Stockpile (A)	Allocated amount (B)	Total available (C)=(A+B)	Projected Use (D)	Projected Stock at year end (C-D)
2005	1,521	1,766	3,287	1,242	2,045
2006	2,045	1,242	3,287	1,242	2,045
2007	2,045	0	2,045	1,242	803

Assumptions:

- Does not include additional 1,005 tonnes of pre-1996 material;
- Assumes full allocations are taken by companies in 2005;
- Assumes United States' use will not increase (i.e. some salbutamol CFC MDI still imported from Europe in 2006/2007), but will not decrease (i.e. worst case);
- Zero tonnes approved for 2007; and
- No nomination for salbutamol CFC MDIs in 2008.

In scenario 3, the stockpile at the end of 2007 is adequate to complete salbutamol CFC MDI phase-out in 2008 and provide an adequate operational supply for remaining non-salbutamol CFC MDIs. This scenario does not rely on pre-1996 stockpiles.

*Scenario 4: Essential Use Allocation unchanged for 2006 (1,900 tonnes) and approved for 2007 tonnes (1,493 tonnes) and includes all pre-1996 stockpile*

Year (1 Jan)	Stockpile (A)	Allocated amount (B)	Total available (C)=(A+B)	Projected Use (D)	Projected Stock at year end (C-D)
2005	1,521 + 1,005	1,766	4,292	1,242	3,050
2006	3,050	1,900	4,950	1,242	3,708
2007	3,708	1,493	5,201	1,242	3,959

Assumptions:

- Includes all pre-1996 stockpile;

- Assumes full allocations are taken by companies in 2005, and full allocations provided for 2006 and 2007, which has never happened in the past;
- Assumes United States' use will not increase (i.e. some salbutamol CFC MDI still imported from Europe in 2006/2007) but will not decrease (i.e. worst case); and
- No nomination for salbutamol CFC MDIs in 2008.

In scenario 4, stockpile increases year-on-year. The stockpile at the end of 2007, of close to 4,000 tonnes, is well in excess of operational supply requirements for non-salbutamol CFC MDIs (current actual use estimated to be about 400 tonnes per year). This would mean that at the end of 2007 close to 3,500 tonnes of CFCs may have been produced that were not required. The same calculations were made assuming that only 57 percent of the amount exempted was allocated in 2006 and 2007 (the previous 10-year average of the amount acquired compared with the amount exempted). Even in this case stockpiles would be about 1,740 tonnes by the end of 2007.

*MTOC conclusion:*

Given the size of the combined pre- and post-1996 stockpile, MTOC recommended a revised quantity of 637 tonnes be approved for 2006 (1,242 of actual use minus the pre-1996 stockpile of 605 tonnes). Together with effective management of existing stocks, this should allow adequate provision of CFC MDIs in the United States during the transition. MTOC was unable to recommend the nomination for 2007. (*Note: TEAP recommendation updates this conclusion, based on the letter sent by the United States during the TEAP meeting.*)

*TEAP recommendation:*

Given the uncertainties surrounding pre-1996 stockpiles outlined by the United States in its letter dated 25 April 2005, TEAP recommends a downward revised quantity of 1,242 tonnes for 2006 minus any available pre-1996 stockpile which satisfies US regulatory requirements sold into the US market for use in MDIs plus up to 180 tonnes if salbutamol CFC MDIs are not imported from the European Community in 2006.

Given the rapidly changing technical and economic environment in these final stages of transition, TEAP believes it would be better able to make its technical assessment in accordance with essential use Decisions if it could consider a nomination for 2007 in 2006. Therefore, TEAP was unable to recommend an exemption for 2007 at this time, with an assessment in 2006 if a nomination for 2007 is submitted by the United States.



## **2 Medical Technical Options Committee (MTOC) Progress Report**

### **2.1 Update of the Handbook on Essential Use Nominations**

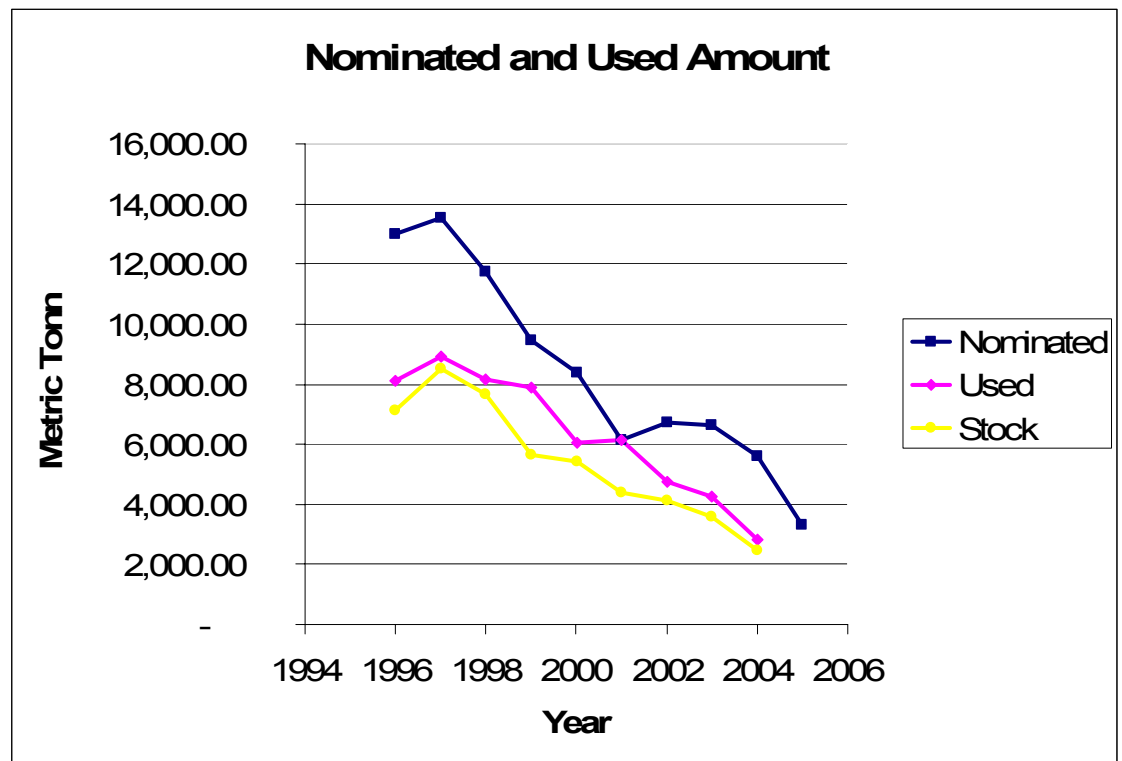
Decision XV/5(9) requests the TEAP to “*modify the Handbook on Essential Use Nominations to reflect the present decision.*” TEAP has responded to this request and has provided an updated Handbook on Essential Use Nominations. The updated Handbook responds to all new Decisions that post-date the last revision in 2001.

### **2.2 Progress Report**

#### *2.2.1 Trends in CFC consumption for MDI production*

The figure below shows the use of CFCs for the production of MDIs for asthma and chronic obstructive pulmonary disease (COPD) in non-Article 5(1) countries. It includes exemptions for the Russian Federation and Ukraine after 2002, hence the increase in the exempted amount for that year. In 2004, 2,841 tonnes of CFCs were used in the manufacture of MDIs under essential use exemptions, as reported through accounting frameworks. The downward trend in CFC use for MDIs continues and is roughly parallel to the decrease in stocks.

Figure 2-1: Quantities relating to the use of CFCs for the production of MDIs



For 2006, CFCs for the manufacture of salbutamol MDIs still account for the major portion of essential use nominations for the Russian Federation and the United States. The FDA final Rule on the essentiality of salbutamol CFC MDIs will change this situation for the United States between now and the end of 2008. A sizeable portion of the European Community's essential use nomination is intended to supply the United States. It should be noted that no nomination was received from the Ukraine for 2006. The Ukraine's last exemption was granted for 2005.

Technically satisfactory HFC alternatives to CFC MDIs are available for short-acting beta-agonists and other therapeutic categories for asthma and COPD. The availability of CFC stocks coupled with these alternatives assures patient safety during the transition.

The management of stockpiles at this last stage of the phase-out will be extremely important to avoid unnecessary production of essential use CFCs. Parties may wish to remind CFC MDI producers that any CFCs obtained under essential use exemptions must be used for the essential uses (including through a transfer), transferred to an Article 5(1) country for basic domestic

need, or destroyed. MTOC is concerned that some users may try to circumvent this rule by claiming that their remaining stockpiles are pre-1996.

### 2.2.2 *Transition to alternatives to CFC MDIs*

There is widespread availability of salbutamol (short-acting beta-agonist) HFC MDIs in developed countries, with more than one version available in over 30 countries. Also, the introduction and acceptance of multi-dose powder inhalers has continued. However, it is clear from accumulating experience that the development of HFC MDIs, their registration and, in particular, their launch into a market cannot alone lead to a full uptake in the market without additional regulatory action.

Use of CFC for salbutamol MDIs has now been declared non-essential in all twenty-five member states of the European Union and, in fifteen member states, all other short-acting beta-agonists as well. In the ten remaining states, a variety of short-acting non-salbutamol beta-agonists (terbutaline, fenoterol, orciprenaline, reproterol, carbuterol, hexoprenaline, pirbuterol, clenbuterol, bitoterol, and procoterol) are still available. The European Community is undertaking a survey on the state of transition within the member states for CFC MDIs other than for the short-acting bronchodilators. In the European Union, alternative products continue to be introduced for a variety of drugs. For instance, a novel, non-propellant multi-dose inhaler to deliver a combination of fenoterol and ipratropium bromide has entered the market in Germany. Additionally, two multi-dose dry powder inhaler (DPI) formulations of combinations of long-acting beta-agonists with inhaled steroids are widely available in the European Union and a new multi-dose DPI containing an inhaled corticosteroid (mometasone furoate) has been approved.

In the United States, where there are now four approved salbutamol HFC MDIs (including a levalbuterol product), salbutamol CFC MDIs will be declared non-essential and will not be marketed after 31 December 2008. Bitoterol, dexamethasone, and terbutaline CFC MDIs have been discontinued with no CFC-free alternatives marketed. In the United States, fluticasone, beclomethasone and salmeterol are now only available as CFC-free products. An ipratropium bromide HFC MDI was recently approved, as was the multi-dose DPI mometasone furoate product and a single capsule DPI containing tiotropium.

Australia has undertaken a number of initiatives to complete transition. These initiatives included an assurance that there were no financial disincentives to the introduction or use of CFC-free alternatives, that companies which imported or manufactured CFC products reported their investigative efforts to identify CFC-free alternatives, and that companies given exemptions demonstrated progress towards introducing CFC-free alternatives. In response, the two companies that previously held exemptions for CFC MDIs

committed to seeking approval for CFC-free alternatives in order to replace all CFC MDI versions no later than 2006.

In Japan, the production and importation of CFC MDIs ceased as of the end of 2004, in accordance with Japan's transition strategy. A total of 22 CFC-free alternatives and new inhalers, which cover the range of existing CFC MDIs, has already been introduced to the Japanese market. Fourteen products are HFC MDIs, 6 products are multi-dose DPIs and 2 products are single-dose DPIs. In addition, 2 multi-dose DPIs of an existing beta-agonist were approved for marketing by April 2005. It is expected that the full transition to CFC-free alternative products will therefore be completed by the end of 2005.

### 2.2.3 *Transition Strategies*

Transition strategies from nine Parties are listed on the UNEP web site. In addition, MTOC is aware that the Philippines' transition strategy was issued during 2004, establishing phase-out dates for salbutamol CFC MDIs by the end of 2007 and for all other CFC MDIs by the end of 2010. The transition strategy establishes provisions for exemptions from the end dates, provided there are compelling health reasons and in the absence of a marketed alternative for that product. Some other Parties, e.g. Brazil, are developing their transition strategies.

Furthermore, plans of action in response to Decision XV/5, for the phase-out of the domestic use of CFC-containing metered dose inhalers where the sole active ingredient is salbutamol, have been submitted by the United States, the European Community and the Russian Federation.

### 2.2.4 *Article 5(1) countries and CEIT*

As in much of the world, prevalence of asthma and COPD in Article 5(1) countries and CEIT continues to rise, leading to greater demand for treatment. An increasing proportion of this treatment is being met with inhaled therapy. This has resulted in a greater use of CFC MDIs.

As mentioned in last year's report, issues surrounding CFC MDIs in CEIT are complex. The MTOC does not have sufficient information for many of these countries to make a full and reasonable assessment of the state of transition, nor to make reasonable technical recommendations on how to assure an effective transition. MTOC notes that at least four CEITs were known to have been producing CFC MDIs, and two of these (Poland and Hungary) are now part of the European Union. Hungary reported two years ago that it is no longer producing CFC MDIs. The Russian Federation has a plan of action. The Ukraine has neither submitted a transition strategy nor a nomination for 2006.



Information on the current use and trends in inhaled therapy in Article 5(1) countries and CEIT were obtained from MTOC members and other sources.

#### 2.2.4.1 Africa

The total population in Africa is approximately 800 million, 42 percent of whom are less than 15 years old. The average prevalence of asthma is in the range of 3 to 5 percent but COPD is rare (tobacco smoking rates range from 2 to 20 percent). With increasing urbanisation, asthma prevalence is increasing (for example it has almost doubled in Ghanaian schoolchildren in last 10 years from 3.1 to 5.2 percent). It is estimated that there are 40 million patients suffering from asthma/COPD.

Oral medications (salbutamol and theophylline) are the mainstay of therapy and few patients can afford inhaled therapy. MDIs come from multinational pharmaceutical companies (no local manufacturer), and the cost of a salbutamol CFC MDI is ~US\$5. DPI use is uncommon and some DPIs are unsuitable for the climatic conditions.

South Africa provides a special case; asthma/COPD rates are higher, but with increasing affluence, a significant proportion of patients can afford MDIs and inhaled therapy is important.

#### 2.2.4.2 Brazil

The population of Brazil is 180 million. The prevalence of asthma is ~10 percent and of COPD is ~6 percent, and both are increasing.

Approximately two thirds of patients take oral medications, and the rest rely on inhaled therapy using primarily MDIs. Local production by multinational and Brazilian local manufacturers accounts for less than 5 percent of total MDIs with the majority being imported.

MDI transition is underway and being co-ordinated by the Ministry of Health. One salbutamol HFC MDI and several different drugs in a variety of DPIs are on the market.

#### 2.2.4.3 China

China has a population of 1.3 billion. The combined prevalence of asthma/COPD is approximately 3 percent, which are 40 million patients. Oral and injectable beta-agonists and theophyllines are the main medications, and inhaled therapy is not popular.

Domestic manufacturers make ~12 million MDIs per year (using about 380 tonnes of CFCs as estimated by the TEAP Replenishment Task Force) and 2 million are imported from multinationals. DPIs are mainly imported by

multinationals with local manufacture of only 10 million individual dose capsules per year.

In addition, there are 16-20 million topical aerosols mainly used for traditional Chinese medicines, which use 800 tonnes of CFCs.

The barriers to transition from CFCs in MDIs and topical sprays are the lack of funding for R&D of alternatives, rather than technical barriers or barriers due to the cost of manufacturing equipment.

#### 2.2.4.4 India

India has a population of approximately 1.1 billion, 32 percent of whom are less than 15 years old. The prevalence of asthma is in the range 5 to 10 percent, and of COPD is less common at approximately 0.4 percent, that is ~50 to 100 million patients with asthma/COPD. Most patients take inexpensive oral medications, and only ~2 percent (2 million) patients use inhaled medications (1.5 million MDI, 0.5 million DPI).

A salbutamol MDI (200 inhalations) costs Rs 80 (US\$2). A local manufacturer introduced a salbutamol HFC MDI, which cost 85 Rs, but it achieved low sales and has been withdrawn. Inexpensive single dose DPIs would be a valuable CFC-free alternative.

#### 2.2.4.5 Russian Federation

The population of the Russian Federation is approximately 144 million.

Based on surveys, the prevalence of asthma is ~4 percent and COPD is 1.3 percent, although these are likely to be underestimates, and there are likely to be ~10 million patients with asthma/COPD.

Currently 20 million MDIs are used per year. Indicative purchase costs are as follows: locally produced salbutamol CFC MDI 30 roubles (US\$1); imported HFC MDI (GlaxoSmithKline, Ivax-Norton) 120 roubles (US\$4); and locally manufactured DPI 120 roubles (US\$4). The market share is approximately 72 percent locally manufactured and 28 percent multinational imported products.

#### 2.2.4.6 Philippines

The Philippines announced a transition strategy in 2004.

### **3 Foams Technical Options Committee (FTOC) Progress Report**

#### **3.1 General**

This update is the second foam sector review published since the 2002 Report of the Flexible and Rigid Foams Technical Options Committee, issued in May 2003. It highlights changes in technology and transition that have occurred in the last year. The key conclusions from this update report are as follows:

##### CFC Transition Issues (Developing Countries)

- Virtually all individually funded MLF foam projects are technically complete, but some CFC-11 phase-out under National Plans is still on-going. Nevertheless, the transition out of CFC-11 has virtually been achieved (remaining usage <5%).
- CFC-11 prices have increased during the last year in line with the removal of key manufacturing capacity. Prices are now at, or above, the levels of HCFC-141b, except in those regions where a combination of local production and poor distribution control still exists.
- In some countries, further expansions in foam manufacturing capacity at SMEs are taking place using HCFC-based technologies for cost reasons, even where the original MLF funded projects were based on hydrocarbons.

##### HCFC Transition Issues (Developed Countries)

- HCFC-141b phase-out in the foam sector has been delayed in some countries by the use of stockpiled materials through 2004. However, stocks are now virtually exhausted.
- The reliance on limited manufacturing sites for the supply of key HFCs (e.g. HFC-365mfc) is continuing to cause difficulties in foam markets and, in some regions, has been challenging the transition out of HCFCs.
- In other cases, such as that of HFC-245fa, regional patent restrictions have the potential to compound the problem further.
- Even for products manufactured at multiple sites (e.g. HFC-134a), recent shortages have served to highlight the on-going vulnerability of the foam industry both in developed and developing countries. Future transitions from ozone depleting substances are likely to become more challenging unless further capacity is installed in the interim. The investment climate is currently being affected by uncertainties over the form of regulation being adopted on HFCs in some regions of the world.
- The use of blends continues to proliferate in order to make best use of the available HFC supply and to limit the impact on foam formulation costs.

- There has been heightened international attention on the adoption of responsible use criteria for HFCs in foams during 2004. Nonetheless, political pressure to control the use of HFCs is increasing in some regions.

#### Other relevant product and market issues

- Growth is well in excess of GDP in several foam markets as insulation levels increase to save energy and the efficiency of foams becomes more widely recognised in spite of blowing agent transition.
- In domestic refrigerators and freezers, product design improvements have more than compensated for deficiencies in the basic thermal insulation performance of some of the alternative blowing agents.
- The focus on foam end-of-life issues continues as consideration is given to the management of blowing agent banks. However, practicality and economic viability of recovery and destruction of ozone depleting substances varies across foam sectors and regions.
- Choices in technology remain limited in flexible box foam applications. In many countries, the use of methylene chloride remains the only viable option. Other technologies are either limited in regional availability, complicated in processing or economically non-viable.
- Other blowing agent options continue to emerge, amongst which Ecomate (a proprietary formulation based on methyl formate) and trans-1,2-dichloroethylene are the latest. The incremental value of these new options continues to be evaluated.

### **3.2 Technology Status**

The following table illustrates the main substitute technologies currently considered in the polyurethane, extruded polystyrene/polyolefin and phenolic foam sectors.

**FOAMS TOC UPDATE REPORT 2005 MAIN TECHNICAL OPTIONS TABLE**

SECTOR	DEVELOPED COUNTRIES	DEVELOPING COUNTRIES		COMMENTS
	CURRENT/FUTURE	CURRENT	FUTURE	
<b>POLYURETHANE RIGID</b>				
Domestic refrigerators and freezers	HCs (cyclopentane & cyclo/iso pentane blends), HFCs	Residual CFC-11, HCFC-141b & HCs	HCFC-141b, HFCs & HCs	HFC-134a & HFC-245fa mainly for the North American market
Other appliances	HCs, HFCs	Residual CFC-11, HCFC-141b & HCs	HCFC-141b & HCs	
Transport & reefers	HCs, HFCs	HCFC-141b, HCFC-22*	HCFC-141b, HCFC-22 HFCs & HCs	*Potentially HFCs but no known use
Boardstock	Mainly HCs, minor use of HFCs	No known production Art 5.1	NA	HFC for stringent product fire standards.
Panels – continuous	Mainly HCs, some HFCs	Residual CFC-11, HCFC-141b & HCs	HCFC-141b & HCs	HFC for stringent product fire standards
Panels discontinuous	Residual HCFC-141b, HFCs, some HC	Residual CFC-11, HCFC-141b	HCFC-141b & HFCs	HFCs, not HCs, for SMEs
Spray	Residual HCFC-141b, HFCs, CO <sub>2</sub> , (HC)	Residual CFC-11, HCFC-141b	HCFC-141b & HFCs	Use of HCs limited to North America
Blocks	Residual HCFC-141b, HCs, HFCs,	Residual CFC-11, HCFC-141b	HCFC-141b & HFCs	HC use increasing
Pipe-in-pipe	Mainly HCs, residual HCFC-141b	Mainly HCFC-141b	HCFC-141b & HCs	Cyclopentane is main HC
One Component Foam	Mainly HCs, some HFCs	Minimal use in Art 5.1	Mainly HCs, some HFCs	HC use driven by cost
<b>POLYURETHANE FLEXIBLE</b>				
Slabstock & block-foam	LCD, EMT, methylene chloride	Methylene chloride, (LCD)	Methylene chloride, LCD, (EMT)	Methylene Chloride is less preferred owing to perceived occupational health risks
Moulded	Mainly CO <sub>2</sub> (water)	Residual CFC-11 (?), mainly CO <sub>2</sub> (water)	Mainly CO <sub>2</sub> (water)	CO <sub>2</sub> (water) is industry standard
Integral Skin	CO <sub>2</sub> (water), HFCs	Residual CFC-11 (?), CO <sub>2</sub> (water), some HCFCs	CO <sub>2</sub> (water), some HCFCs	
Shoe Soles	CO <sub>2</sub> (water), HFCs	CO <sub>2</sub> (water), HFCs	CO <sub>2</sub> (water), HFCs	HFC-134a used primarily
<b>PHENOLIC</b>				
Board & block	Mainly HFCs, some HCs (particularly in Japan)	HCFC-141b	HCs	HFCs are used to retain fire performance in some markets
<b>EXTRUDED POLYSTYRENE</b>				
Sheet	HCs	Mainly HCs		Some safety issues in Art 5.1 countries
Boardstock	HCFC-142b, HFC-134a, HFC-152a, CO <sub>2</sub> , CO <sub>2</sub> /ethanol, (HCs in Japan)	Mainly HCFC-142b, some HCFC-22	HCFC-142b, HFC-134a, CO <sub>2</sub> , blends of CO <sub>2</sub> /ethanol	HCFC-142b use in North America until 2010. Final choice is end-product specific
<b>POLYOLEFIN</b>				
Sheets, planks & tubes	HCs (iso-butane & LPG)	Mainly HCs		Some safety issues in Art 5.1 countries

### 3.3 Regional Developments

#### 3.3.1 *Developed Countries*

The transition from HCFC-based technologies is continuing in developed countries although there are still some notable areas of continued use in the United States, Canada and Australia. In North America, the major continuing use is in extruded polystyrene (mostly HCFC-142b). There is also some minor continuing use of HCFC-22 in PU foams for reefers, panels and doors under the current regulatory provisions within the United States. However, both the PU and XPS sectors are expected to phase-out usage by 2010.

Hydrocarbon technologies have been adopted for a wide range of applications and are already established as the most widespread family of blowing agents in use, despite initial flammability concerns in both product and process. Debate continues over whether hydrocarbons will ultimately be a comprehensive replacement technology for the remaining market segments (e.g. continuous & discontinuous panel, spray).

In North America, HFCs are considered necessary to successfully transition from HCFCs, particularly for extruded polystyrene. This is in contrast to the situation in Japan where specific fire tests permit the use of hydrocarbons. HFC-134a is also expected to be retained in those extruded polystyrene products requiring high thermal performance in Europe.

For PU spray foams, commercialisation of hydrocarbon technologies is in its early stages in parts of the United States. Although the main motivation continues to be economic, recently expressed concerns over the use of HFC-245fa systems in the hot climates of the South West States have added to the industry's uncertainties. Similar concerns have also been expressed by PU spray foam contractors in Spain where the forced change from HFC-365mfc to HFC-245fa on the back of supply problems has been reported to cause technical problems in the Spanish climate. In contrast, however, there is clear evidence from both blowing agent suppliers and PU Systems Houses that such issues can be, and have been, managed successfully. Meanwhile, both Europe and Japan remain opposed to the application of hydrocarbon technologies on safety grounds. In Japan, there is some investigation of super-critical CO<sub>2</sub> technologies but the investments required in equipment are currently limiting uptake.

In the domestic refrigeration and freezer sector, hydrocarbons continue to dominate in all but the North American market, where investments are viewed to be prohibitive in existing plants. HFC-based technologies are also seen to deliver incremental energy saving benefits. Although these are achievable by other means in this and other markets, HFC-based solutions are often the most cost-effective. In Japan, there is some use of vacuum panel technology in

most 400-500 litre models in order to achieve increasingly stringent energy targets. However, cost remains a concern in this competitive market.

Phenolic foams are increasingly being blown by hydrocarbons, particularly in Japan where the technology is well advanced.

### 3.3.2 *Developing Countries*

In developing countries, the phase-out of CFC-11 use is progressing well – encouraged by the increase in CFC-11 prices which has occurred in the last year following the closure of key manufacturing capacity. Remaining usage is believed now to be below 5% of the original baseline and should be fully phased-out within the next three years. Progress is being slowed down in part because of the implementation of complex National Plans.

The single step nature of the funded transitions under the Multilateral Fund has resulted in substantial continuing use of transitional technologies. There is continuing concern among some Parties about the amount of HCFCs being used in replacement technologies in developing countries. As a result, bi-lateral agreements are beginning to emerge outside of the Multilateral Fund to support further transitions. This is a particularly important development because current evidence suggests that incremental growth in foam manufacturing capacity, especially in the construction sector, is being based on HCFC technologies because of investment limitations – even where the originally funded projects might have been hydrocarbon-based. This is less the case where multi-national owners are involved and investment capital is available (e.g. in domestic appliances) since the variable cost benefits of hydrocarbon use remain highly attractive in the medium to long term.

## 3.4 **Developments in Blowing Agent Regulation**

### 3.4.1 *CFCs*

In an effort to strengthen the effect of National Plans, there are now mandatory use restrictions on CFCs in most countries where the National Plans have been enacted. This is to prevent any return to CFC use after conversion.

### 3.4.2 *HCFCs*

In order to prevent the future manufacture of HCFC-141b based foams, the US EPA, through its SNAP Programme, has declared the blowing agent unacceptable for use in all foam applications in the United States as of 1<sup>st</sup> January 2005. This also prevents the use of imported PU systems containing HCFC-141b. However, the import of foamed products containing the blowing agent is still permitted under the Clean Air Act. There is a provision under the

SNAP ruling to allow those PU systems already containing HCFC-141b as of 31<sup>st</sup> December 2004 to be used during the first six months of 2005.

The ruling signals the final phase-out of HCFC-141b use in the United States except for designated military and aeronautical applications such as the Space Shuttle.

### 3.4.3 *HFCs*

The first Parliamentary reading of the HFC draft regulation in the European Union took place in mid-2004. Under the current proposals, the use of HFCs in one-component (gap filling) foams will be banned one year after the regulation enters into force. A similar ban on HFC use in shoe soles will occur on 1<sup>st</sup> January 2006, although its effect will depend on the interpretation of the 'placement on the market' provisions. For other applications of HFCs in foams, the legislation proposes to review the justification for use within a further four years. The legislation also makes provision for the recovery of HFCs from foams at end-of-life under terms similar to those applied for ozone depleting substances under EC Regulation 2037/2000.

In Japan, there is continuing interest in restricting the growth of HFC consumption and an agreement has been reached between the polyurethane foam industry and the Japanese Government to cap the consumption of the industry in 2010. The figure is linked to the previous consumption level of HCFC-141b which was phased-out at the end of 2003. There continues to be discussion in Japan, as elsewhere, about the claimed life cycle benefits of HFCs. The debate centres round the basis of comparison of insulation types within TEWI analyses. The choice is one of constant thermal resistance (R-value), constant thickness or constant budgetary spend, the latter being particularly relevant where renovation measures are being considered.

Finally, in Australia, the Government has taken the opportunity to combine its ODS legislation with its controls on Synthetic Greenhouse Gases (including HFCs). This has resulted in the requirement for the delivery of Environmental Improvement Plans from foam manufacturers. Good Practice Guidance will be drawn up for each of the major foam sectors active in Australia and the performance of individual manufacturers will be assessed against these benchmarks.

## 3.5 **Related Reports**

In co-operation with the Inter-Governmental Panel on Climate Change (IPCC), the TEAP has been working on a Special Report related to the selection of HFCs and alternatives in various former ODS applications. The report includes a chapter on foams which assesses the criteria for selecting HFCs and evaluates the impact of such selections. The report draws particular attention to the long life-times of banked blowing agents and illustrates that



emissions occur at lower rates but over much longer periods than those occurring with refrigerants. Although there are important distinctions between blowing agent banks in appliances and those in buildings, the chapter emphasises the value in researching end-of-life management options for foams.

In parallel with this Special Report, Decision XV/10 under the Montreal Protocol requested TEAP to provide an update of technologies for the end-of-life management of foams, with particular attention on foams located in buildings. The recovery efficiencies achievable and the economic implications of recovery and/or destruction are specifically considered in this report which is published alongside this Update for consideration by Parties to the Protocol at the 2005 Meeting of the Parties.



## **4 Halons Technical Options Committee (HTOC) Progress Report**

The HTOC met on March 7-9, 2005 in Eschborn, Germany at facilities provided by GTZ Proklima. This was the first meeting of the full HTOC since December, 2002. Attending HTOC members were from the following countries: Bahrain, Canada, China, Denmark, Germany, India, Japan, Poland, Russia, UK, and USA.

The purpose of the meeting was to reaffirm the continuing role of HTOC over the next several years in providing guidance and technical advice, as required, on issues related to the global transition away from halons. This was a particularly important objective in recognition of the changes since the Committee's last meeting including a change in HTOC's co-chairs, the ratification of the Kyoto Protocol, the loss of some members, and the addition of new members attending their first Committee meeting. In addition, the meeting covered a review of issues that have emerged since the last HTOC meeting and plans for work to complete the 2006 Assessment Report.

The HTOC reviewed current information at the meeting, updating the status of the transition from halons according to the various sectors of use. In addition, several issues have been identified that are key and timely to the success of the global transition away from halons. These are summarised below:

### **4.1 Update on Decision XV/11**

The HTOC co-chairs assembled and transmitted to the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) information on currently available halon alternatives for use on board aircraft. They further arranged for a meeting with ICAO Operations/Airworthiness representatives in November, 2004. In accordance with the Decision, a plan of action was developed as follows:

HTOC will submit an article on alternatives and their current use status for the ICAO Journal.

HTOC will project halon supply, cost and emissions.

ICAO will issue a State Letter in 2006, inviting States to require the use of proven alternatives in new aircraft designs.

The ICAO Secretariat will introduce an ICAO/HTOC working paper at the 2007 ICAO Assembly.

The requirement for States to use proven alternatives in new airframe designs will begin January, 2009.

## 4.2 Update on the use of halon alternatives on board aircraft

HTOC members were encouraged by the first reported in-service example of commercial aircraft using a non-halon fire protection system. Lufthansa advised that it has 8-10 Airbus A340-600 aircraft in-service that have an alternative lavatory waste receptacle extinguishing system using HFC-236fa. Although the rest of the aircraft's fire protection systems continue to use halon, these are the first civilian aircraft (to the knowledge of HTOC) with any on board halon alternative fire protection system. The HFC-236fa lavatory waste receptacle extinguishing system is available as a direct (drop-in) replacement and costs significantly less than the normal halon 1301 extinguishing system. While typically there is no drop-in replacement for halon, in this application HFC-236fa (or other alternatives) can be used because the fire challenge is very small in relation to the quantity of agent in the container. The quantity of halon 1301 used is in great excess to minimum requirements and thus, the same quantity of a less effective agent is still sufficient for this fire extinguishing task.

Subsequent correspondence between the HTOC, Airbus Industries and their supplier, has revealed that the HFC-236fa lavatory waste receptacle extinguishing system has become standard equipment on the A318/A319/A320/A321/A340 series of aircraft, and will shortly be certified for deliveries of the A380. However, there are currently no plans to promote this alternative as a replacement for the existing units on aircraft that were originally delivered with halon based systems.

## 4.3 Review of HTOC halon bank estimates

The HTOC discussed the need to clarify the use of the term "halon bank", as used in HTOC reports. Specifically, the HTOC defines the global bank of each of the halons as the halon that is in fire protection equipment as well that which is in storage tanks. The halon bank is the sum of all halon ever produced minus the sum of all halon losses (i.e., emissions due to fires, false discharges and leaks, and destruction).

The HTOC reviewed current data on halon supplies and emissions, including the current HTOC model for halons 1211 and 1301, global atmospheric concentrations of halons 1211 and 1301, and measured atmospheric concentrations attributed to Europe (as reported in *Scientific Assessment of Ozone Depletion: 2002*. Global Ozone Research and Monitoring Project, Report No. 47, World Meteorological Organization, Geneva), Japan's measured bank, and China's production since 1987. The main observations of this review were as follows:

Atmospheric concentrations of halon 1211 between 1999 and 2002 are about 50% lower than the HTOC model's 7-18% emission rate would predict.

There has been a significant decrease in annual emissions of halon 1211 since the beginning of 2001, as measured by atmospheric concentrations.

The Chinese halon 1211 bank appears to be larger than needed to meet the predicted, significantly reduced, demand.

Atmospheric concentrations for halon 1301 in the same time frame are close to the HTOC model's emissions predictions using a 5% annual emission rate.

There was a significant increase in annual emissions of halon 1301 between 1997 and 2000, as measured by atmospheric concentrations.

Emission rates in Japan have been recorded at 0.1 – 1.0% for halon 1301 fixed systems.

A recent study (Verdonik, D.P. and M.L. Robin, 2004: Analysis of Emission Data, Estimates, and Modeling of Fire Protection Agents, Proceedings of the Earth Technology Forum, Washington, DC, 2004, 11 pp.) has proposed an annual emission rate of 2%±1% for the installed base of fixed fire protection systems.

The Japanese halon bank is almost twice as large as the HTOC model predicts.

In light of the new evidence, the HTOC bank model for halons 1301 and 1211 needs to be updated, and also needs to include halon 2402. The HTOC will revise its bank model as part of its work to complete the 2006 Assessment Report.

#### **4.4 Implementation challenges in Article 5(1) countries**

The HTOC discussed the progress and challenges in the transition away from halons among Article 5(1) countries and the implementation of halon projects. These challenges may be specific to the MLF funded halon projects and how well they match the specific country's needs and supporting infrastructure; the challenges may also be specific to the final ozone protection or halon regulations and policies enacted within each country. There is a need to improve the understanding of these countries' challenges to transition away from halons and to determine an effective role for the HTOC to provide timely guidance and advice to implementing agencies, the MLF and Parties in addressing them. The HTOC has identified the following challenges related to some halon projects in the Middle East and Africa:

The ability of some host countries to operate and maintain recycling centres has been problematic.

Equipment needed to properly recycle halon is expensive and requires continuing financing for the recruitment, retention, and training of qualified staff in the host country to operate the recycling centre and maintain the equipment.

Contaminated halon is a serious issue in Africa, and there is currently a lack of independent laboratories able to assess and certify the purity of recycled halons.

MLF Decision 17/5 on halon banking, which does not distinguish between imports of newly produced and recycled halons, appears to have caused problems related to the treatment of recycled halon that could otherwise be imported by Article 5(1) countries from non-Article 5(1) countries. The consequence has been an inability of some countries to support their banking needs and to supply halon for installed systems. The HTOC recommends that the MLF Decision 17/5 be clarified to only ban the import of halon that would be counted towards consumption.

It has been reported that the MLF Executive Committee has decided that there will be no more funding for halon projects beyond those already approved.

#### **4.5 Destruction challenges**

The HTOC discussed the growing importance of ensuring the option to safely and effectively destroy halons, as well as other ozone-depleting substances, to prevent emissions from surplus or contaminated supplies and as part of a sound ODS management plan. The current availability of destruction facilities has arisen from the demand for the disposal of contaminated halons and to destroy surplus halons resulting from bans on use in Australia, the European Union, and more recently Canada. The UNEP Task Force on Destruction provided initial guidelines on various destruction technologies including two commercially available methods: plasma arc and high temperature incineration.

Two plasma arc facilities exist world-wide, one in Australia and one in the United Kingdom, where halons have been destroyed. The Australian facility has destroyed a significant quantity of halon 1211, but so far the predicted need to destroy unwanted halon in Europe has not materialised sufficiently to make the UK facility a viable concern. Small additional quantities of halons have been destroyed in hazardous waste incineration facilities in Europe. There are no halon destruction facilities in Canada.

As part of its work to complete the 2006 Assessment Report, the HTOC will include a new chapter on the issues related to halon destruction.

## **5 Refrigeration, Air-conditioning and Heat Pumps Technical Options Committee (RTOC) Progress Report**

HFCs continue to be the main alternatives to the CFCs and HCFCs in most of the refrigeration, air-conditioning and heat pumps sectors. However, the use of hydrocarbons, ammonia, carbon dioxide and fluorocarbons with relatively low GWP has increased further. There is also an increasing trend to use indirect refrigeration systems using heat transfer fluids (HTFs) in secondary-loop delivery (distribution) systems to reduce refrigerant charge and hence likely emissions.

A number of specific studies, in which RTOC members were involved, have been published since 2002: the HCFC Task Force report, the Basic Domestic Needs Task Force report, the Chiller Task Force report and the IPCC-TEAP Special Report on Ozone and Climate. This progress report gives updates on the status of the technical options for different applications (sub-sectors).

### **5.1 Refrigerant Data**

There are four areas of progress in refrigerants: 1) addition of new alternatives commercialised since the 2002 Assessment, 2) refinement of the data, 3) expansion of the data presented on heat transfer fluids (“secondary refrigerants”), and 4) the status of or findings regarding hydrofluoroethers (HFEs).

While the primary alternatives and even the primary candidates warranting further consideration remain the same, manufacturers continue to develop new refrigerants, both single compounds and blends. In particular new blends have appeared, encompassing both different compositions (which components) and different formulations (which composition ratios). The new blends are the focus of investigation both for original manufacture, especially in Article 5(1) countries, and for aftermarket service (retrofit) of installed equipment, including those in current use and those that will be installed within the allowed current phase out schedules but still have later service life. One category warranting specific attention is blends that include one or more HCFCs blended with other components to reduce overall ODP or the combination of ODP and GWP values.

New thermophysical, safety, and environmental data continue to emerge, for example new consensus ODP and GWP values from the WMO Scientific Assessment and IPCC WG1 Fourth Assessment Report efforts. The next RTOC refrigeration assessment will compile these data and tabulate them along with calculated derivative values for blends.

As interest grows in use of hydrocarbons, ammonia, and fluorochemicals with relatively low GWPs (that tend to be at least marginally flammable), parallel

attention grows in indirect refrigeration (or heat pumping) systems using heat transfer fluids (HTFs) in secondary-loop delivery (distribution) systems. The 2002 RTOC assessment added a focused summary of HTF characteristics and properties. With the increased interest, we plan to add tabular data on common HTFs to summarise their physical, safety, and environmental data.

Finally, systematic efforts to screen hydrofluoroether (HFE) candidates have now progressed to where the 2006 RTOC assessment most likely will add discussion of their status.

As in prior RTOC assessments, the individual application sections rather than the introductory section on refrigerants will discuss the status, outlook, and needs for specific refrigerants by application.

## **5.2 Domestic Refrigeration**

No new alternatives have surfaced, which are energy-efficient or cost competitive with conventional vapour-compression refrigeration for domestic refrigerator applications. HFC-134a or HC-600a continue as the dominant refrigerant options for application in products. Conversion of Article 5(1) country domestic refrigerator production from CFC-12 to either HFC-134a, HC-600a or the HC-600a/HC-290 blend has further increased. Quantitative information is not available on the proportion of applications having been converted or the relative proportion of the refrigerant options being used. The perception is that the 2:1 ratio of HFC-134a use to hydrocarbon use is trending more towards parity. The binary HC-600a/HC-290 hydrocarbon blend is being used to match the volumetric capacity of existing CFC-12 compressors. Its use avoids retooling compressor mechanical parts. As discussed in earlier reports, this step was an interim conversion step in Europe toward the later conversion to pure HC-600a refrigerant. The limited second generation conversion in Japan from HFC-134a to HC-600a refrigerant reported in the 2002 RTOC assessment report continues to gain momentum. No reports have been received of proliferation of this action to other countries.

Conversion of the service demand for CFC-12 refrigerant is more sluggish. Approximately one-half of the approximately 1500 million domestic refrigerators in service originally contained CFC-12 refrigerant. This percentage is even higher in Article 5(1) countries. The simplest and most typical service procedures use the refrigerant selected by the original manufacturer of the equipment. CFC-free blends have been specifically developed to satisfy service demand for CFC-12 containing units. The use of these blends, however, only becomes significant when CFC-12 has a premium cost or limited availability. In reality, CFC-12 usage is primarily influenced by regulations. It is banned in some countries, available only as premium-cost, reclaimed material in others and readily available at economic prices in some others.



Refrigerator energy efficiency continues as an aggressively competitive product attribute. Market incentives for demand side management are driving leading edge applications of technologies such as variable speed compressors and dual evaporator systems. Shipment weighted average energy efficiency data indicates that a new unit typically will use less than one-half the energy of the unit it replaces.

### 5.3 Commercial Refrigeration

New trends are quite different for stand alone equipment, condensing units and machinery rooms for supermarkets.

#### *Stand alone equipment*

Global companies such as Coca Cola, McDonald's and Unilever have pledged to choose equipment with refrigerants other than HFCs. After two years of research and development by Coca Cola, the main conclusion was that CO<sub>2</sub> is the preferred refrigerant for vending machines. But, at the same time, Coca Cola indicates that "they will go as fast as possible and as slow as necessary", implying that the additional costs and logistical complications are still prohibitive to implement CO<sub>2</sub> systems in all their new vending machines. It is significant that one compressor manufacturer has launched a production line capable of producing up to 60,000 CO<sub>2</sub> hermetic compressors dedicated to small commercial systems, although the company has indicated that they are not sure whether the 2005 demand will be as high as 60,000.

In the case of commercial freezers installed by companies operating globally, the replacement of HFC-134a by isobutane (R-600a) is significant, i.e., about 50% of the newly installed systems uses the hydrocarbon refrigerant.

#### *Condensing units*

For condensing units no significant changes have occurred. The refrigerant charges are at least 1 kg, up to several tens of kilograms, and the preferred refrigerants are HFC-134a for medium temperature and R-404A for low temperature applications. In the USA, the use of HCFC-22 is still quite significant and the blends R-404A and R-507A are applied in about 50% of the new equipment. In developing countries, HCFC-22 is the refrigerant of choice, while HFC-134a and R-404A are now used in some applications.

#### *Centralised systems*

The same trends in choice of refrigerants for condensing units are observed in centralised systems. The use of HCFC-22 in the USA and in developing countries is also very significant both for new equipment and for servicing. In the USA, a possible shortage of HCFC-22 is responsible for the introduction of HFC blends (R-404A and R-507A) in 50% of the equipment. In Europe

and in Japan, HFCs are the preferred refrigerants with some significant differences, i.e., R-407C is being used for medium temperature applications in Japan, which is not the case in Europe. The use of hydrocarbons and ammonia remains limited to Northern European countries. In Europe the uptake of indirect systems in display cases and cooling chambers is becoming significant. Some installers are introducing indirect systems at the same price as R-404A direct expansion systems, while two years ago the initial additional cost was about 15%. Moreover, installers have become more confident that these systems can be easily maintained.

In some European countries (The Netherlands, Norway, Sweden, and Denmark) significant progress has been made in the reduction of emissions (in the range of five to ten percent), driven by the very high taxes on HFCs or by regulations that enforce a high level of containment. In many other countries, the emission levels are still very high, i.e., between 15 and 30%. Generally, the higher the refrigerant charge, the higher the emission level will be.

#### **5.4 Large Size Refrigeration (Industrial, Cold Storage and Food Processing)**

The status of technical options continues to change, particularly in low temperature applications with CO<sub>2</sub> as the heat transfer fluid and refrigerant. In the case of NH<sub>3</sub> systems, there is an increased tendency to reduce the refrigerant charge.

Several research activities have continued in the USA, Japan and Europe concerning CO<sub>2</sub> as a refrigerant and CO<sub>2</sub> compatible lubricant oils. New industrial systems and concepts have been realised, particularly for low charge NH<sub>3</sub> and for CO<sub>2</sub> systems. In 2004, new CO<sub>2</sub> compressor designs were introduced for discharge pressures of 40 to 60 bar with the use of CO<sub>2</sub> for defrosting of evaporators. Some efforts have been made in Japan to develop CO<sub>2</sub> heat pumps for industrial customers, driven by the high energy costs.

Mainly in Europe and Japan, strong efforts have been made to develop standard cascade systems based on CO<sub>2</sub> and NH<sub>3</sub>. The technology was introduced to the market in 2004. Below temperatures of -35 to -45°C, depending on system size, CO<sub>2</sub> has been used as the refrigerant, and at higher temperatures as the heat transfer fluid.

CO<sub>2</sub> technology has been developed in small and large scale systems up to 5 MW cooling capacities in the U. S., Japan, and Europe. Most new CO<sub>2</sub> systems are developed in The Netherlands owing to governmental support. CO<sub>2</sub> as a refrigerant and as a heat transfer fluid seems to be state of the art in new systems in Europe.

Some systems have been retrofitted from HCFC-22 to CO<sub>2</sub> or brine systems, mainly in the sector of cold storage. The trend towards small NH<sub>3</sub> charges has increased, even in industrial refrigeration systems. Some efforts have been

made with HCs but with limited market penetration. In a number of new systems HFC-410A was used as the low temperature refrigerant.

No increasing interest in non-ODP technologies has been reported from the developing countries.

## **5.5 Transport Refrigeration**

Transport refrigeration accounted for about 1% of all refrigerants used in 2002. The market share of HFCs used in transport refrigeration systems was 2% of all HFCs used in 2002, the market share of CFCs was 0.5% and that of HCFCs was 0.3%. These figures show that the transport refrigeration sector has already shifted more towards HFCs than the other refrigeration industry sectors. The typical life span of a transport refrigeration system is lower than for the average stationary refrigeration and air conditioning equipment. All over the world (including in Article 5(1) countries), new transport refrigeration systems are commissioned with HFC refrigerants, thereby continuously decreasing the quantities of ODS containing equipment in this sector.

Nonetheless, ODS emissions from transport refrigeration equipment are still high, accounting for about 1% of all emissions, indicating that the leakage rate of transport refrigeration equipment is higher still than the industry average.

A literature study and a market survey among relevant equipment manufacturers, transport refrigeration system owners and operators, as well as service companies is being conducted by the Karlsruhe University of Applied Sciences. Initial results from that study are expected in July 2005. The study will be concluded by October 2005 and the results will be used to update the transport refrigeration chapter. The overall structure of the chapter, i.e. categorisation into refrigerated (reefer) ships, intermodal containers, merchant marine refrigeration and air conditioning, road transport, refrigerated railcars and air conditioning in rail cars will be continued from the 1998 and 2002 RTOC report.

## **5.6 Unitary Air Conditioning**

The status of technical options has experienced only incremental change since the publication of the RTOC 2002 Assessment Report. The primary changes have been the continued penetration of HFC technologies into the markets of the developed countries and the significant growth in HCFC-22 usage in China.

In Japan, the transition to non-ODP technologies in new equipment is tracking ahead of the Japanese 2010 deadline. Japanese manufacturers are almost exclusively using HFC refrigerants in their transition strategy. They are using both R-407C and R-410A to replace HCFC-22. Initially, some product types

were converted from HCFC-22 to R-407C. Currently, R-410A is starting to replace R-407C in new products designed for these applications.

Rapid growth in air conditioning production in China (primarily ductless splits and window room air conditioners) continues to increase China's use of HCFC-22. Approximately 34 million window and ductless splits units were produced in 2003.

In the United States, the shift to non-ODP technologies in unitary products has been occurring at a modest pace. Most US manufacturers have introduced residential (7 to 15 kW) ducted products using R-410A. In 2004, approximately 10% of the HCFC-22 usage had been replaced by HFC refrigerants. The penetration of non-HCFC technologies is expected to increase significantly after 2005, as manufacturers redesign their residential ducted products to meet new US minimum efficiency standards that will go into effect in January 2006. In 2010, all unitary air conditioning products manufactured in the US will be required to use non-ODP alternatives.

In Europe, the legal requirement to phase-out HCFC refrigerants occurred in 2004. The HCFC replacement technologies have included both hydrocarbon and HFC refrigerants with HFC refrigerants being the predominant technology.

Research has continued on other non-ODP technologies and refrigerants--particularly CO<sub>2</sub>. At this time, none of the other technologies and refrigerants has been commercialised in air conditioning products.

## **5.7 Chiller Air Conditioning**

Centrifugal chillers using CFC refrigerants are gradually being replaced by new chillers using HCFC or HFC refrigerants. Conversion of existing chillers to use non-CFC refrigerants (HCFC-123 for CFC-11 or HFC-134a for CFC-12) has nearly ended because most good candidates for conversion have already been converted in markets where there are regulatory and financial incentives.

Screw compressors have replaced reciprocating compressors for use in new chillers in the capacity range from 140 kW to 700 kW. Screw compressors also are displacing centrifugal compressors in new water-cooled chillers in capacities up to about 2275 kW. HFC-134a has displaced HCFC-22 as the refrigerant used in most new screw chillers. Centrifugal chillers continue to be offered in capacities to 7000 kW and beyond using HFC-134a or HCFC-123 refrigerants. In the capacity range from 7 to 350 kW, scroll compressors are being used to an increasing extent, often in multiples, compared to reciprocating compressors. A transition to R-410A from HCFC-22 is accelerating in new chillers in this capacity range. R-407C, an alternative to HCFC-22, also is being used as a transitional chiller refrigerant. Air-cooled

chillers are produced in larger numbers than water-cooled chillers in the capacity range from 35 to 1500 kW.

The number of CFC chillers in Article 5(1) countries has been stable following the phase-out of manufacturing in the mid-1990s. Most CFC chillers have been kept in operation. CFC chiller replacement programs involving grants, and revolving funds are being actively considered. Further information can be found in the Chiller Task Force Report, which was part of the 2004 TEAP Progress Report.

Concerns about the global warming impact of refrigerant emissions, whether HCFCs, or HFCs, led to design improvements in chillers to minimise refrigerant leakage. New chillers today have leakage rates in the 1%/yr range. Now, attention must be paid to minimising emissions during servicing and at the end of a chiller's life. Remote monitoring is becoming an established method of monitoring performance of chillers. Remote monitoring also can be used to detect refrigerant leakage, alerting maintenance personnel to take early action to repair leaks and maintain performance.

## **5.8 Water-heating Heat Pumps**

Water-heating heat pump markets continue to grow, particularly in Japan. Heating-only, space-heating, heat pumps are available in sizes ranging from 1 kW heating capacity for single-room units to 50-1000 kW for commercial/institutional applications. Heat sources include outdoor, exhaust, and ventilation air, sea and lake water, sewage water, ground water, earth, and industrial waste water or process waste heat. Air-source and ground-coupled heat pumps dominate the market.

In countries with cold climates such as northern Europe, heat pumps are used for heating only. In countries with warmer climates, heat pumps serving hydronic systems with fan coils provide heat in the winter and cooling in the summer. Heat pumps for combined comfort heating and domestic hot water heating are used in some European countries.

Heat pumps for comfort heating have capacities up to 25 kW. Supply temperatures are 35<sup>0</sup> to 45<sup>0</sup> C for comfort heat in new construction and 55<sup>0</sup> to 65<sup>0</sup> C for retrofit. HCFC-22 still is used as one of the main refrigerants in heat pumps but manufacturers are introducing models using HFC-134a, R-407C, R-404A, or in smaller systems, hydrocarbons as refrigerants. When hydrocarbons are used, the refrigerant circuit is located outdoors using ambient air, earth, or ground water sources, and is connected to hydronic floor heating systems. Carbon dioxide is being introduced in Japan and Norway as a refrigerant for heat pumps, particularly those with a domestic hot water heating function.

Sales of water-heating heat pumps were small around the world prior to 1995 but have increased at an accelerating pace since that time. Information about production quantities is scattered and anecdotal. The Swedish Energy Agency estimated that over 300,000 heat pumps are in operation there, a small portion of which are air to air heat pumps. The application of heat pumps in China reached 35,000 units in 2002 due to nation-wide housing projects where there is a preference for hydronic systems.

## **5.9 Vehicle Air Conditioning – 2005 Status**

Vehicles (cars, trucks, and buses) built before the mid-1990s used CFC-12 as the refrigerant. Since 1994 in developed countries and 2004 in developing countries, in accord with the Montreal Protocol, new vehicles with A/C have been equipped with HFC-134a refrigerant systems. HFC-134a has now replaced CFC-12 as the globally accepted mobile A/C (MAC) refrigerant and the industry is busy expanding global production to meet the increasing demand. By 2008, when most vehicles with CFC-12 air conditioning will have been retired, almost all vehicles on the road are expected to be using HFC-134a and the transition from CFC-12 will be complete.

HFC-134a is a potent greenhouse gas (latest 100-year GWP = 1410) and, due to concerns about emissions of HFC-134a from MAC systems, vehicle makers and their suppliers are reducing their system leakage and improving energy efficiency. This joint activity is an industry-wide co-operative effort known as I-MAC (Improved Mobile Air Conditioning), which is organised by the US EPA, the Society of Automotive Engineers (SAE) and the Mobile Air Conditioning Society. Targeted improvements include a 50% or greater reduction in refrigerant emissions and a 30% or greater reduction in energy use. Currently, it is not clear whether Improved-HFC-134a, HFC-152a, or CO<sub>2</sub> systems will achieve the highest life-cycle climate performance, particularly in the hottest climates where air conditioning is most needed.

As a result of an impending ~2011 ban on the use of HFC-134a in MACs in Europe, vehicle makers have been searching for replacement refrigerants. In the timeframe 1998-2005, the leading potential replacement refrigerant has been carbon dioxide (CO<sub>2</sub>, also known as R-744) for which many global vehicle manufacturers and suppliers have demonstrated prototype cars. The use of HFC-152a (latest 100-year GWP = 122) was proposed in 2001 and has been publicly demonstrated in several prototype vehicles. Adoption of either a carbon dioxide system or an HFC-152a system would completely eliminate HFC-134a emissions from vehicles. The decision of which refrigerant to choose will be based on other considerations, such as energy usage and associated greenhouse gas emissions, cost, heat pump capability, safety, and servicing.

CO<sub>2</sub> has the advantage that it may also be useful in a heat pump system (a sophisticated reversible A/C system), allowing both heating and cooling of the

vehicle. CO<sub>2</sub> systems require completely redesigned components using new manufacturing processes to withstand the very high operating pressures, as well as additional components and controls to allow operation at, or near, optimum energy efficiency. Both capital costs and consumer costs (especially for A/C only systems) are expected to be significant.

HFC-152a in a direct expansion system shows better cooling with less fuel needed for operation than HFC-134a. It has a very low GWP and its carbon-equivalent emissions from vehicles would be offset by its fuel savings relative to HFC-134a systems. HFC-152a systems use the same components as HFC-134a systems, allowing flexible manufacturing and/or and low cost transition from HFC-134a. The only drawback is its flammability. It is anticipated that, due to the small refrigerant amount needed, combined with safety engineering (such as discharge systems, evaporator solenoid shut-off valves, or secondary loop), its use will result in a commercially acceptable MAC system. HFC-152 systems may be particularly attractive in developing countries where the higher cost and complication of servicing CO<sub>2</sub> systems may be prohibitive.

The European HFC-134a ban for MAC systems is currently being debated and finalised under the European legislative process. The choice of whether or not to allow HFC-152a under a GWP 150 cap, will likely have a major effect on the future of the industry.





## **6 Chemicals Technical Options Committee (CTOC) Progress Report**

### **6.1 Introduction**

The Solvents, Coatings, and Adhesives Technical Options Committee (STOC) of the Technology and Economics Assessment Panel (TEAP) was disbanded in view of the successful phase-out of most ODS solvent uses. Remaining responsibilities were assigned to a newly organised Chemicals Technical Options Committee (CTOC).

The CTOC is responsible for annual progress updates on Solvents, Feedstocks, Laboratory and Analytical Uses, Non-Medical Aerosols and Miscellaneous Uses, and also for completing assessments on Process Agents, Carbon Tetrachloride (CTC), Destruction Technologies, and on new chemicals such as n-Propyl Bromide (n-PB).

Its membership incorporates Solvent, Feedstock, and Laboratory and Analytical Use experts mainly from the STOC; and CTC, Non-Medical Aerosol and Miscellaneous Uses experts from the similarly disbanded Aerosol Products and Miscellaneous Uses Technical Options Committee (ATOC). In addition the experts on Process Agents and Destruction Technologies have been recruited from the former task forces.

The first CTOC meeting was held on February 23-25, 2005 in Caracas, Venezuela with the support of Spray Química C.A. Attending CTOC and TEAP members were from the following countries: Australia, China, India, Japan, Netherlands, USA and Venezuela.

The main purpose of the meeting was to confirm the structure, membership and role of the newly organised CTOC. Apart from necessary discussions to assess the current trends of the matters included in the scope of the CTOC, the table of contents of the 2005 CTOC Progress Report was decided, and the lead authors were identified. The following sections deal in detail with these issues.

### **6.2 Process Agents**

#### *6.2.1 Review of the 2004 Report of the Process Agents Task Force*

The 16<sup>th</sup> Meeting of the Parties, held in Prague in November 2004, received the Report of the Process Agents Task Force that had been established earlier that year by the TEAP. The Task Force reviewed requests submitted by some Parties to the Ozone Secretariat in 2003 and 2004 in accordance with Decision XV/7.

The 2004 Process Agents Task Force reviewed nominations from the Democratic Peoples' Republic of Korea, Romania, the United Kingdom and the United States of America, and concluded that all the processes reviewed met the criteria defined by the Process Agents Task Force in its 1997 Report. Parties were invited to include these Process Agent Uses in Table A, which was created by Decisions X/14 and XV/6.

Some Parties considered that it was important that the dates when the Process Agent Uses started were clearly indicated. These dates were only mentioned explicitly for the nominations made by the DPR of Korea, although the nomination for radiolabelled cyanocobalamin reported use of CTC from 1995 onwards. Parties did not include in Table A any of the nominations at the 2004 Prague Meeting of the Parties (16MOP). Of the Parties that made nominations in 2003 and 2004, the United States of America resubmitted its request for consideration of the CFC-113 use in High Modulus Polyethylene Fibre production as a Process Agent. In 2005, the CTOC considered the new information submitted by the United States and reaffirmed its evaluation of the other pending nominations.

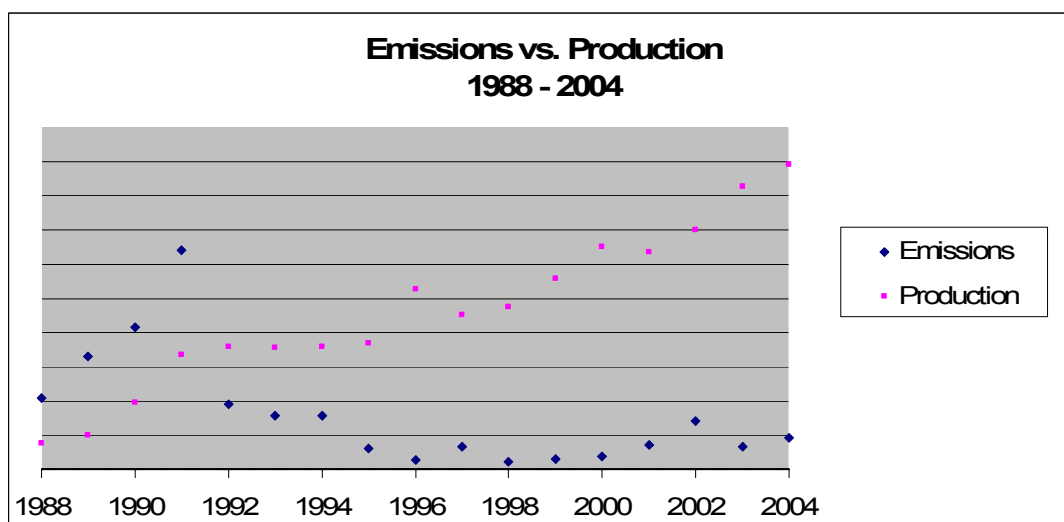
#### 6.2.2 *Additional Information for High Modulus Polyethylene Fibre*

**Decision XV/7 paragraph (7)** notes that “because the two uses of controlled substances at the end of the table below were submitted to the Technology and Economic Assessment Panel but not formally reviewed, those applications are to be considered process-agent uses”, and “are to be reconsidered at the Seventeenth Meeting of the Parties”.

These two uses are the manufacture of High Modulus Polyethylene Fibre (USA) and of Losartan Potassium (Argentina). The Party that proposed BCM as a Process Agent for the production of Losartan Potassium withdrew its nomination.

Additional information was received from the United States in respect of the use of CFC-113 to produce High Modulus Polyethylene Fibre. This process commenced commercial operation in 1985 and output has grown steadily with plant expansions in the same site, where more spinning capacity was installed to increase output. Information provided by the manufacturer showed that several stages of expansion were accompanied by substantial reductions in emissions of CFC-113 as shown in Figure 1. Note that for reasons of commercial confidentiality, no units are shown in the diagram.

**Figure 6-1 Emissions of CFC-113 vs. HMP Fibre Production 1988-2004**



Continued production after the phase-out of CFCs in USA was initially possible by the use of pre-1996 stockpiled CFC-113. The Parties granted temporary status as a Process Agent in 2004 that allowed operation to continue utilising currently produced CFC-113, but that temporary classification will lapse at the end of the year.

In 2005, the government of the United States submitted a revised application for the classification of High Modulus Polyethylene Fibre as a Process Agent, and at the request of the CTOC, additional information was received from the manufacturer indicating that, over the past 15 years, 'hundreds of non-ODS materials' had been tested as replacements for CFC-113, but none had been able to achieve the technical performance of CFC-113 in respect of flammability, boiling point, toxicity, compatibility with materials of construction, economy, and recoverability while retaining required product properties and performance.

The interaction of the spinning solvent with the fibre plays an important role in the unusual strength of the end product. Therefore, the CTOC reaffirms its finding that use of CFC-113 to produce High Modulus Polyethylene Fibre satisfies the technical criteria as a Process Agent Use.

The CTOC looked carefully at *Decision X/14/ (Clause 3)* "That quantities of controlled substances produced or imported for the purpose of being used as process agents in plants and installations in operation before 1 January 1999, should not be taken into account in the calculation of production and consumption from 1 January 2002 onwards...", and also *Decision X/14(Clause 7)*: "Parties should not install or commission new plant using controlled substances as process agents after 30 June 1999, unless the Meeting

of the Parties has decided that the use in question meets the criteria for essential uses under decision IV/25".

The CTOC considers that there is ambiguity in the meaning of 'new plant' as it is used in *Decision X/14*. One interpretation would be that 'new plant' involves construction of a new facility, separate from any facility that might have existed before 1 January 1999. An alternative interpretation would be that an expansion after January 1999 of an existing facility would constitute 'new plant' and would require an Essential Use Exemption for the expanded capacity.

If Parties decide on the latter interpretation it will be necessary to allow time for nomination, review, and manufacturing response.

#### TEAP Recommendation

##### Process Agent Classification for High Modulus Polyethylene Fibre, with comment on timeline for potential Essential Use Nomination

TEAP concurs with the CTOC finding that High Modulus Polyethylene Fibre satisfies the technical criteria as a Process Agent Use. If Parties approve new Process Agent Uses for listing on Table A, they may wish to adjust Table B to reflect additional Process Agent Uses and progress in reducing emissions for already classified uses. Adjustment of Table B could be based on a new CTOC assessment of approved Process Agent uses.

If Parties decide that an Essential Use Nomination is required for expanded production of High Modulus Polyethylene Fibre after 30 June 1999, as indicated in *Decision X/14 (Clause 7)*, TEAP recommends that the capacity existing today be temporarily classified as a Process Agent until 2008 or later to allow nomination as an essential use by 31 January 2007 for decision by Parties at the 19<sup>th</sup> MOP. If Parties do not grant Essential Use status at the 19<sup>th</sup> MOP, this schedule would allow the nominating Party at least one year to make any necessary transition.

### 6.2.3 *CTC Emergency Exemption for the Manufacture of Cyanocobalamin*

The EU made Emergency Requests to the Ozone Secretariat to authorise the use of 8 litres. CTC required for the manufacture of radiolabelled cyanocobalamin in 2005 and 2006. In both cases TEAP co-chairs recommended approval of the emergency request.

The CTOC has not been informed that a new waste disposal, which had been identified by the manufacturer to minimise emissions, has been put in place. The nominating company indicated in its nomination that it held 59 litres of CTC which, if authorised, would allow continued production until 2010 or beyond.

In the light of the small volume required, of the diagnosis value of radiolabelled cyanocobalamin, and of the impossibility of validating economically an alternative process, Parties may wish to consider granting a long-term exemption.

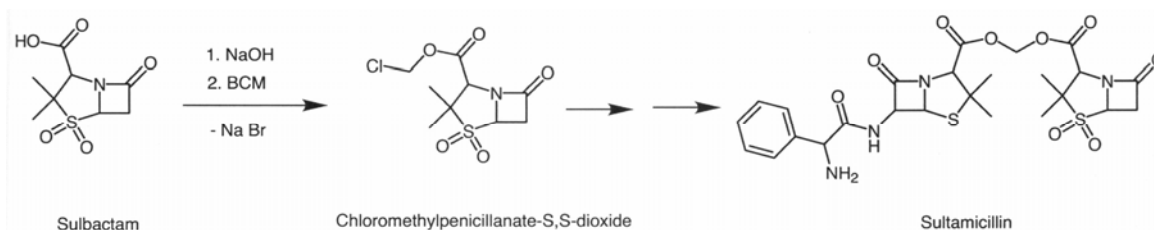
Conversely, Parties may also wish to consider whether there should be any limit to the renewal of an Emergency Exemption. For example, Parties could grant the Secretariat permanent authority for approving small recurring quantities or could ask Parties to submit Essential Use nominations for uses that continue for more than two or three years.

### 6.2.4 *New Nomination for the Production of Sultamillicine*

The Republic of Turkey has submitted a nomination for classification of the use of bromochloromethane (BCM) in the production of Sultamillicine as a Process Agent. The antibiotic Sultamillicine, whose production in the Republic of Turkey started in 1991, is a substance in which sulbactam, a beta lactamase inhibitor, is covalently linked through an ester group with ampicillin. The Government of the Republic of Turkey has requested the manufacturer to change technology so as to avoid the use of BCM.

In the production of the antibiotic, it is necessary to convert a certain carboxylic acid, R-CO<sub>2</sub>H, to a functionalised ester, RCO<sub>2</sub>CH<sub>2</sub>Cl and this is accomplished by reaction of the sodium salt of the acid with bromochloromethane. Any unreacted - that is, excess - BCM is recovered and recycled into the reaction. The quantity of BCM emitted in the years 1999 to 2002 was, respectively, 211.6, 38.5, 57.7, and 192.7 kg.

In this application the BCM is being consumed as feedstock and so it cannot be accepted as a Process Agent Use. The Committee notes that these quantities of BCM should be considered as feedstocks, and therefore are not subject to control under the Montreal Protocol.



As seen in the reaction scheme, the bromine in BCM is converted to NaBr in the presence of equimolar sodium hydroxide.

### 6.2.5 CTC Use in the Production of Vinyl Chloride Monomer (VCM)

The CTC is aware of the existence and use of this process for example, in Brazil. Although a formal request for consideration of the process by TEAP was not received, TEAP and its CTC have assessed available information on this process.

The case for improved selectivity and higher yield in the manufacture of VCM, when a small amount of CTC is added to the polymerisation reactor was made by Brazil.

CTOC learnt that in all balanced VCM processes CTC is formed. CTC is distilled and incinerated, but a very small amount stays in the reactor section (about 0.1-0.2 %) and this is due to the accelerated cracking of EDC. However, because CTC is always formed in the process, the control of CTC is the preferred route to optimal conditions. This seems to be a Process Agent Use, but the CTC will need more information from the users of this process and the respective formal request by the Party concerned.

### 6.2.6 Review of Process Agent Uses Listed in Table A (Decision XV/7)

**Decision XV/7 on Process Agents requested TEAP and the Executive Committee in paragraph (5)** to “report to the Open-ended Working Group at its twenty-fifth session, and every other year thereafter unless the Parties decide otherwise, on the progress made in reducing emissions of controlled substances from process-agent uses and on the implementation and development of emissions-reduction techniques and alternative processes not using ozone-depleting substances;”

**Paragraph (6)** noted that “those applications [in the Table below] are to be considered process-agent uses of controlled substances in accordance with the provisions of decision X/14 for 2004 and 2005, and are to be reconsidered at the Seventeenth Meeting of the Parties”

The Executive Committee authorised the Fund Secretariat, at its 44th Meeting to hire a consultant to catalogue Process Agent uses in Article 5(1) countries and their related emission levels. The results are contained in a technical study entitled “A study to catalogue process agent uses and emissions levels

involving substances controlled under the Montreal Protocol in countries operating under Article 5(1) of the Protocol”. (UNEP/OzL.Pro/ExCom/45/53)

This study included a survey of process agent uses in Article 5(1) countries conducted via questionnaires to 26 countries that reported uses of more than 1 ODP tonne of CTC, CFC-113 or BCM and identified annual Process Agent Use in Article 5(1) countries of 13,623 ODP tonnes in 2003. Ninety seven percent of this use is concentrated in China, India and DPR Korea- The report identified 18 processes that have not been included in Decisions XV/6 and XV/7, including those reported to the Ozone Secretariat by DPR Korea and Romania and reviewed by the PATF in 2004 and the use of BCM to manufacture Sultamillicine described above, which is confirmed as a feedstock use by the CTOC.

The study commissioned by the ExCom identified a large discrepancy between the figures provided by Article 5(1) countries in annual reports to the Fund Secretariat and to the Ozone Secretariat as required under Article 7 of the Protocol. The sum of the latest Process Agent consumption reported to the Fund Secretariat in country programme data is 21,185 ODP tonnes.

The Executive Committee in UNEP/OzL.Pro/ExCom/45/53, concludes that “Since the three major consumers, accounting for 97 per cent of total consumption, all have either national CTC phase-out plans in place or in prospect for the new uses, consumption for process agent uses as defined under the Montreal Protocol will cease in these countries when Multilateral Fund projects are completed, irrespective of current data discrepancies.”

Furthermore, the Executive Committee has chosen to fund alternative processes rather than emission abatement as the favoured route to phase-out Process Agent Uses in Article 5(1) countries. It also has considered make-up equal to emissions in the case of Article 5(1) countries.

With regard to non-Article 5(1) countries, Canada, the EU, and the US have reported to the Ozone Secretariat their Process Agent Uses and related emissions. The US reported aggregated emissions for all Process Agents for the period from 1999 to 2003, while the EU data covers emissions and make-up quantities for every Process Agent Use in the years from 2000 to 2003. Emissions in 2002 were 50.4 ODP tonnes for the US and 5.3 ODP tonnes for the EU. These figures are well below the limits set in Table B of Decision X/14. It is also interesting to note that reported emissions are less than 1% of make-up figures for the EU, which reports a make-up consumption of 676.8 ODP tonnes in 2003.

It is interesting to note that only 12 out of the 31 Process Agent Uses listed in Table A of Decision XV/7 have been reported to the Ozone Secretariat as actually used by non Article 5(1) countries. Of these one (tralomethrine) has

not been produced in the EU since 2001. These processes are listed in Table 2.1.

**Table 6-1** *Process Agents Reported by Parties*

#	Process Name	Use Reported by
1	Elimination of NCl <sub>3</sub> in the production of chlorine and caustic	Canada, EU, US
2	Recovery of chlorine in tail gas from production of chlorine	EU, US
3	Manufacture of chlorinated rubber	EU
7	Manufacture of chlorosulphonated polyolefin (CSM)	EU, US
8	Manufacture of poly-phenylene-terephthalamide	EU
9	Manufacture of fluoropolymer resins	US
10	Manufacture of fine synthetic polyolefin fibre sheet	US
14	Photochemical synthesis of perfluoropolyetherpolyperoxide precursors of Z-perfluoropolyethers and difunctional derivatives	US
16	Preparation of perfluoropolyether diols with high functionality	US
18	Production of tralomethrine (insecticide)	EU
19	Production of Cyclodime	EU

The CTOC also reviewed the list of Process Agent Uses approved by the Executive Committee which is included in Appendix III of UNEP/OzL.Pro/ExCom/45/53 and which includes the manufacture of endosulphan (process #4) used in India; the text of this Appendix however lists in most cases the replacement substance for CTC and the factory for which the funds are intended, rather than the process name. If the Parties wish, the CTOC will further investigate whether the remaining 18 processes for which there has been no reporting are actually used commercially and can report its findings to Parties in 2006. The CTOC will welcome information that Parties can provide concerning actual use of these processes including whether they are no longer commercially used.

#### 6.2.7 *Review of Process Agent Uses Listed in Table B (Decision XV/7)*

As mentioned by the Process Agents Task Force in its 2004 report, Israel provided information on emissions of CTC as Process Agent for removing of NCl<sub>3</sub> in the production of chlorine.

A new request was made by Israel in 2005. Since this is a well known Process Agent use, the CTOC recommends that Israel is included in an updated version of Table B of Decision XV/7.

#### 6.2.8 *Guidance Note and Pro-forma for Process Agent Applications*

A guidance note with pro-forma has been prepared by the CTOC to help Parties provide all necessary information when making nominations for Process Agents. (See Appendix 1).

The guidance note reiterates the Decisions that underpin the classification of uses as meeting process agent criteria, and the pro-forma indicates the



information needed by the CTOC to make a recommendation. The information is provided for clarification only and is treated in confidence by the Chemicals Technical Options Committee which will review submissions and report to Parties.

### **6.3 Feedstocks**

#### *6.3.1 What are feedstocks?*

CFCs and HCFCs can serve as chemical building blocks in the preparation of other chemical products. In their use as a raw material, they are converted to other products. The degree of feedstock conversion into the end product depends on the reaction. Unreacted material is generally recovered and recycled for further reaction until it is virtually converted in its entirety. If the process is conducted efficiently, the environmental impact of feedstocks is avoided with the exception of very small amounts. These could be residual levels in the ultimate product (which are typically minuscule on a unitary basis) or fugitive leaks in the production and/or transport processes.

#### *6.3.2 Definition in Montreal Protocol*

The Montreal Protocol defines “Production” in the following way: “Production means the amount of controlled substances produced, minus the amount destroyed by technologies to be approved by the Parties and minus the amount entirely used as feedstock in the manufacture of other chemicals. The amount recycled and reused is not being considered as Production.” Based on this definition, substances controlled by the Montreal Protocol are not subject to phase-out regulations while being used in feedstock applications.

#### *6.3.3 Where are they used?*

CTC, CFCs and HCFCs can be feedstocks either by being fed directly into the process as a raw material stream or they can be produced as an intermediate in the synthesis of another product. Fugitive leakage when CTC, HFCs and HCFCs are directly fed is likely to be somewhat higher since losses can occur during transport, if necessary, and transfers. Intermediates are normally stored and used at the same site and so fugitive leaks are somewhat lower in this case.

Common feedstock applications include, but are not limited to the following:

- conversion of CFC-113 to chlorotrifluoroethylene. The latter is subsequently polymerised to poly-chlorotrifluoroethylene, a barrier resin used in moisture-resistant packaging;
- conversion of CFC-113 and CFC-113a to HFC-134a and HFC-125 this is one of the options to produce those HFCs;

- conversion of HCFC-22 to tetrafluoroethylene (TFE). TFE forms the building block of many fluoropolymers both by homopolymerisation and copolymerisation. This is a very high volume use;
- conversion of HCFC-142b to vinylidene fluoride which is polymerised to polyvinylidene fluoride or to copolymers;
- conversion of carbon tetrachloride (CTC) to CFC-11, CFC-12, etc. This has historically been a very high volume application. However, as the phase-out of CFC production continues, volumes of CTC for this application will diminish;
- use of bromochloromethane (BCM) in the preparation of intermediate chemicals for pharmaceuticals; and
- use of methyl bromide to prepare quaternary ammonium bromide salts.

#### 6.3.4 *Estimated emissions of ODS*

Decision X/12 requested TEAP to report on emissions from use of CTC and other ODSs as feedstocks, but no consolidated data are available. Such emissions are likely, of course, to be small, but nonetheless may be significant as the major sources of emissions are phased out under the Montreal Protocol.

A useful comparison can be made with disposal and destruction of ODS, which were dealt with in detail under Decision IV/11 and Annex VI and VII, while for other ODSs, it was recommended that “atmospheric releases of ODSs shall be monitored at all facilities with air emission discharges (where applicable), to ensure compliance with the recommendations of the report of the ad hoc Technical Advisory Committee on Destruction Technologies”.

The IPCC recommends that emissions can be estimated from production facilities at 0.5% for HFCs and 0.2% for SF<sub>6</sub>. This includes fugitive and transport emissions. Given that emissions will vary according to a number of variables, which include plant location, technology used, plant size, availability and transport of ODS, and local regulations it seems appropriate to consider ranges of emissions. If one accepts that 0.5-4% is an appropriate guidance level for products transported and used as raw materials while 0.2-2% is an accepted leakage rate for intermediates with no interplant transport, calculations from 2002 production data suggests that there are three major groups of feedstock uses.

- ODS used in production of HFCs equals to 334,000 tonnes.
- Emission volume of ODSs between 668-6,680 tonnes.
- ODP impact of emissions equals to 315-3,150 ODP tonnes.
- Production of fluoropolymers equals to 225,000 tonnes.
- Emission of ODS between 1,125-9,000 tonnes.

- ODP impact of emissions equals to 62-496 ODP tonnes
- CTC used in production of CFCs equals to 107,000 tonnes in the year 2000).
- Emission of ODS between 214-2140 tonnes.
- ODP impact of emissions equals to 235-2350 ODP tonnes.

Therefore total emissions from feedstock use are on the order of 2,000-18,000 tonnes and contribute about 612-6,000 ODP tonnes.

Additional research into all feedstock uses, levels of emission and methods to limit emissions will be done by the CTOC for the preparation of the 2006 progress report.

## **6.4 Laboratory and Analytical Uses**

Under Decision IX/17 an Essential Use Exemption for laboratory and analytical uses of ODS was introduced, Decision X/19 extended this exemption until 31 December 2005. Decision XV/8 further extended the exemption until 31 December 2007 and asked TEAP to report annually on the development and availability of laboratory and analytical procedures that can be performed without using the controlled substances in Annexes A, B, and C (groups II and III). The CTOC has prepared the following update.

### *6.4.1 Update on Laboratory and Analytical Procedures*

A review of international standards utilising a commercially available standard searching service was initiated for bromochloromethane (BCM) and carbon tetrachloride (CTC). The search for “bromochloromethane” and “chlorobromomethane” produced 104 active standards, most of which covered fire suppression. Only five of the standards were found that use BCM for laboratory or analytical purposes and in very small amounts as an internal standard.

The search for “carbon tetrachloride” found over one thousand active standards. A review of all of these has not yet been completed, however 52 of them are ASTM “Standard Test Methods” and 22 of them are ASTM “Standard Practices” which are likely to require use of CTC for laboratory and analytical uses. Many of the ASTM documents reviewed so far utilise CTC for minor or even optional portions of the standards. However, more time will be needed to assess the total impact that these and other industry standards will have on CTC usage.

To cover all standards organisation and all substances in Annexes A, B, and C, groups II and III, of the Protocol will indeed take a great effort. This has been recognised earlier and suggested in the TEAP 2003 report to “consider holding a workshop on the elimination of controlled substances in laboratory

and analytical uses. Such a workshop could review the new methods that have enabled the phase out of the uses as defined under Decision XI/15. This would assist Parties, especially in Article 5(1) countries, to revise their analytical standards and thereby eliminate ODS use. The workshop could also identify remaining uses of controlled substances and their potential substitutes. This could expedite the incorporation of new analytical methods into national and international standards.”

#### 6.4.2 *Comments and Recommendations*

No new non-ODS methods have been forthcoming which would enable the TEAP to recommend the elimination of further uses of controlled substances for laboratory and analytical uses.

The recent formation of the Chemicals Technical Options Committee (CTOC) will allow the subject of laboratory and analytical uses to receive renewed attention.

The CTOC will appreciate any information that Parties may supply on new ODS-free testing methods that come to their attention.

A workshop on the elimination of controlled substances in laboratory and analytical uses would assist Parties to phase out the uses as defined under Decision XI/15. The workshop could also identify remaining uses of controlled substances and their potential substitutes. This could expedite the incorporation of new analytical methods into national and international standards.

In light of Decision X/19, Parties may wish to further extend the global laboratory and analytical essential-use exemption as defined in Decision XVI/16.

Parties may wish to consider that there are Laboratory and Analytical Uses for Methyl Bromide and note that these uses are not currently included in the global laboratory and analytical essential-use exemption.

Parties may wish to consider extending the laboratory and analytical use exemption to allow the use of methyl bromide in laboratory and analytical uses as an exempted use with appropriate standards of purity, special packaging and other strategies to avoid unauthorised use.

#### 6.5 **Aerosol Products, Non-medical**

The April 2000 TEAP Report already indicated that there were no technical barriers for the transition to alternatives for aerosol products other than MDIs. Some residual uses of CFCs still remain in the aerosol sector of some Article 5(1) countries; these uses are apart from medical aerosols, which are dealt

with by the MTOC. CFC uses belong usually to the following categories for which there may be local use exemptions:

- technical aerosol products that need to be non-flammable;
- cans that contain CFC refrigerant only; and
- products made by SMEs that cannot use Hydrocarbon Aerosol Propellants (HAPs).

Products in the first group include consumer type aerosol products that must be applied in an environment where flammability must be avoided such as aircraft insecticides, and disinfectants for operating rooms; and technical specialties such as spinneret sprays, contact cleaners, and welding anti spatter. Consumption of CFCs in China for this sector has been estimated at 150 ODP tonnes, consumption in other countries is much smaller.

The second category is related to the servicing refrigeration sector, it allows purchase of refrigerant with a small out-of-pocket expense. However, this use should be discouraged as it is associated with small users, which are poorly trained and will incur in large CFC unitary losses.

The third group has been addressed by projects of the Multilateral Fund. Any remaining consumption must be small and hard to identify. Access to CFC propellants for this type of users will become increasingly difficult due to the phase-out schedule of CFCs after 2005.

Technical aerosol products can be formulated using HFCs, which are also non-flammable, but the price difference against CFC products is too large for the markets of Article 5(1) countries, and therefore conversion will not occur unless specifically mandated.

## **6.6 Carbon Tetrachloride (CTC) Emissions and Opportunities for Reduction (Decision XVI/14)**

Under the decision XVI/14, TEAP is requested;

1. To assess global emissions of carbon tetrachloride being emitted:
  - (a) From feedstock and process agent sources situated in Parties not operating under paragraph 1 of Article 5;
  - (b) From sources situated in Parties operating under paragraph 1 of Article 5 already addressed by existing agreements with the Executive Committee of the Multilateral Fund;

(c) From feedstock and process agent uses of carbon tetrachloride applied in Parties operating under paragraph 1 of Article 5 not yet addressed by agreements with the Executive Committee of the Multilateral Fund;

(d) From sources situated both in Parties operating under paragraph 1 of Article 5 and in those not so operating that co-produce carbon tetrachloride;

(e) From waste and incidental quantities of carbon tetrachloride that are not destroyed in a timely and appropriate manner;

2. To assess potential solutions for the reduction of emissions for the categories above;

3. To prepare a report for the consideration of the Parties at the Eighteenth Meeting of the Parties in 2006.

In accordance with decision XVI/14, TEAP will provide a full report on the issue in 2006. An interim report on the subject is provided below.

#### 6.6.1 *Emission Sources*

##### 6.6.1.1 Production and Consumption

The current production and consumption of CTC are discussed in the October 2004 TEAP BDN Task Force Report. According to this report some of the data given in Table 6-1 show an irregular “unreliable” behaviour and it is impossible to derive any relationship between production and consumption of non-Article 5(1) countries, and the consumption of Article 5(1) countries, taking into account their own production.

What could be assumed with the data given in the October 2004 TEAP BDN Task Force Report is that the numbers quoted in Table 6-2 should be close to the total production, as the use for process agent and solvent would be minor compared to the use as feedstock. From this table and from David Sherry's Study for the World Bank on “CTC Production and Consumption 1992-2002”, the production for non-Article 5(1) countries in 2002 could be assumed to be approximately as follows: EU 60,000 tonnes; USA 20,000 tonnes, Russia 10,000 tonnes and Japan 10,000 tonnes for a total of 100,000 tonnes in non-Article 5(1) countries.

EU and USA are said to have exported 20,000 tonnes and 10,000 tonnes, respectively from these productions to Article 5(1) countries. This leaves the EU with 40,000 tonnes, USA with 10,000 tonnes, Russia with 10,000 tonnes and Japan with 10,000 tonnes for their domestic feedstock uses. No more recent statistics are available.

Among Article 5(1) countries, the two major countries that produce CTC are China and India. Using the same basis as for non-Article 5(1) countries, that

is considering the use for process agent and solvents as minor compared to the use as feedstock, it is possible to derive production figures from Table 6-2 of the October 2004 TEAP BDN Task Force Report and from the study by Sherry. Thus, the production for the two countries in 2002 could be assumed as follows; China 60,000 tonnes, and India 20,000 tonnes. As China banned imports of CTC since April 2000, the majority of imports shown in Table 6-2 is for India and is assumed to be around 20,000 tonnes. Both China and India are assumed to have used the majority of their production and import as feedstock for CFC production. Solvents uses of CTC as cleaning agent are known in Article 5(1) countries and the 2002 STOC Report gave an estimate of the solvent use among them in 2000 at around 14,000 tonnes, of which 5,000 to 6,000 tonnes were assumed to be used as process agents. More recently, China has reported Process Agent Uses of about 10,000 tonnes and 1,000 tonnes for solvent uses.

Other Article 5(1) countries that may be producing CTC are Brazil, South Korea and North Korea, but their usages are unknown. No new statistical numbers are available. From the numbers given above, total world-wide production of CTC can be estimated at less than 200,000 tonnes in 2002.

#### 6.6.1.2 Emissions

Among non-Article 5(1) countries USA, Japan and some EU countries report emissions on CTC.

Fugitive atmospheric emission records of CTC in the US are made public for the years 2000, 2001 and 2002 at 32.6 tonnes, 30.4 tonnes and 115.4 tonnes, respectively. The record does not give any details about the nature of the sources whether they are from feedstock operation or from use as Process Agents. As there is no information available to assume the production and consumption for the years 2000 and 2001, the reason for the significant increase in emissions in 2002 compared to the two previous years cannot be explained.

Japan reports fugitive atmospheric emission of CTC for the years 2001, 2002 and 2003 at 71.9 tonnes, 65.7 tonnes and 45.9 tonnes, respectively. As for 2003, additional information is provided and within the 45.9 tonnes reported for that year, 41.0 tonnes are emitted by the chemical industry. As Japan does not have any Process Agent Uses, these are likely from feedstock operations.

Among EU countries, UK reports its atmospheric releases of CTC for the years from 1998 through 2003 at 30.1 tonnes, 31.7 tonnes, 26.4 tonnes, 15.0 tonnes, 5.0 tonnes and 8.7 tonnes, respectively. No further information is available to identify the source.

Article 5(1) countries currently do not report CTC emissions, so no data are available neither on the volume emitted nor the sources that may be making

emissions. No numbers were available on the CTC emission from sources that co-produce CTC, or on waste and incidental quantities not destroyed in a timely and appropriate manner.

If CTC emissions from all feedstock uses are assumed to be 2,500 ODP tonnes, emissions of Process Agent Uses are estimated at 15,000 ODP tonnes and emissions from solvent cleaning and laboratory and analytical uses are calculated at 3,000 ODP tonnes, total emissions of CTC should be around 20,000 ODP tonnes per year.

CTOC is aware of different studies that estimate CTC emissions from *in situ* atmospheric abundances (i.e. AGAGE). Estimated emissions derived from tropospheric CTC measurements show a decline in the extent of emissions, but still remain two to three times higher than those that could be expected for a world-wide production level of 200,000 tonnes and assumed emissions of less than 25,000 tonnes. CTOC will study these discrepancies and report its findings next year.

#### 6.6.2 *Overviews of Potential Solutions for the Reduction of emissions*

It is difficult to identify potential solutions for the reduction of emissions, as there are no accurate numbers that relate the emissions directly to specific operations. The information available only enables to provide a general overview.

As most of the operations in non-Article 5(1) countries are expected to have reasonable control on the release of chemicals to the atmosphere, and as CTC is a controlled and toxic chemical that cannot be produced nor used freely, CTC emissions are assumed to be under fairly tight control in non-Article 5(1) countries. Tightening of emissions from venting, and increasing recovery rates are considered as potential methods to further reduce these emissions. At the same time, production and consumption of CTC in non-Article 5(1) countries should be further reduced with decreased usage as feedstock for CFCs.

In Article 5(1) countries, gradual phase-out of CFCs according to phase out national programs, for example in China and India, should contribute significantly to the reduction of CTC emissions. Tighter control on operations where CTC is used as feedstock or as Process Agent should be introduced as in non-Article 5(1) countries.

Disposal of CTC should also be considered as a method of reducing emissions. Proper destruction procedures and good housekeeping in destruction operations should be utilised where there is surplus CTC.



## 6.7 Solvents

### 6.7.1 *Technical Progress*

Since the signing and ratification of the Montreal Protocol, intense research efforts have been underway to replace the critical solvents that are ozone depleting substances. Primarily, CFC-113 and 1,1,1-trichloroethane were used extensively in precision and metal cleaning. The former Solvents Technical Options Committee dedicated several chapters to uses and replacement by alternatives for these solvents.

Since the phase-out of the widely used CFCs and 1,1,1-trichloroethane in non-Article 5(1) countries a number of new solvents that claim to be replacements are being marketed. The critical parameter for alternatives continues to be that they are non-ozone depleting substances. A notable exception is the hydrochlorofluorocarbons (HCFCs) which possess low ozone depletion potentials, but they are scheduled to be phased out by the year 2020 or before in non-Article 5(1) countries.

Several promising alternatives have emerged from the intense research dedicated to finding replacements to the traditional ODS solvents. Hydrofluoroethers (HFEs), hydrofluorocarbons (HFCs), and hydrochlorofluorocarbons (HCFCs), which have an ODP themselves, are some of the more widely used substitutes. HFEs and HFCs unfortunately do not possess the solvent power of the compounds they are replacing. They therefore require additional substances to render them solvent effective. As a result blends or azeotropes are required to replace solvents that were single species.

Ideal replacements have not been found; therefore, the trend to more conventional, and actually less desirable solvents, becomes necessary. Some of these include non-halogenated organic solvents such as alcohols, aliphatics, ketones, aldehydes and blends of aliphatic, cyclic or aromatic hydrocarbons and derivatives. Chlorinated compounds such as trichloroethylene, perchloroethylene and methylene chloride have resurged in the solvent sector.

Volatile methyl siloxanes and chlorinated aromatics have also been evaluated.

Perfluorocarbons while excessively high in global warming potential are being reconsidered. n-Propyl bromide is being widely explored in the United States as a solvent substitute but has considerable disadvantages (See Section 7.2).

Another category of alternative solvents being explored is that of bio-based materials. Essentially these are compounds formed from bio-organic products such as corn and soy beans. While there is considerable enthusiasm in this

area, the likelihood of these replacing solvents that have been used for critical cleaning applications appears small at this time.

Stockpiling of critical cleaning solvents was considered an option. Of course when the supply is depleted a critical situation again arises and stockpiling only delays reality.

The UNEP and country environmental protection agencies recognise that there are areas where there is no direct replacement of solvents for high technology projects. These projects were developed predicated on the benefits of the solvent. In these cases a mechanism of essential exemption exists. Proposals are made to continue the use of critical solvents until suitable replacements are found or the project terminates. This is a process that grants exemptions only in very few cases and is not intended to be a method of circumventing the need for continuing research and development.

Summary: Since the last UNEP STOC report no new and novel alternatives have been developed. Further it is unlikely that there will be new solvent alternative breakthroughs. Major chemical companies are reluctant to embark on expensive research projects, the products of which are subject to extensive scrutiny by federal and state agencies. In addition the time frame is extremely long, in some cases many years. Thus far only the HFCs, HCFCs and HFEs are leading the field in halogenated solvent replacements, although they have a high purchase cost per unit weight. Aqueous and “no-clean” techniques are most widely used for replacement of OD solvents.

#### 6.7.2 *n*-Propyl Bromide (*n*-PB) Update (Decision XIII/7)

Under Decision XIII/7, TEAP was requested to report annually on *n*-PB use and emissions.

##### 6.7.2.1 Market Trends

Use of *n*-propyl bromide (*n*-PB) continues (in spite of toxicity concerns and pending proposals to reduce exposure guidelines) due to its good solvency and relatively low cost. Its current use estimates range from 2,200 MT to 9,100 MT per year. This substance has a very short atmospheric lifetime of 11 to 25 days, and its ODP for emissions in the tropics is greater than the ODP for emissions at northern latitudes. *n*-PB has an ODP that ranges from 0.013 to 0.1 depending on where it is emitted.

*n*-PB has been used as feedstock for the synthesis of pharmaceuticals and other organic compounds for a long time. In the last few years, its uses have grown as a solvent for industrial cleaning for degreasing, metal processing and finishing, electronic defluxing and other cleaning applications in aerospace and aviation. It has also successfully captured some applications in aerosol formulations and as a carrier solvent for adhesives, inks and coatings.

n-PB is also promoted by its vendors as a substitute for non-OD trichloroethylene, dichloromethane (methylene chloride) and perchloroethylene and ozone depleting chlorofluorocarbons (CFC) in many applications.

It is marketed as n-Propyl Bromide or Propyl Bromide as well as under many trade names such as Leksol, Ensolve, Solvon, Abzol, VDS-3000, Hypersolve, and Lenium. (This is not a complete list of all trade names under which n-PB and its blends are sold).

Guidelines from manufacturers suggest exposure limit of around 10-25 ppm. Only a few stay with 100 ppm.

#### 6.7.2.2 Recent Toxicity Data and Proposed Regulatory Actions

Long term (chronic) testing of n-PB in animals has shown toxicity to the reproductive systems of both males and females. In males, it affects sperm counts and motility, testicles and prostate. In females it damages ovaries and results in sterilisation. Based on the reproductive toxicity data the Commission of the European Communities has proposed adding n-PB to the list of dangerous chemicals that can cause cancer, have mutagenic properties or are toxic to reproduction.

The Environmental Protection Agency (EPA) of the USA has suggested an exposure limit of 25 ppm.

n-PB also has significant neurotoxicity to animals and humans. The animal study showed significant neurological effects on animals at various dose levels. A recent case study involving five workers whose job was gluing foam cushion with glue containing the solvent n-PB, reports that they developed serious neurological symptoms, some of which appear to be permanent.

Based on these recent findings and until more toxicological test data become available, the American Conference of Industrial Hygienists (ACGIH) has recommended an exposure limit for solvents containing n-PB of 10 ppm. Hazard Evaluation System and Information Services (HESIS) of California Department of Health Services have gone a step further and has suggested that worker exposure should be limited to about 1 ppm (a meeting has been called for May 2005, proposing the 1 ppm recommendation be made mandatory). Also the Office of Environmental Health Hazard Assessment (OEHHA) of California announced on Nov 8, 2004 its intention to add n-PB to the Proposition 65 list as a chemical known to the State to cause reproductive toxicity. So far only one of the n-PB vendors has reduced the recommended exposure limit to 10 ppm.

## **6.8 Update on Essential Use Exemption for 1,1,1-Trichloroethane (Methyl Chloroform) Used in Aerospace Applications**

### *6.8.1 Brief History of 1,1,1-Trichloroethane (Methyl Chloroform) Solid Rocket Motor Essential Use Exemption*

At the Sixth and Seventh Meetings of the Parties (Decision VI, Nairobi, 1994 and Decision VII/28, Vienna, 1995) Parties granted an initial Essential Use Exemption (EUE) to the United States for the use of 1,1,1-trichloroethane for aerospace applications including the manufacture and assembly of solid rocket motors used on the Space Shuttle and Titan. One important reason that the EUE was granted is that 1,1,1-trichloroethane is chemically unstable and could not, at that time, be reliably stockpiled for critical uses in aerospace applications where extraordinarily high technical standards must be achieved. At the Tenth Meeting of the Parties (Decision X/6, Cairo, 1998) Parties agreed that the remaining quantity of 1,1,1-trichloroethane, authorised for the United States at previous meetings, be made available for use in manufacturing solid rocket motors until such time as the allowance is depleted, or until such time as safe alternatives are implemented for remaining essential uses.

NASA and their contractors are currently working to re-qualify the Space Shuttle for return to flight status, following the February 2003 accident when the Space Shuttle Columbia was lost during its re-entry into earth's atmosphere causing the death of the seven astronauts onboard.

NASA/Thiokol estimates that the remaining quantity of 1,1,1-trichloroethane granted under the existing EUE is sufficient for anticipated Shuttle flights and for the first stage of the transition to the next-generation space vehicles that will monitor the earth's ecosystems and explore outer space.

### *6.8.2 Progress on Reducing Use and Emissions*

There has been some progress in further reducing and eliminating the use and emissions of 1,1,1-trichloroethane, but alternatives and substitutes are not yet available for some critical applications. Since 1989, 1,1,1-trichloroethane use has been reduced from 635 tonnes per year to approximately 16 tonnes per year in 2002, 2003, and 2004. Actual future use depends on the number of Shuttle flights, the inventory of rocket motors, and adjustments in manufacturing procedures to maintain safety and to upgrade technology.

### *6.8.3 Accounting Framework and 1,1,1-Trichloroethane Inventory*

Until January 2005, Thiokol/NASA used stockpiled 1,1,1-trichloroethane for uses not requiring the highest levels of purity and purchased small batches of freshly-manufactured 1,1,1-trichloroethane for the most critical applications, where absolute purity is essential. In 2004, Thiokol/NASA placed a portion of the remaining 102 tonnes of 1,1,1-trichloroethane granted under the EUE

authorisation and placed this inventory in a sophisticated leak-tight, refrigerated storage system designed to maintain chemical purity. To date, Thiokol has used or stockpiled about 47% of the total amount granted under the EUE. The strategy of manufacturing and storing 1,1,1-trichloroethane was made necessary by national legislation prohibiting the manufacture of 1,1,1-trichloroethane after January 1, 2005. NASA has reconfirmed that it will destroy any 1,1,1-trichloroethane manufactured under terms of the EUE that is unneeded or unusable.

#### 6.8.4 *TEAP Recommends Continued EUE*

TEAP concurs with the NASA/Thiokol technical assessment confirming the importance of the continuing use of 1,1,1-trichloroethane for their critical aerospace applications and reaffirms its recommendation for the already-granted EUE.

### 6.9 **Destruction Technologies (Decision XVI/15)**

Under Decision XVI/15 (Review of Approved Destruction Technologies Pursuant to Decision XIV/6), the following requests were made:

- to solicit information from the technology proponents on destruction technologies identified as “emerging” in the 2002 Report of the Task Force on Destruction Technologies;
- if new information is available, to evaluate and report, based on the development status of these emerging technologies, whether they warrant consideration for addition to the list of Approved Destruction Technologies; and
- report through the TEAP to the 25<sup>th</sup> OEWG

#### 6.9.1 *Review of 2002 Task Force Report*

The TEAP Task Force on Destruction Technologies reported update of ODS destruction technologies on April 2002. The report assessed 45 identified technologies both in demonstration-scale and pilot-scale.

The criteria for screening the destruction technologies:

- destruction and removal efficiency (DRE) which is more than 95% for dilute sources (foams) and more than 99.99% for concentrated sources;
- environmental standards such as atmospheric emissions of PCDDs/PCDFs, HCl, HF, HBr/Br<sub>2</sub>, CO, and TSP (total suspended particulates); and

- technical capability in which the processing capacity of an acceptable pilot plant or demonstration plant must be no less than 1.0 kg/hr of the substance to be destroyed, whether ODS or a suitable surrogate.

The application of criteria such as DRE to the destruction of materials where the ODS are contained, such as foams, cannot be done without considering the several steps that might constitute a “destruction technology”. Handling of these materials is often complicated by the fact that they are used as composites in which foam, metal, or building and other materials may be incorporated.

Disposal at end-of-life may involve shredding or otherwise abrading the ODS-containing material, and may lead to unaccounted emissions of ODS. Further losses may occur during transport of the material to the point of destruction, which may be a kiln or incinerator (see below) which has high destruction efficiency. Despite the high DRE that might be observed in this final step, the overall process may not have high DRE because of uncontrolled emissions in the earlier stages of collection. In other cases, such as disposal in a blast furnace where emphasis on metal recovery and conditions are such as to destroy ODS, a single step is involved and high DRE can be achieved. Hence, it is necessary in assessing any technology to consider all aspects of the disposal process, not merely the final step. This matter is discussed in the foams section of the 2005 TEAP Report

#### 6.9.2 *Recommended Destruction Technologies*

Sixteen technologies were evaluated as “screen-in” technologies, among which the Task Force recommended 12 technologies now being operated in commercial-scale and shown in Table 6-2.

Japan mandated the component recovery and recycling law from domestic appliances, which include the refrigerants from the compressor in April 2001. As a result, the recovery of refrigerants increased from 136 tonnes in the period between April 2001 and March 2002 to 287 tonnes between April 2003 and March 2004. The number of approved destruction facilities increased from 29 sites in July 2002 to 69 sites in July 2003. Since the law enforced recovery of the blowing agents from domestic appliances from April 2004, the amount of ODS for destruction is expected to increase.

Similar destruction plants in the EU are found in UK and Germany. Draft regulations have been prepared which will require fluorinated gases such as HFCs and PFCs to meet stipulations similar to those that apply to ozone-depleting substances.

**Table 6-2** Screened-In Technologies and their Applicability

Technology	Applicability		
	Foams CFCs	CFCs	Halons
Cement Kilns*	P	Y	P
Liquid Injection Incineration*	X	Y	Y
Gaseous/Fume Oxidation*	X	Y	Y
Municipal Solid Waste Incineration*	Y	X	X
Reactor Cracking*	X	Y	P
Rotary Kiln Incineration*	Y	Y	Y
Argon Plasma Arc*	X	Y	Y
AC Plasma	X	P	P
CO <sub>2</sub> Plasma	X	P	P
Inductively Coupled Radio Frequency Plasma*	X	Y	Y
Microwave Plasma*	X	Y	P
Nitrogen Plasma Arc*	X	Y	P
Gas Phase Catalytic Dehalogenation*	X	Y	P
Gas Phase Chemical Reduction	X	P	P
Solvated Electron Decomposition	X	P	P
Superheated Steam Reactor*	X	Y	P

Y (Yes) = Technology demonstrated on this category of ODS

P (High Potential) = Technology not demonstrated specifically on this category of ODS, but considered likely to be applicable based on evidence of destruction of other substances (i.e., refractory halogenated organics), and on professional judgement.

X = not applicable

\* = Recommended Destruction Technologies

### 6.9.3 Emerging Destruction Technologies

Twenty-nine destruction technologies were “screened-out” in the report of 2002 Task Force on Destruction Technologies. Limited surveys indicated that no emerging technology meets the criteria of the recommendation in pilot-scale or demonstration-scale. However, because the destruction of fluorinated gases (HFCs, PFCs, and SF<sub>6</sub>) may be required for mitigation of global warming, such destruction technologies should be investigated in near future, i.e. HFC-23, a by-product of HCFC-22 manufacture, is destroyed by the technologies recommended by the 2002 Task Force Report.

**Table 6-3** Screened-Out Technologies

#### 1. INCINERATION TECHNOLOGIES

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- 1.1 Waste gasification
  - 1.2 Gas Injection Oxidation/Hydrolysis
  - 1.3 Blast Furnaces
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#### 2. PLASMA TECHNOLOGIES

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- 2.1 Plasma Conversion of CFCs into Harmless Polymer Using Ethylene or Ethane as Co-monomer
- 2.2 Destruction of ODS in Dilute Exhaust Stream Using Energetic Electron Induced Plasma-Adsorbent Filter Hybrid System

- 2.3 High Voltage Gliding Arc Plasma Discharge Reactor for CFC Destruction
- 2.4 CFC-113 Destruction in Air under the Effect of Nanosecond Corona and Microwave Discharger

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### 3. CHEMICAL DESTRUCTION TECHNOLOGIES

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- 3.1 Chemical Reduction of ODS using Metallic Sodium on a Solid Substrate
- 3.2 Chemical-Thermal Destruction of Halogenated Hydrocarbon with Calcium Silicate or Oxide
- 3.3 Mineralisation of CFCs with Sodium Oxalate
- 3.4 Aerosol Mineralisation of CFCs by Sodium Vapour Reduction
- 3.5 Molten Metal Technology (MMT)
- 3.6 Pressurised Coal Iron Gasification (P-CIG)
- 3.7 Dormier Incineration Process in Steel Smelter
- 3.8 Destruction of CFCs during Chemchar Gasification
- 3.9 Liquid Phase Chemical Conversion

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### 4. PHOTOCHEMICAL TECHNOLOGIES

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- 4.1 UV Photolytic Destruction
- 4.2 UV Laser Photolysis for the Destruction or Transformation of Halon 1301 into CF<sub>3</sub>I
- 4.3 Photochemical Degradation of Organic Wastes with a TiO<sub>2</sub> Catalyst
- 4.4 UV Laser Controlled Decomposition of CFCs

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### 5. CATALYTIC TECHNOLOGIES

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- 5.1 Dry Distillation Destruction System for Waste Foam and Refrigerants
- 5.2 Halohydrocarbon Destruction Catalyst
- 5.3 Catalytic Oxidation of CFCs with a Pt/ZrO<sub>2</sub>-PO<sub>4</sub> Based Catalyst
- 5.4 CFC Oxidation in a Catalyst-Sorbents Packed Bed
- 5.5 Transformation of CFCs to HFCs Using Dehalogenation Catalysts in a H<sub>2</sub> Environment

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### 6. OTHER TECHNOLOGIES

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- 6.1 Use of Waste CFC in an Antimony Process
- 6.2 CFC Destruction into Biocatalytic System
- 6.3 Supercritical Water Oxidation (SCWO)
- 6.4 Electrohalogenation of CFC-113 on Pb/Pd Cathodes Combined with H<sub>2</sub> Diffusion Anode

The CTOC notes that there are similarities in the search for and investigation of destruction technologies for ODS and that for technologies for destruction of Persistent Organic Pollutants (POPs) such as PCBs and organochlorine pesticides, under the Stockholm Convention. In this latter case, UNEP Chemicals and the GEF have sponsored preparation of an evaluation of non-incineration technologies for POPs, and this is available at [www.unep.org/stapgef](http://www.unep.org/stapgef).

Six commercialised technologies with considerable experience and licensed to destroy high-strength POPs stockpiles were identified: gas-phase chemical reduction, base catalysed decomposition, super-critical water oxidation,



sodium reduction, plasma arc and pyrolysis/gasification. A number of other technologies were classified as nearing commercial status.

## **6.10 Conclusions**

In a limited survey, the destruction technologies are updated as:

- among the identified 45 technologies reported by the 2002 Task Force on Destruction Technologies, the number of facilities equipped with recommended 12 technologies is increased in Japan;
- no appreciable advance is found in the rest of the 29 emerging technologies; and
- because of the mandatory recovery and recycling of ODS and fluorinated gases, a comprehensive update of destruction technologies for fluorocarbons is necessary in the near future.

## **APPENDIX 6-1 Proposed ODS – Process Agents Handbook**

Parties have clarified the distinction between the use of a controlled substance (ODS) as feedstock – in which case the substance is converted into some other substance which may or may not itself be a controlled substance – or as a process agent which is not consumed during the chemical reaction but may play an important role.

Decision X/14 does not include a definition of process agent but instead specifies (Clause 1) that 'the term "process agents" means the use of controlled substances for the applications listed in table A' included in the decision. There followed a list of 25 uses that were classified by Decision of the Parties as involving process agents, and a footnote to the effect that the Technical and Economic Assessment panel (TEAP) would investigate and advise on additions proposed to the list. Decision X/14 included provision (Clause 4(a)) for annual reporting of 'their use of controlled substances as process agents, the levels of emissions from these uses, and the containment technologies used by them to minimise emissions of controlled substances'.

Decision X/14 has exempted from the control measures the ODS produced or imported for use as process agents in plants in operation before 1 January 1999, subject to two other significant conditions for exemption. The first (Clause 3) was that the emissions of ODS from the process agent use should have been reduced:

- In case of non-Article 5(1) Parties, to the limits indicated in Table B of the decision, and
- In case of Article 5(1) Parties, to levels agreed by the Executive Committee of the Multilateral Fund.

The second (Clause 7) was that 'Parties should not install or commission new plant using controlled substances as process agents after 30 June 1999, unless the Meeting of the Parties has decided that the use in question meets the criteria for essential uses under decision IV/25'. Under Decision IV/25, uses qualify as 'essential' by Decision of Parties if they are necessary for health, safety or critical functioning of society and that there are no technically or economically feasible alternatives.

Decision X/14 also includes agreement (Clause 5) that the incremental cost of a range of actions that might be proposed by Article 5 countries 'should be eligible for funding in accordance with the rules and guidelines of the Executive Committee of the Multilateral Fund'. This decision also made provision (Clause 4) for annual reporting of 'their use of controlled substances as process agents, the levels of emissions from these uses, and the containment technologies used by them to minimise emissions of controlled substances' and 'the quantities of ODS produced or imported for process agent

applications'. The Ozone Secretariat will review these data and call for any other necessary information to ensure that the exemptions satisfy the conditions. Clause 8 provides, *inter alia*, for a review of Tables A and B by the TEAP.

Earlier, in decision VI/10, the Parties had agreed to request the TEAP identify uses of controlled substances as process agents and 'to evaluate alternative process agents or technologies or products available to replace controlled substances in such uses'

The 2001 TEAP Process Agents Task Force found that controlled substances are typically used in chemical processes as process agents for at least two of the following unique chemical and/or physical properties:

- Chemically inert during a chemical reaction.
- Physical properties, e.g.
  - boiling point
  - vapour pressure
  - specific solvency.
- To act as a chain transfer agent.
- To control the desired physical properties of a process, e.g.
  - molecular weight
  - viscosity.
- To increase plant yield.
- Non-flammable/non-explosive.
- To minimise undesirable by-product formation.

Parties making submissions for classification of the use of a controlled substance as process agent need to indicate which of the criteria are met by the particular use being described.

Also, to take account of other Decisions, further information is required on:

- The date when the operation using the chemical process was started;
- The actual quantity of the end-product produced in the year to June 1999 and in each of the last five years;
- The quantities of the emissions of the ODS in the process;
- A description of the measures being taken to reduce the emissions of ODS; and

- What efforts have been made, or might feasibly be made, to replace the ODS.

A flow chart of the process should be provided, containing information about all the chemicals, reactions and separation steps involved in the manufacturing process. The flow chart might include only one step that involves an ODS, but for a recommendation to be made about process agent status, it will be helpful if the whole sequence of reactions is shown. The critical step involving the ODS might be, for example, the conversion of an acid to an acid chloride using a reagent like thionyl chloride, oxalyl chloride or phosphorus oxychloride in solution in carbon tetrachloride, with the acid chloride might then perhaps be involved in further reaction steps that lead to the final product which is mentioned in the submission.

With regard to quantities emitted to the environment, some submissions in the past have provided information about make-up quantities of ODS, leaving open the question of whether or not this quantity equals the total emissions from the process. 'Emissions' can occur directly through leaks or other volatilisation, through discharges of solid or liquid waste containing some of the ODS, or even in product which leaves the process contaminated with small amounts of the ODS. Submissions are more helpful if they show the route and quantity of loss of ODS as well as the make-up quantity. These need to be seen against the background of the quantity of product so that some impression is conveyed of the efficiency of containment of the ODS. If any particular nomination already made is incomplete in respect of any information, the CTOC may identify the information required and request the Secretariat to approach the nominating party to provide this.

### Nomination of a Controlled Substance as a Process Agent

Information Requested	Response from nominating party
Brief description of process (also, attach flow chart).	
Is process agent recoverable unchanged?	
<ul style="list-style-type: none"> <li>▪ Which other criteria are met? Physical property (specify).</li> <li>▪ Chain transfer agent?</li> <li>▪ Control of molecular weight or viscosity?</li> <li>▪ Increase of yield?</li> <li>▪ Non-flammable/ non-explosive?</li> <li>▪ Minimisation of by-product(s)?</li> </ul>	
Date of commencement of process.	
Annual quantities of make-up and emissions of the controlled substance.	
What measures are taken to minimise emissions?	
What alternatives to the use of the controlled substance have been explored?	
What alternatives to the use of the controlled substance could be explored?	
Please add any other matters considered relevant.	



## **7 Methyl Bromide Technical Options Committee (MBTOC) Progress Report**

This section on methyl bromide (MB) updates trends in MB production and consumption, and gives progress in the development and adoption of alternatives. Preliminary information is also given on the registration status of various alternatives in part fulfilment of Decisions Ex.I/4(9i) and Ex.I/4(9j).

### **7.1 MB production and consumption update**

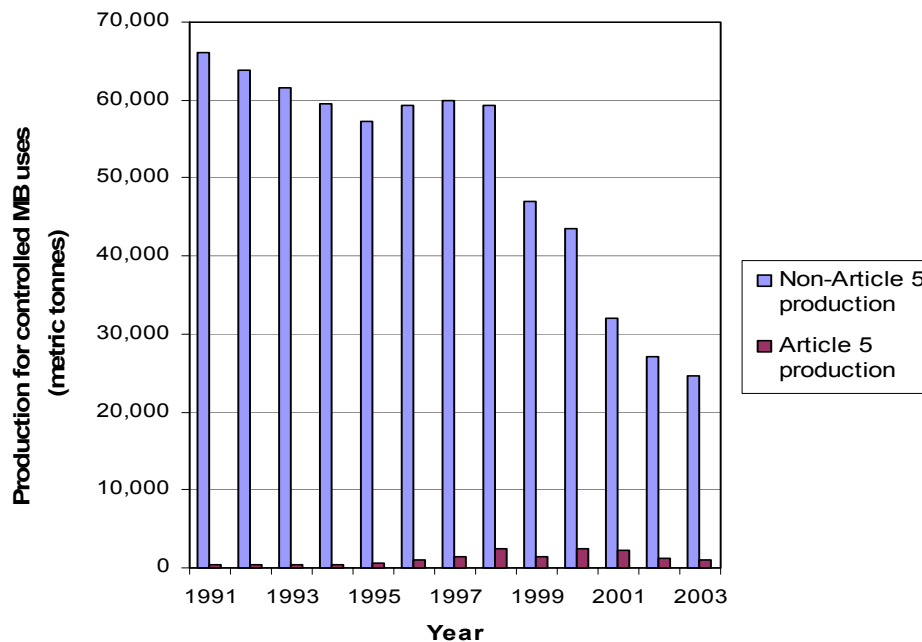
This section provides an update on MB production and consumption, compiled from the Ozone Secretariat's database on ODS consumption and production dated April 2005 (Ozone Secretariat, 2005). The majority of Parties have submitted data for 2003, and the MB data is much more complete than in the past. In the few cases where data gaps still exist, data from the previous year was assumed to apply.

#### *7.1.1 Production trends*

Trends in the reported global production of MB for all controlled uses (excluding QPS and feedstock) are shown in Figure 7-1. MB production for controlled uses in 2003 was about 25,540 metric tonnes, which represented 38% of the 1991 production level (66,430 tonnes). Informal data indicates that production has been further reduced since 2003. Actual use for controlled uses may have been larger or smaller than reported production as a result of changes in the stockpile of MB.

Figure 7-1: Historical trends in reported global production of MB for all controlled uses, excluding QPS and feedstock, 1991 - 2003 (metric tonnes)

Data for 1991 and 1995-2003 was taken from Ozone Secretariat dataset of April 2005. Data for 1992-94 was approximated by MBTOC from several sources.



Non-Article 5(1) countries reduced controlled production from about 66,000 tonnes in 1991 (baseline) to less than 24,580 tonnes in 2003. Non-Article 5(1) MB production was 37% of the baseline in 2003; this included production for use in Article 5(1) countries. Article 5(1) countries reduced their controlled production from a peak of more than 2,380 tonnes in 1998 to approximately 960 tonnes in 2003. Article 5(1) production was 70% of the baseline in 2003 (baseline 1,375 tonnes, average of 1995-98).

A list of known MB production facilities was published in the MBTOC Assessment of 2002 (MBTOC 2003, Table 3.2). In 2003, MB for controlled uses was produced in 2 Article 5(1) countries (China and Romania) and 4 non-Article 5(1) countries (France, Israel, Japan and USA). Several other countries were reported to production of MB for QPS purposes only.

### 7.1.2 Global consumption

Under the Protocol, consumption at national level is defined as MB production plus MB imports minus exports, minus QPS, minus feedstock, so it represents the national supply of MB for uses controlled by the Protocol (i.e. non-QPS fumigant). Note that uses from stockpiles of MB produced before the phase-out are not reported to the Ozone Secretariat. Some countries have

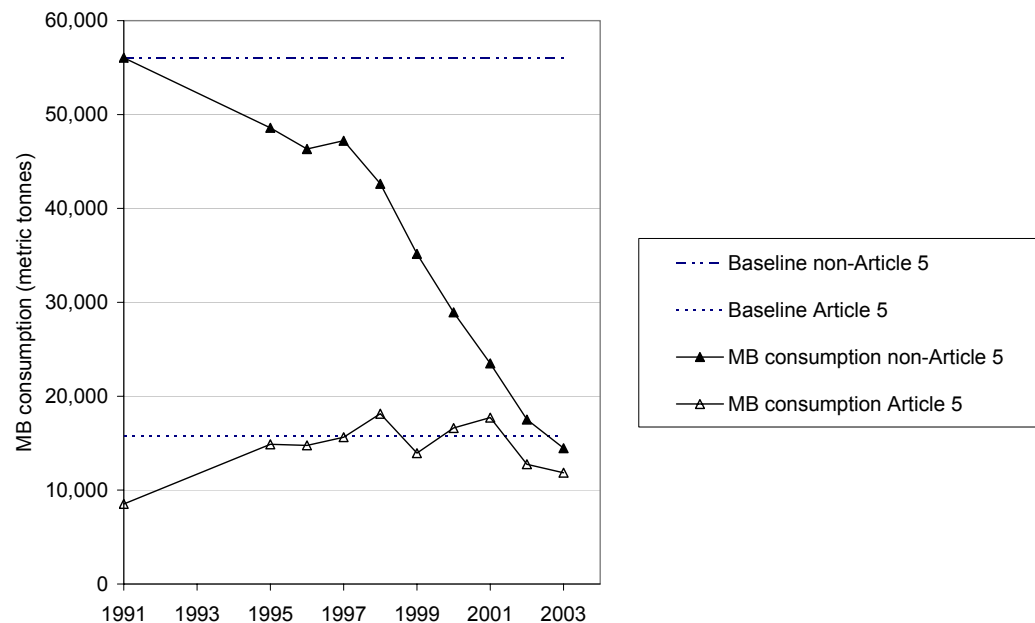


revised or corrected their historical consumption data, so the official figures and baselines change from time to time as a result. However, the corrections, overall, are relatively small. Global consumption of MB for controlled uses was estimated to be about 64,565 tonnes in 1991 and remained above 60 – 63,000 tonnes until 1998. On the basis of Ozone Secretariat data available in April 2005, global consumption was estimated to be 45,527 tonnes in 2000, falling to about 26,336 tonnes in 2003.

Figure 2 shows the baselines and trends in MB consumption for non-Article 5(1) and Article 5(1) regions for the period 1991 to 2003. By 2003, Non-Article 5(1) consumption was 26% of the baseline (baseline was 56,043 tonnes in 1991). By 2003, Article 5(1) consumption was 75% of the baseline (baseline was 15,765 tonnes, average of 1995-98).

*Figure 7-2: Baselines and trends in reported MB consumption in non-Article 5(1) and Article 5(1) regions, 1991 – 2003 (metric tonnes)*

Source: MBTOC estimates calculated from Ozone Secretariat data of April 2005



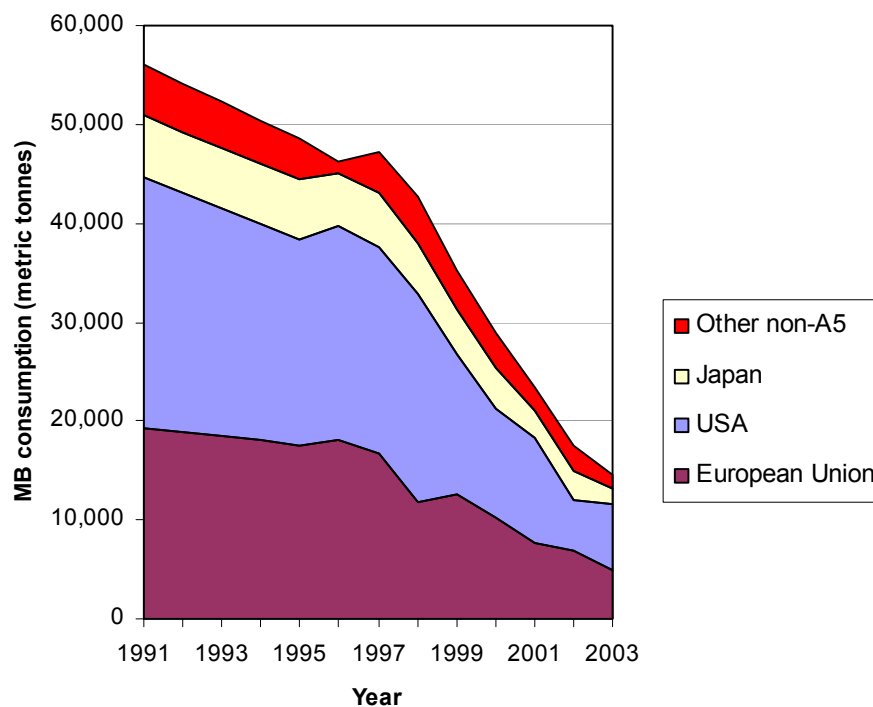
### 7.1.3 Consumption trends in Non-Article 5(1) regions

In non-Article 5(1) regions, controlled MB consumption was reduced from 56,043 tonnes in 1991 to 14,478 tonnes in 2003 (Figure 7-3). By 2003, the three Parties that consumed the largest quantity of MB (USA, European Union and Japan) had reduced national consumption to 26%, 25% and 23% of their respective national baselines. The Montreal Protocol schedule permitted up to

30% of baseline in 2003, so these countries were well within the compliance limit.

*Figure 7-3: Trends in MB consumption in the three largest non-Article 5(1) Parties, and other non-Article 5(1) countries/ regions, 1991- 2003 (metric tonnes)*

Source: Ozone Secretariat data of April 2005



#### 7.1.4 Consumption trends in Article 5(1) regions

Calculated from Ozone Secretariat data, MB consumption in Article 5(1) regions peaked at about 18,140 tonnes in 1998 and fell to about 11,858 tonnes in 2003 (Figure 7-2).

Many Article 5(1) countries achieved considerable MB reductions by 2003:

- Total Article 5(1) consumption in 2003 was 25% below the baseline.
- 106 Article 5(1) Parties reported MB consumption between zero and 10 ODP tonnes in the most recent year (mainly 2003). Of these, 82 Parties reported zero MB consumption.
- Many Article 5(1) countries are implementing MLF projects to reduce or totally phase-out MB. This includes 14 of the 15 largest MB consuming

Article 5(1) countries (i.e. countries that consumed more than 300 metric tonnes in 2000). The exception is South Africa, which is currently preparing a GEF project for MB phase-out.

Ozone Secretariat data indicates that the vast majority of Article 5(1) countries that have ratified the Copenhagen Amendment achieved compliance with the freeze in 2002. The majority of Article 5(1) countries are on track for complying with the 20% reduction step in 2005, according to the MB consumption data reported for 2003. Analysis of the Ozone Secretariat data (Table 7-1 below) indicates that, by 2003, MB consumption in 117 Article 5(1) countries was less than 80% of the national baseline. The table indicates that countries have achieved substantial reductions in advance of the 20% reduction step required in 2005. Only 25 Article 5(1) countries consumed more than 80% of national baseline in 2003.

*Table 7-1: Analysis of national MB consumption (in 2003) compared to national baselines*

Analysis of Ozone Secretariat data of April 2005 covering 142 Article 5(1) countries.

<b>National status in 2003</b>	<b>Number of Article 5(1) countries</b>
MB consumption was 0% of national baseline	87
MB consumption was 1 - 50% of national baseline	19
MB consumption was 50 - 80% of national baseline	11
MB consumption was more than 80% of national baseline	25

#### 7.1.5 *Regarding harmful trade in MB*

The MBTOC was unable to complete the assessment of harmful trade in MB, requested in Decision Ex.I/4(9,a), because its current membership lacks expertise in trade issues, environmental crime, customs codes and procedures, and other technical topics necessary for such evaluation. Therefore, MBTOC respectfully suggests that TEAP work as a committee or task force to comprehensively respond in its 2006 report on this request from Parties. The TEAP can involve relevant experts from national and regional governments, UNEP DTIE, international trade and crime organisations, environmental crime NGOs, and agricultural organizations concerned with food quality fairness of trade. Experts involved in issues of harmful or illegal trade in other ODSs could be valuable in transferring lessons and focusing TEAP's work.

## 7.2 Alternatives in soil sector - update

Many sectors have achieved the necessary MB reductions by the adoption of alternative fumigants, such as fumigant mixtures (e.g. 1,3-D/Pic) or sequential applications of fumigants (e.g. 1,3-D and pic; pic or 1,3-D/Pic followed by metham sodium) (Trout and Damodaran, 2004; Spotti, 2003, 2004). In some cases users have adopted combinations of chemical and non-chemical treatments, such as grafted plants + fumigant (e.g. grafted eggplant + 1,3-D or Pic) (Spotti, 2003, 2004). Non-chemical alternatives such as substrates have been adopted to a lesser extent than chemical alternatives. There is renewed interest in combining alternative fumigants with low permeability barrier films (VIF, or equivalent), because this can increase the efficacy and/or allow reduced doses of alternatives to be used (Ajwa *et al.* 2004), providing shorter plant back times, lower neighbourhood exposures and reduced environmental impact.

Transition strategies can reduce the quantity of MB used per unit area of soil, such as by using mixtures of MB/chloropicrin and/or reduced doses of MB by adoption of low permeability barrier films (e.g. VIF or equivalent) (Gilreath *et al.* 2005; Gullino *et al.* 2003; Reuven *et al.* 2000; Navas- Becerra *et al.* 2000; Hamill *et al.* 2004). Such transition strategies have been widely adopted and have also assisted Parties to reduce amounts of MB to meet 'Critical Use' requirements. However, the state of California in the US prohibits the use of VIF over concerns of possible worker exposure to MB when seedlings are planted or the film is removed (California Code of Regulations Title 3 Section 6450(e)). The use of low permeability barrier films (e.g. VIF or equivalent) is compulsory in the 25 member countries of the European Union (EC Regulation 2037/2000).

An increasing number of research studies (given below) are showing that new or modified formulations of fumigants and new application methods for fumigants are producing yields similar to methyl bromide in diverse situations. In many instances, this has involved a change in cropping practice, i.e. slightly longer plant back times and a greater awareness of soil conditions which improve the efficiency of alternatives, and modification to application machinery. These modifications may have economic implications. Adoption of alternative fumigants has commonly been facilitated by large commercial scale-up studies and field demonstrations so growers become familiar with altered soil and crop management practices. In several instances, industries heavily reliant on methyl bromide have almost completely switched to chemical fumigant alternatives (e.g. tomato and pepper production in Australia). The key chemical alternatives adopted are outlined in the sections below.

### 7.2.1 *Chemical alternatives adopted in commercial practice*

#### ***Chloropicrin***

Owing to its excellent fungicidal activity, chloropicrin (Pic) continues to be developed and adopted as one of the major components of fumigant strategies to replace MB. Traditionally it has been injected into soils as a mixture with MB, but new application methods have improved its use as an MB alternative applied alone or with other products (e.g. 1,3-D/Pic, or Pic followed by metham sodium).

A review of studies in the strawberry fruit sector found that on average the relative yield of shank-injected Pic was 98%, 104% and 101% compared to MB at 100%, in the USA, Spain and Australia respectively. Drip-applied chloropicrin provided an average relative yield of 104% compared to an average of 100% for MB in 5 US studies (Porter *et al.* 2004a). Chloropicrin applied under VIF at dose of 100 kg/ha provided similar yields to MB, while doses of 150 kg/ha provided statistically higher yields than MB (Lopez-Aranda *et al.* 2004; De Cal *et al.* 2004).

Recently, an encapsulated formulation of chloropicrin was developed in China. Much of China's current consumption of MB is applied by smallholders using simple application systems and disposable cans of MB typically weighing about 500g. The encapsulated formulation is simple to apply without special tools. The chloropicrin formulation has been registered in China since 2002 and is in commercial use as a MB alternative.

Emulsifiable formulations of chloropicrin were registered several years ago in Italy, the USA, and Japan (Triagriberia 2002). These formulations are proving a suitable alternative to MB in crop production systems where drip irrigation can be used to facilitate production and in soil types where the fumigant can move freely through the soil. Chloropicrin EC has been adopted as a MB alternative by some strawberry fruit producers in Italy, for example (VDPI, 2004). The formulation can be applied through irrigation/fertigation drip lines, avoiding the need for injection equipment, and also allowing chloropicrin to be used as a MB alternative in some situations where injection equipment cannot be used.

#### ***Chloropicrin and fosthiazate***

In Japan, soil treatment by consecutive applications of chloropicrin and a granular formulation of fosthiazate has become popular among vegetable farmers formerly using MB. Fosthiazate (Nematorin-Ace®) is registered for the control of nematodes as a pre-plant treatment. Chloropicrin is more effective against fungi than against nematodes. Fosthiazate supplements the activity to give a broader spectrum of pest control. In one system, fosthiazate granules are applied to the soil surface and then incorporated into the soil. The

soil is then ploughed and prepared for planting of the seedlings. Next, chloropicrin is applied under plastic film with the covering left in place for at least for ten days. After removing the film, seedlings are transplanted. This can be used in either open field or protected cropping systems. It often used for protected sweet potato cultivation. This method is labour-saving and gives better treatment efficacy because the treated soil has a much smaller chance of contamination with untreated soil because there is no ploughing before transplantation. In an alternative application method, chloropicrin is applied first under plastic. After the plastic is removed, the soil is ploughed to allow residual fumigant to degas. Fosthiazate granules are incorporated into the soil at this time. This method is usually applied in open field systems. This method is applied to chloropicrin-sensitive plants such as tomato and strawberry, because chloropicrin is degassed sufficiently (Tataya and Mizobuchi, 2005).

### ***Chloropicrin and cadusafos***

Cadusafos is an effective alternative for the control of nematodes and insects in soil. In Japan chloropicrin and cadusafos are applied consecutively, in the same way as chloropicrin and fosthiazate. This combined treatment is becoming popular among farmers who grow vegetables (Tateya and Mizobuchi, 2005)

### ***1,3-dichloropropene and chloropicrin***

Formulations of 1,3-D mixed with chloropicrin are registered in a number of countries such as USA, Spain, Australia, Portugal, Lebanon, Chile, Cuba, Morocco, Colombia, and Costa Rica (Norton, 2004; Dow AgroSciences, 1998, 2001; Shanks *et al.* 2004; Carrera *et al.* 2004; UNIDO, 2005b; UNDP, 2005). 1,3-D and chloropicrin have continued to increase in acceptance as a key alternative to MB/Pic, particularly for certain crops such as strawberry fruit, melons and carnations. By August 2004 in Italy, for example, a major MB fumigation company had converted about 2000 farms to 1,3-D/chloropicrin, comprising 45% of the agricultural areas where that company had applied MB in the past (Spotti, 2004).

A review of studies in the strawberry fruit sector in the USA found that the average relative fruit yield was 101% for 1,3-D/Pic when shank-injected, and 108% on average when 1,3-D/Pic was applied by drip irrigation, compared to 100% average for MB; the average yield was substantially less in the untreated controls. A similar review of studies in strawberry fruit in Australia and Spain also found that 1,3-D/Pic provided higher yields on average than MB (Porter *et al.* 2004a). In Spain, the results of farm studies over a number of years showed that the agronomic response to 1,3-D/Pic (61:35) was similar to that obtained with MB/pic (50:50) in strawberry fruit (Lopez-Aranda *et al.* 2004). Small increases in crop yield may compensate for increases in pest control costs, particularly during the transition when farmers or applicators may need to learn new techniques.

It has also been shown that reduced dosages of these chemicals give adequate control of soilborne pathogens and weeds, including nutgrass when used with VIF (Fennimore *et al.* 2003, 2004; Gilreath *et al.* 2003; Gilreath *et al.* 2005). Orchard replant field trials in Tasmania demonstrated that 1,3-D/Pic (injected) produces results almost the same as MB; one advantage is that operators are able to use the same equipment that they used for MB (VDPI, 2005). A limitation of the technique is that pathogens and pests are only controlled where the soil is wetted. A uniform distribution of the product is thus a necessity. Practical experience during several years shows that use of these fumigants requires greater attention to soil and moisture conditions during soil preparation and application (VDPI, 2005).

1,3-D/Pic (injected) provides acceptable results in Australian melon production and has been commercially adopted; during the 2003-04 season rockmelon growers in particular increased the use of 1,3-D/Pic (VDPI, 2005). In the vegetable sector of Bundaberg, once Australia's main user of MB, about 70% of the pepper and vegetable growers have adopted 1,3-D/Pic, and only 5% still used MB in 2004. 1,3-D/Pic is also the main alternative used by vegetable producers in the Carnarvon region of Australia where MB has not been available since 2002 (VDPI, 2005).

Emulsifiable formulations of 1,3-dichloropropene and chloropicrin products are registered in USA and elsewhere and adoption is increasing. InLine (emulsifiable 1,3-dichloropropene + chloropicrin) and Telone EC (emulsifiable 1,3-dichloropropene) when applied through buried drip lines provided excellent control against a number of soil pathogens and pests (nematodes and weeds), in melons, citrus, grapes and strawberries (Ajwa *et al.* 2002; Martin, 2003; Martinez *et al.* 2000). Co-application or sequential application of 1,3-D and chloropicrin through drip lines also gives results similar to MB in vegetables and strawberry fruit in Greece and Italy (Loumakis, 2004; Spotti, 2003, 2004). The experience of substantial commercial adoption in Italy indicates that the traditional usage of MB can be viably substituted in the majority of cases in this region, and that the cost of 1,3-D and chloropicrin competes favourably with the cost of MB (Spotti, 2004). In Greece the cost of fumigation with 1,3-D + chloropicrin (co-applied through drip lines) is also similar to MB - both treatments cost about 6000 Euro/ha (Loumakis, 2004).

In 2002, about 10% of the strawberry fields in California were drip-fumigated (with 1,3-D and/or chloropicrin); drip fumigation increased to an estimated 20% in 2003 and is expected to increase further in 2004 (Trout and Damodaran, 2004). The area of Californian strawberry production treated with 1,3-D or 1,3-D/Pic increased from 42 hectares (104 acres) in 2000 to an estimated 2176 ha (5378 acres) in 2003 (Trout and Damodaran, 2004), representing a 50-fold increase in two years.

Regulatory restrictions (township caps) will tend to limit the further uptake of 1,3-D in some regions of California, and karst topography restricts its use in parts of Florida; its use is not permitted in certain locations such as Prince Edward Island in Canada. In both the latter cases, the restriction is due to risk of groundwater contamination that may arise with certain types of topography. In situations where use of 1,3-D is limited, other fumigants (especially metham sodium) are increasingly being examined for their potential to replace 1,3-D or reduce doses of 1,3-D formulations. In California, for example, demonstration trials have confirmed earlier research that showed metham can be applied after 1,3-D/Pic to reduce application rates of 1,3-D/Pic without a loss in yield (Ajwa *et al.* 2004). Other research has found that pic + metham (applied sequentially) can provide similar yields to MB/Pic and 1,3-D/Pic – refer to section on metham sodium and chloropicrin for details.

### ***Fumigant alternatives combined with VIF***

The use of VIF is increasingly being examined as a way to increase the efficacy of alternative fumigants and/or reduce doses. Reduced doses of 1,3-D/Pic under VIF controlled *Pratylenchus penetrans* and *Meloidogyne hapla* to a similar degree as MB/Pic (Lopez-Aranda *et al.* 2004). US studies have shown that the application of fumigants under VIF or equivalent barrier films can enhance weed and pathogen control (Ajwa *et al.* 2004; Gilreath *et al.* 2005; Gilreath *et al.* 2003; Hamill *et al.* 2004; Noling and Gilreath, 2004). Studies in strawberry fruit found that the use of VIF with alternative fumigants (chloropicrin alone, and 1,3-D/Pic) increased the effectiveness of most treatments, with resulting yield increases, compared to the standard PE films used in California (Ajwa *et al.* 2004).

### ***Metham sodium and chloropicrin***

Previous research has shown that sequential application of metham sodium following reduced doses of 1,3-D/Pic (drip applied), or chloropicrin, controlled soil pests in strawberry fruit and produced fruit yields equivalent to standard MB/Pic fumigation (Ajwa *et al.* 2004). Chloropicrin followed by drip application of metham sodium or metham potassium was found to be an effective MB alternative in IR-4 studies (Norton, 2004). Metham sodium used in combination with chloropicrin proved efficacious for controlling yellow nutsedge (*Cyperus esculentus*) (Hutchinson *et al.* 2004). The combination of chloropicrin and metham sodium, usually applied sequentially, is gaining increasing interest, particularly in areas where the use of 1,3-D is restricted by township caps or similar regulations. In California, metham sodium is recommended as a follow-on treatment after drip-applied alternatives, especially chloropicrin, to improve weed control (Trout and Damodaran, 2004). In Australia, chloropicrin and metham applied sequentially is also recommended as a very effective alternative for fungi, nematodes and weeds (Shanks *et al.* 2004).



Dazomet (which, like metham, generates MITC) has been used as a bed top treatment with 1,3-D/Pic or chloropicrin (applied in the bed) in many trials in strawberry and tomato with consistently good results comparable to MB/Pic (Norton, 2004).

***Metham sodium, dazomet (MITC generators)***

Use of fumigants that generate methyl isothiocyanate - metham sodium and dazomet - as alternatives to methyl bromide has been limited in the past by inconsistency of results and longer plant back times compared to MB/Pic mixtures. Dazomet uptake has also been limited by cost and lack of registration in certain countries (e.g. USA) and metham sodium because of enhanced degradation in certain circumstances (e.g. sandy soils with high pH (Matthiessen *et al.* 2003)). These products, however, continue to be considered as an alternative to MB/Pic mixtures, because they have the ability to control both pathogens and weeds, and also provide an alternative that offsets the need for chloropicrin or 1,3-D. Increased knowledge of fumigant movement, development of application methods that apply these products more consistently to soil, and their use in combination with other treatments, are offering more consistency of these products (Norton, 2003). For instance, dazomet granules are replacing MB/Pic use for several high value industries in Australia, e.g. turf in golf courses, assisted by improved application equipment (Mitchell 2004 pers. comm., Park and Landschoot, 2003). Recent research shows that dazomet can be a feasible alternative to methyl bromide for weed control (*Poa annua*) in turfgrass (Branham *et al.* 2004). Some large cut flower producers in the Queensland region of Australia are using a combination of dazomet and steam (VDPI, 2005).

Metham sodium (drip applied) is being used as a MB alternative by some growers of bell peppers in Australia (VDPI, 2004). In 2004, about 25% of the pepper and vegetable growers in the Bundaberg region of Australia used metham sodium as a MB alternative (VDPI, 2005). In Costa Rica some growers adopted metham sodium some time ago due to strong opposition associated with MB use (VDPI, 2004). The consistency of metham sodium has been improved by new application technologies through drip irrigation or injection-spading techniques (Barel, 2004). Guidelines for the use of drip-applied metham sodium and metham potassium in the USA have been published (Duerksen and Ajwa, 2004). In the Carnarvon region of Australia, new equipment can apply metham sodium more effectively at the same time as applying plastic mulch, while in the Sydney region some growers have built their own rigs to deliver metham more precisely (VDPI, 2005). The consistency of metham is also improved by combining it with other fumigants (e.g. 1,3-D or Pic). For example, 1,3-D/Pic EC followed by metham applied a week later is being used commercially as an alternative to MB in strawberry crops in the US on limited acreage, while use of pic followed by metham has also increased (Norton 2003, Trout and Damodaran 2004).

Metham sodium has been adopted as a MB alternative in diverse regions and crops, such as Chile (greenhouse tomatoes and peppers, grape replant, stone fruit tree replant), South Africa (field bulbs, lettuce), France, Netherlands and Belgium (field grown strawberry fruit) (Carrasco et al 2002; Barel 2003b; Koppenol 2004; Mutitu and Barel 2003). In Spain, metham sodium is used for about 1500 ha strawberry fruit, 1400 ha field tomato, 120 ha protected tomato, and 600 ha pepper, applied by drip irrigation or injection. In Italy, metham sodium is used on about 900 ha greenhouse vegetables, 350 ha tomato and about 180 ha cut flowers, mainly applied by drip irrigation, although injection is also used (Rabasse 2004 pers. comm.; Barel 2004). Many MLF phase-out projects have adopted metham sodium, often via drip irrigation, as a major MB alternative.

Metham potassium is useful in soils where manganese or salt levels are high (Rabasse, pers. comm). It is used in South Africa, for example, for crops such as lettuce, lilies and bulbs, in specific fields where salts are a problem (Koppenol, pers. comm.). Metham potassium is receiving renewed interest in trials on MB alternatives in several countries.

In the last decade, the development of rotating-spading injection (RSI) techniques in northern Europe has increased efficacy of this product significantly, and more consistent control is achieved at depths of up to 45cm in a range of soil types (Mulder 2001; Barel, 2004). This rotating-spading injection equipment can avoid groundwater contamination and meets the stringent water protection requirements in the Netherlands (Mulder 2001). Rotating-spading injection machines have expanded to a number of countries and crops including strawberry fruit and lettuce (open field), potatoes and carrots in Belgium; 1000 ha of crops (strawberries, carrots, fruit trees, potatoes) in The Netherlands; about 800 ha of strawberries, carrots, lettuce and other crops in France; 300 ha field grown bulbs and about 400 ha lettuce in South Africa; and production of several protected crops including tomatoes and peppers in Chile (Carrasco 2003; Koppenol 2004; Peters 2004; Barel 2004). In some areas, metham sodium has a reputation as a fumigant with variable effectiveness. This is probably due to inadequate fumigant distribution, except in unusual areas where enhanced degradation is established. In general, improved application techniques, usually involving mechanical distribution of the metham sodium in the soil, have led to improved performance and reliability of this fumigant.

### 7.2.2 *Chemical alternatives under development*

#### ***Dimethyldisulfide***

In recent years dimethyldisulfide (DMDS) has been developed and trialed in France and Italy. DMDS applied under VIF produced higher yields in strawberry fruit trials than DMDS applied under LDPE sheets, but both were lower than MB/pic standard (Lopez-Aranda *et al.* 2004). However, DMDS

(125 kg/ha) combined with chloropicrin (125 kg/ha) under VIF produced yields equal to MB in strawberry fruit trials (Lopez-Aranda *et al.* 2004). Further development is required to confirm its potential to replace MB.

### ***Ethanedinitrile***

Ethanedinitrile (EDN, also called cyanogen) is showing promising results as an alternative fumigant to MB for soil disinfestation in trials in Australia for strawberry runners, strawberry fruit, carrots and turf (Ren *et al.* 2003; Mattner *et al.* 2003). In a study on strawberry runners in Australia, EDN provided a higher yield (in terms of number of strawberry runners) than MB (Porter *et al.* 2004b). Preliminary results show a broad range of efficacy against pathogens and weeds, and EDN has delivered equivalent weed and disease control, and crop yields, compared with MB in preliminary trials (VDPI, 2005). However, EDN has not been tested extensively against nematodes (Mattner *et al.* 2003). EDN remains in the soil for a short period and potentially offers short plant-back times (VDPI, 2005). It requires sealing with LDPE for improved results. A company is pursuing registration of EDN in Australia (VDPI, 2005).

### ***Methyl iodide***

Methyl iodide (iodomethane) continues to show similar efficacies to methyl bromide in trials (Ajwa *et al.* 2002, 2003; Hutchinson, 2004). Methyl iodide in combination with chloropicrin (50:50 and 33:67) has been consistently equal in biological performance to MB/Pic when used at rates above 340 kg/ha, providing broad spectrum control of nematodes, fungal pathogens and weeds in IR-4 studies (Norton, 2004). Methyl iodide has proven equally effective to MB in preliminary US trials in ornamentals, for example in rose plant nurseries for nematode control (Schneider *et al.* 2003) and in *Liatris* plantings for controlling soil fungi (Gerick, 2004). Trials conducted with this chemical in *Ranunculus* crops at the grower level also gave satisfactory results (Johnson, 2005). In Australia initial results indicate the methyl iodide performs as well as MB in cut flower production (VDPI, 2005). Methyl iodide provided yields about 22% higher than MB (in terms of number of runners per metre of row) in a study on strawberry runners in Australia (Porter *et al.* 2004b). Field trials in Australia have shown that methyl iodide has given equivalent weed, disease and nematode control, and crop yields, when compared with MB (VDPI, 2005).

Recent studies are focusing on lowering the dosage rate and validating performance when used in combination with chloropicrin (Browne *et al.*, 2003; Dickson *et al.*, 2003; Elmore *et al.*, 2003; Ren *et al.*, 2003; Schneider *et al.*, 2003; Hutchinson, 2004). Research is also considering ways to reduce the potential for offsite exposures to methyl iodide resulting from post-fumigation off-gassing. Registration is being sought in the US with a possible decision before the end of 2005. In Australia, registration trials are evaluating two

formulations of MI/Pic (50:50 and 30:70), and the manufacturer is pursuing registration (VDPI, 2005).

### ***Propylene oxide***

Although propylene oxide is registered for protection of some specific stored products, trials have shown that it also has broad spectrum activity as a soil fumigant, and performs well against weeds, nematodes and fungal pathogens when used at rates of 170L/ha per acre or more (Norton 2003, 2004). Soil applications by shank injection at approx. 50 L/ha have been as effective as other fumigants used in trials in the US, but further development is required to improve consistency of treatments. Trials in strawberry fruit in Spain in 2003-04 indicated that propylene oxide under VIF provided yields that were statistically similar to MB (Lopez-Aranda *et al.* 2004). Propylene oxide produced high yields in bell peppers in trials in Bundaberg, Australia (VDPI, 2005).

### ***Sodium azide***

Trials in the US are continuing to evaluate effective application methods and rates using sodium azide to achieve consistent control of weeds, nematodes and fungal pathogens. Good results have been obtained in trials on weeds and nematodes in tomato and green pepper, fusarium crown rot in tomato and hybrid Bermuda grass in Alabama (Rodriguez-Kabana *et al.* 2003ab; Guertal *et al.* 2003; Walker *et al.* 2003).

Several grapevine nursery/vineyard replant trials in California applied sodium azide through drip irrigation lines at a rate of 336 kg/ha. At the end of the first and second growing seasons, rootknot nematode populations on susceptible grape varieties had increased in the azide treated plots to levels comparable to the levels found in untreated control plots and were significantly higher than in plots treated with methyl bromide (Schneider *et al.* 2002a; Schneider *et al.* 2003). At harvest, 20-70% of the grapevine nursery plants from azide treated plots had galled roots as compared to 75% in untreated plots and 0% in methyl bromide treated plots (Schneider *et al.* 2002b). In another grapevine nursery/vineyard replant trial, azide treatments reduced the citrus nematode populations at the time of planting to levels comparable to those found in the methyl bromide treated plots (Schneider *et al.* 2003). Data on nematode population levels and amount of root galling at harvest are not yet available. Additional trials using the Alabama formulation and multi-stage application protocol are planned.

The IR-4 program has obtained effective results with sodium azide (SEP-100) during the past two seasons whereas in past years results had been erratic. This improvement was due to a better understanding of how to apply the product (Norton, 2004).

### ***Sulfuryl fluoride***

Experimental results in tomato, cucumber and tobacco previously showed that sulfuryl fluoride (SF), 25-50 g/m<sup>2</sup>, presented good efficacy for control of both soilborne fungal pathogens and nematodes (Cao, 2005). Yield of crops after applying SF was similar to that obtained from methyl bromide treated plots. Application of SF can be more convenient than that of methyl bromide, because sulfuryl fluoride is a gas at normal ambient temperatures. It can be applied in cold weather without the need for a heated vaporiser. SF is broken down rapidly in soils so the plant-back period is shorter than for MB. In China tests on SF are continuing and it is the process of registration as a soil fumigant.

#### **7.2.3 *Progress for Non-chemical Alternatives***

A range of non-chemical treatments continue to be considered as MB alternatives, often as part of integrated pest management strategies. Several non-chemical methods of soil disinfestations can give crop yields equal to or better than soil fumigation with MB (Shanks *et al.* 2004). However, knowledge of the environmental factors that influence their effectiveness is often more critical than for fumigation (Shanks *et al.* 2004). Non-chemical methods can often be combined with chemical methods to provide optimum control of pathogens, nematodes and other pests. For example, the combination of an alternative fumigant with improved hygiene practices and resistant varieties can provide superior results compared to fumigation alone (Shanks *et al.* 2004).

This section lists some of the more important changes in the status of several non-chemical methods as alternatives to methyl bromide, but does not cover the full list of options that are being considered or adopted to replace MB in some specific circumstances.

#### ***Biofumigation***

Biofumigation is currently being used in combination with other alternative strategies by some sectors in Australia. The strawberry runner industry, for example, uses brassicas for biofumigation in rotation with strawberry runner production (Shanks *et al.* 2004).

#### ***Grafted plants***

Grafting of both perennial and of annual crops (almonds, tomato, cucurbits) is widely used in many countries because they offer a range of commercial benefits. When combined with other treatments, grafted plants can avoid the need for MB fumigation (De Miguel, 2004b). In Italy, for example, grafted plants are used with alternative fumigants (e.g. 1,3-D or chloropicrin) as MB alternatives (Spotti, 2003, 2004). The results, expressed as marketable yields,

gall index or disease severity, are normally as good as with MB (Koren, 2002; Besri, 2003; Browne *et al.* 2003; Hafez *et al.* 2003; Minuto *et al.* 2003). Applicability of grafted plants may be limited by availability of rootstocks tolerant to local pests and diseases.

In the Mediterranean region, grafting is one of the most commonly used MB alternatives in cucurbits (watermelon, melon and cucumber) (De Miguel 2004a, c). Resistant rootstocks are available for pests and pathogens such as *Meloidogyne* sp. and *Fusarium oxysporum* in melon, watermelon and cucumber, *Monosporascus cannonballus* in melon, and *Phomopsis sclerotiodes* in cucumber (De Miguel, 2004a,c).

In France grafting is used on 1000 ha of melon, where grafting has been found to be as effective as MB fumigation for *Phomopsis sclerotiodes*. Grafting is an important tool in dealing with *Fusarium oxysporum* in cucumber in Greece, and in melon in Turkey. Grafting combined with other practices replaced the use of MB in watermelon in Spain, where about 30 million plants are grafted annually, covering an area of about 12,000 ha (mainly in Almería, Valencia and Murcia). Grafting is used for 5-6 million melon plants and about 20 million watermelon plants in Italy. The practice of grafting is spreading in cucurbit production in Jordan and Israel (De Miguel, 2004a). Grafting is commonly used in Japan and South Korea for cucurbits and eggplant (Lee, 2003). Grafting combined with calcium cyanamide has been found to be an efficient alternative to methyl bromide for the control of fusarium wilt in melons (Blestos *et al.* 2005).

Grafted tomato has increased in Spain from less than one million plants 4-5 years ago to about 45 million plants in 2003/4. Grafted tomato is used in France on about 2800 ha, to prevent problems such as corky root caused by *Pyrenochaeta lycopersici* (De Miguel, 2004b; Beyries, 1974). In Greece, the combination of grafting with solarisation is considered to be a good MB alternative for tomato. While in Morocco, grafted tomato plants are considered to be viable MB alternatives when combined with alternative fumigants (1,3-D, pic, metham), solarisation, biofumigation or other practices (De Miguel, 2004b; Besri, 2000, 2003).

Italy has experienced a steady rise in the demand for grafted tomato; about 10-12 million tomato plants are grafted annually (Spotti, 2004; De Miguel 2004b). In the last 3 years Italy has also seen a 'veritable explosion' in demand for grafted eggplant. In Sardinia, the production of grafted tomato plants increased from almost nil in 1996 to about 1.7 million in 2003 (Leoni and Ledda 2004). The area of tomato production fumigated with MB in Sardinia has been reduced from 50% in 1992 to about 4% currently, due to agronomic changes which include the adoption of grafted plants and resistant varieties (Leoni and Ledda, 2004; Leoni *et al.* 2004).

### ***Heat treatments***

Steaming has long been established as a method of disinfesting soils, including as an MB replacement. Recently hot water treatments have also been developed as a MB replacement. Mobile machines using hot air are at an advanced stage of development. These may be applicable to both protected cultivation and small scale broadacre production systems and appear to be more energy efficient than steaming systems for the same energy input and cost.

#### *Hot air treatment*

Remote controlled soil sterilising machines that operate with heated air were developed in Israel, and are being further developed by a Dutch company (Peters, 2004). They have been reported to be as effective as methyl bromide and other fumigants for soil disinfestation (Cultiv, 2004). These machines can treat strips of soil up to 250m long in approximately one hour. Versions of the machines are under development for both broadacre and protected cultivation systems. Further development and commercial scale up of these machines is required before an accurate assessment of their potential as an MB replacement can be fully identified.

#### *Hot water treatment*

Hot water treatment consists in applying hot water of 80-95°C onto the field in order to raise the soil temperature to levels high enough to control pathogens. This control measure has been recently developed in Japan and is being adopted on tomatoes, melon, cucumber, watermelon, spinach, cut flowers and other crops (Nishi, 2002). Hot water treatment is useful for control of fungal diseases, bacterial diseases, nematodes and weeds, but has not proven successful for controlling virus diseases (Uematsu et. al., 2003). This technique has been trialled for over 10 years and proven successful for the control of verticillium wilt of tomato (*Verticillium dahliae*) and corky root of tomato (*Pyrenochaeta lycopersici*). Successful disinfection of soil-less substrates used for gerbera production has also been reported (Uematsu et al. 2003b).

Hot water equipment systems are supplied by nine companies in Japan. Two types of systems are available: tube-watering and dragging types. In tube-watering systems, hot water is sprinkled using tubes installed on the field. In the dragging system, hot water is supplied to the soil surface using watering equipment made of metal pipes that is designed to roll smoothly on the ground when dragged. The treatment price varies from US\$ 27,000 to 64,000 per ha depending on the system and areas up to 300m<sup>2</sup> can be treated in a day (Uematsu et al. 2003a).

### *Steaming*

Use of steaming or pasteurisation has continued to increase as an alternative to methyl bromide, particularly in intensive protected, high-value cropping systems such as flowers and vegetables. This is largely due to new and more efficient equipment being available, such as negative pressure steaming, hood steaming (for seed beds) and improved, more flexible equipment for sheet steaming (Carrasco, 2003; Pacett, 2003; Runia, 2000; Barel, 2003a). Negative pressure steaming allows treatment at much deeper soil depths than sheet steaming, and uses almost half the fuel of sheet methods (Runia, 2000). Different fuel options for operating the boilers, for example gas in Argentina and Bolivia, and wood in Brazil, (UNIDO, 2005a; Barel, 2005) are helping growers reduce costs, which often restrict the use of this alternative.

Examples of soil steaming in commercial and routine use include: Australia (cut flowers), USA (cut flower production in California), South Africa (tomatoes, chrysanthemum cuttings), Kenya (chrysanthemum cuttings), Uganda (chrysanthemum cuttings), Tanzania (cut flowers and chrysanthemum cuttings), Colombia (cut flowers and cuttings), Brazil (flowers and cuttings), Italy (cut flowers, ornamentals and cuttings), Belgium (strawberry (protected), tomato, lettuce, leek and onion seedlings), the Netherlands (about 50% of cut flower production, including 900 hectares of chrysanthemum, cuttings and radish), UK (protected tomato and lettuce), Lebanon (strawberry), Guatemala (cut flowers), and in other crops and countries mentioned in MBTOC 2002 Assessment Report (Shanks *et al.* 2004; VDPI, 2004; Barel, 2004; Solís and Calderón, 2002; Haroutunian, 2003; Ellis, 1991; Gullino, 1992; Pizano, 2003). Steam was used on about 2000 hectares in France in the year 2000 (Fritsch 2002).

Steaming is also comparable to methyl bromide for sterilising plug or seedling trays. This is mostly achieved in an enclosed box or chamber inside which steam is circulated at a controlled temperature. Common materials that can be sterilised by this method include trays and pots for production of seedlings of crops such as tobacco and lettuce. This system is used in many countries, including the US, Netherlands, Belgium, Chile, South Africa, Argentina and Uganda (Nesmith, 1997; Hensley, 2002; Pearce and Palmer, 2002; INTA, 2003; Melton and Broadwell, 2003).

Steam has replaced the use of MB for sterilization of substrates in a number of areas. For example, steam treatments (with negative pressure systems) in bunkers or containers have been adopted by some forest tree nurseries in Chile; *Trichoderma* is mixed into the substrate after the steam treatment, providing cuttings with on-going protection against disease (Carrasco *et al.* 2002, 2003; Barel, 2003b). Bolivia has recently adopted small steam boilers for sterilising substrates (new and re-used) for seed potato, vegetables and ornamentals, as part of a UNDP MB phase-out project (Barel, 2005). Steam has also been adopted as a MB alternative for substrates in the Netherlands,



and for plant nurseries in South Africa (Jansen, 2004; Runia, 2000). Steaming of peat is very difficult using normal sheet steaming methods, but is very effective when using negative pressure methods. Negative pressure steaming is more energy-efficient than other steam methods (Barel, 2003a; Runia, 2000).

### ***Resistant cultivars***

The range of varieties with resistance to pathogens previously requiring fumigation with MB is widening, particular for tomato and melon. In many crop production systems, cultivation of resistant cultivars is widely adopted to control many soilborne pathogens (Laterrot, 2002). Resistant varieties of several commercially grown cut flowers – particularly carnations with different levels of resistance to fusarium wilt – have also been developed in several countries for example Italy, Israel and Spain (Llauradó, 2004). Use of resistant cultivars and grafting, as a stand alone treatment, generally would not provide the grower with a means to replace MB. However, integration with other treatments or integrated pest management strategies can provide strategies as effective as MB fumigation (Gantz *et al.* 2002; Sachs, 2002).

### ***Solarisation***

Commercial adoption of solarisation continues to increase in certain countries where cropping and climate conditions make this technique an efficient alternative to methyl bromide (Roe *et al.* 2004; Abdul-Baki *et al.* 2004; Cantliffe and Vansickle, 2003b). In Costa Rica for example, an estimated 20% of the melon cropping area (about 2000 ha) is now using solarisation, which has proven particularly successful when combined with metham sodium (Chaverri, 2004). The same has been reported from China for the control of soilborne diseases affecting strawberry and tomato (Cao, 2005, pers. comm.)

A method known as “high temperature soil solarisation” or “double-tent solarisation”, has been developed by the University of California Riverside, UC Davis and Kearney Agricultural Center as a control measure for pests attacking young seedlings or transplants, containerised plants (including nursery plants), and for home gardeners (Stapleton *et al.* 1999, 2000). The system has been approved by the California Department of Food and Agriculture for treatment of containerised soil. Soil must be either in polyethylene planting bags or in piles not more than 30 cm high, placed on a layer of polyethylene film, concrete pad, or other material, which will not allow reinfestation of soil, and covered by a sheet of clear polyethylene film. An additional layer of clear polyethylene film is suspended over the first layer to create a still air chamber over the soil. Soil moisture content must be near field capacity. Soil temperature at the bottom centre of the pile or bag must be monitored and recorded to ensure that the required temperature (70°C for 30 continuous minutes, or 60°C for 60 continuous minutes) is achieved (Stapleton *et al.* 1999, 2000).

Research in Israel indicates that solarisation efficacy can be enhanced with special plastic covers, e.g. a double mulch of black polymer and anti-drip film for controlling sudden wilt of melons (Arbel *et al.* 2003). Solarisation combined with organic amendments appears to be a long term alternative to MB for warm climate locations such as Florida (Ozores-Hampton *et al.* 2004, 2005).

In Brazil, low cost device has been developed for treating small volumes of substrates. It is based on the principle of solarisation and known as the “solar collector”. It consists of six black-coloured metal tubes 15 cm in diameter, placed in parallel in a wooden box of 1.5 m in length, 1.0 m in width, and 0.3 m in depth. A transparent plastic film is placed over the top of the box, and aluminium foil is placed on the bottom to further enhance heating. Soil or substrate is then placed within and recovered after 24 hours and a day of full sun. It reaches temperatures between 70 and 80°C, which guarantees complete disinfestation. The substrate is ready for use immediately after treatment or it can be stored for later use; although only 120L of substrate can be treated at a time, the low cost of the collector allows growers to build several units in order to accommodate their needs. Research has found that one day of full solar radiation is sufficient to control several fungal plant pathogens, including species of *Fusarium*, *Pythium*, *Rhizoctonia*, *Sclerotium*, *Sclerotinia*, *Phytophthora*, as well as nematodes such as *Meloydogyne* (root knot). The yearly cost of treatment per m<sup>3</sup> of substrate was found to be comparable to that of MB. Over the last ten years, many growers, nurseries and research institutions have adopted this system with very good results (Ghini, 2004).

### ***Substrates***

Adoption of crops grown in substrates continues to be a strong trend in protected, intensive agriculture (e.g. for cut flowers, nursery plants, vegetables) both in Article 5(1) and non-Article 5(1) countries (De Hoog, 2001; Kipp *et al.*, 2000; Pizano, 2003; Savvas and Passam, 2002; UNIDO, 2004; Savvas, 2003; Urrestrazu, 2004; Pizano, 2004a, 2005; Leoni *et al.* 2004). Although initial investments are normally high, it has been proven that increased productivity and yield, due to higher planting densities and/or better quality, pay off extra costs rapidly (Valderrama and La Rota, 2003; Cavelier, 2003; Savas and Passam, 2002; Schnitzler and Gruda, 2002; Maloupa *et al.* 1999). A study in Almería, for example, noted that conventional soil cultivation of sweet peppers provided a yield of 105,000 kg/ha and net revenue of Euro 8,000/ha, while substrates provided yields of 160,000 kg/ha and net revenue of Euro 33,000/ha (Caballero and De Miguel, 2002). The Netherlands tends to use more intensive substrate systems, providing average yields of 260,000 kg/ha and net revenue of Euro 41,000/ha (KWIN, 2003). An economic study that compared soil cultivation with various types of substrates systems in Greece concluded that substrates can substantially improve farmers’ incomes (Grafiadellis *et al.* 2000). Similar conclusions were

reached with tomatoes, cucumbers and carnations in Turkey (Akkaya *et al.* 2004).

Substrates are used on about 12,000 ha in Western Europe (Stanghellini and van Os, 2004). In France, for example, substrate culture was adopted for strawberry fruit initially in the north and has expanded significantly, especially in southern regions, from 70 ha in 1999 to about 300 ha in 2004 (Lieten, 2004; European Commission, 2005a). Production on substrates has increased to about 87 ha recently in Huelva, the major strawberry producing region of Spain. The Almería region of Spain produces greenhouse vegetables (tomato, peppers, eggplant, cucumber, muskmelons) on a large area; substrates such as perlite are used on approximately 3600 - 4000 ha, which is about 10% of the greenhouse area (Cantliffe and Vansickle, 2003). Soilless culture is increasing significantly as a replacement for MB for tomato in France; by 2002 substrates had been adopted on about 950 ha tomato (Fritsch, 2002; European Commission, 2005a).

Adoption of substrates continues to increase in (protected) floriculture in many countries around the world. In the Victoria region of Australia for example, some greenhouses produce flowers such as roses, gerbera and lilies in substrates. Substrates (e.g. potting mix or coir/peat) have also been adopted by some flower producers in New South Wales and Queensland, and by vegetable producers in the Sydney region (VDPI, 2005). Roses, carnations and gerberas are the flowers most commonly grown in substrates, but other flower types are also being produced with this cropping system (Nucifora, 2001; van Os *et al.* 2004; Gullino *et al.* 2003; Grillas *et al.* 2001; Pizano, 2005). Similar changes are occurring in Article 5(1) countries. In Kenya, for example, several cut flower producers have replaced MB with substrates (mainly pumice and coconut fibre) for roses and carnations; substrates will be adopted on a number of farms assisted by the MB phase-out project (Mutitu and Barel, 2003).

Substrates are also an excellent option for propagation purposes, including of woody plants such as roses, in which the “mini-plant” system allows for rooting and grafting the rootstock and scion at the same time. This system is also extremely efficient with respect to production space (e.g. number of plants produced per unit area) (Vargas and Samper, 2003; World Bank, 2002, 2005).

Leoni and Ledda (2004) note that in Sardinia (Italy) the limitation on MB has stimulated scientific and technical development in the last few years, and has stimulated the growth of substrate cultivation and use of grafted plants in the region. Soilless culture spread quickly: production using substrates was nil a decade ago and is now used for about 8% of vegetable production in Sardinia (Leoni and Ledda, 2004; Leoni *et al.* 2004).

Local sourcing of substrate materials may be necessary, because imported substrates can be too expensive to make this alternative cost efficient (Valderrama and La Rota, 2003; Cavelier, 2003; Savvas, 2003; Carrijo *et al.* 2002). Growers in many countries have gained experience with very diverse substrates such as rice hulls, coffee husks, volcanic scoria, pumice stone, coconut peat or coconut coir, grape bagasse and many other materials (Calderón, 2001; Lopez-Medina 2004; Urrestrazu, 2004; Savvas, 2003; Carrijo *et al.* 2002). Substrates that are to be reutilised generally need to be sterilised. Steaming and solarisation are feasible non-MB options (Barel, 2004; Ghini, 2004).

### ***Substrates for production of transplants (plug plants)***

Plug plants (or seedlings, transplants) offer a means of avoiding soilborne diseases and the need for fumigation with MB. The widespread adoption of tobacco plug plants (produced in floating trays) has been previously reported by MBTOC (2002); adoption continues to increase in high volume tobacco producers such as Brazil, Zimbabwe and Argentina (Sibanda and Way, 2004; PROZONO, 2003). Lettuce plug plants have also been adopted as a MB alternative in South Africa; *Trichoderma* is also added to the plugs (Koppenol, 2005).

Strawberry plugs are providing a useful commercial alternative to MB in northern Europe and other areas where short production seasons suit their use. Further development of plug plants is required for strawberry crops grown over longer production seasons, such as most strawberries in California. Presently plugs only support a very small proportion of the transplant market in the major strawberry production regions of the world (<1%), and further development is required if they are to replace the need for in-field fumigation.

### ***Miscellaneous cultural practices***

Mulches can assist with the suppression of a range of weed species including yellow nutsedge. Synthetic opaque mulches are reported as having good efficacy as weed management tools used in California strawberry production, for a wide range of weeds including yellow nutsedge, bluegrass chickweed, knotweed, little mallow, cudweed, filaree and shepherd's purse (California Strawberry Commission, 2003). In Florida, studies indicated that yellow nutsedge growth is suppressed (but not controlled) by conventional polyethylene mulches, and that farming operations are the main cause of yellow nutsedge dispersal in the field (Webster, 2005). A preliminary study that needs further confirmation indicated that purple nutsedge growth may be promoted by the polyethylene black mulches that are commonly used in horticulture in southeastern US states (Webster, 2005).

For control of *Phytophthora* (crown rot and root rot) in strawberry fruit, irrigation control and clean nursery stock are reported as having excellent

efficacy as disease management tools used in California strawberry production (California Strawberry Commission 2003).

Crop rotation is used as a MB alternative in some regions, often combined with other methods. In South Africa, for example, a combination of metham sodium and crop rotation has been adopted for lettuce, cabbage, carrots, lilies and other bulbs (Koppenol, 2005). Extension guidelines on nematode management in the Netherlands have identified the crops that harbour or suppress individual species of nematodes, assisting growers to develop suitable rotations for open field crops such as dahlia, gladioli, lily and tulip (Molendijk, 2000; Beers and Molendijk, 2004).

#### 7.2.4 *Crop specific strategies*

The section below provides an overview of the main strategies adopted in major crops.

##### ***Ornamental crops***

Cut flower production is increasingly moving to developing countries. Industrialized countries are concentrating on developing new varieties and producing/ exporting propagation materials. Even so, floriculture is still an important economic activity in many non-Article 5(1) countries. The top five floral producers in the industrialized world (including flowers and plants) are USA, the Netherlands, Germany, France and Italy. With the exception of Germany, these countries also rank in the top ten importers. Floriculture is a complex industry in the world-wide context. Different countries, flower types and cropping systems are involved (Pizano, 2004a).

Because floriculture generally requires high investment and products must meet strict quality standards, many flower growers in industrialized countries traditionally relied on MB for soil disinfection. However, many examples of successful alternatives are now in place and significant progress towards phase-out has been made. The Netherlands, for example, the largest world flower exporter, has not used MB for soil fumigation since the 1992. Germany does not permit the use of soil fumigants like methyl bromide. Many flower producers in Europe and Article 5(1) countries have adopted MB alternatives in order to comply with commercial codes of practice set by supermarket groups and other organisations (e.g. EUREP-GAP, MPS, FLORVERDE).

Shifting to alternatives often requires growers to change production practices substantially, at times with increased investment, but often with improved quality and yields, as seen particularly with substrates. The constraints that apply in the cut flower sector are generally the same as in other crops: regulatory issues (e.g. township caps in USA), and registration of new products (e.g. iodomethane; mixtures of fumigants).

### *Substrates in ornamentals sector*

Adoption of substrates continues to increase in (protected) floriculture in many countries around the world. Roses carnations and gerberas are the flowers most commonly grown in substrates, but other flower types are also being produced with this cropping system (Nucifora, 2001; van Os *et al.* 2004; Gullino *et al.* 2003; Grillas *et al.* 2001; Pizano, 2005; Savvas, 2003). Substrates are used on about 600 ha (approx. 400 farms) for rose flower production in the Netherlands (Research Station for Floriculture, 2001; Pizano, 2004a). 100% of the roses grown in Israel are produced in soil-less culture. Preferred substrates are generally those that can be locally sourced such as tuff or pumice, although coconut coir is also becoming popular; the experience with roses is leading the way for adoption of substrates on other crops such as gerbera, lily, anemone and carnation (Ausher, 2004). Growers of flower crops in Australia are shifting to substrates and finding increased yields (up to 30%) and quality (almost doubling stem length in roses). In 2003, Victorian flower crops produced in substrates include: tulips (70%); Lilies (10% mainly in boxes); gerberas (25 %); and roses (25 %) (FAQ, 2003). 40% of flowers in Colombia are grown on substrates (Pizano, 2004b).

Although the initial set up cost of a soil-less production system is expensive growers are able to compensate the extra cost through significantly better yields and quality that result from higher planting density, optimum plant nutrition and better pest and disease control. Recent studies and publications have further confirmed this in the flower sector (Grafiadellis *et al.* 2000; Akkaya *et al.* 2004; Pizano, 2004a).

### *Solarisation and biofumigation in ornamentals sector*

Solarisation produces good results in the specific climatic conditions typical of several growing areas, e.g. Israel (Reuven *et al.* 2002). Solarisation + biofumigation trials have given good weed control in areas of California where high radiation occurs, reducing annual weeds by 99% (Elmore *et al.* 2003). An economical, simple option developed in Brazil for sterilizing substrates and known as the “solar collector” is showing increasing adoption (Ghini, 2004). The reactor is ideal for smaller farmers and is a much quicker option than regular solarisation.

### *Steam in ornamentals sector*

Steaming, although expensive, controls soil fungi at levels that are comparable to MB when properly applied (Reuven *et al.* 2005; Barel, 2003b). Steam is generally suited for protected flower production and for sterilizing re-utilised substrates. A less expensive option is increasingly being adopted in Brazil, where wood operated boilers are used; wood comes from commercial Eucalyptus plantings and is thus a renewable resource (UNIDO, 2005a). Other

fuel options which can make steam locally economically feasible and are currently in use include gas (used in Argentina) and coal (used in Colombia).

#### *Chemical alternatives in ornamentals sector*

Certain chemicals such as dazomet, metham sodium and 1,3 dichloropropene have proven equally effective to MB in Israel (Reuven *et al* 2002). Injection methods improve efficacy and consistency of metham sodium (Barel, 2004).

InLine Telone C-35 (1,3-D/Pic) has proven to be a feasible alternative for rose nurseries (Schneider *et al.* 2003) and other field grown flowers in the United States. Agrocelhone (1,3-D/Pic) proved equally effective as MB for controlling soil-borne pests and diseases in carnations in southern Spain (Peguero, 2004). Combined chemicals such as 1,3 D, chloropicrin and metham sodium or dazomet have given “good repeatable results” for the control of pests and diseases in field-grown cut flowers in the United States (Elmore *et al.* 2003).

#### ***Strawberry fruit***

##### *Chemical alternatives in strawberry fruit sector*

To date, the most effective chemical alternatives for strawberry fruit production are 1,3-D + chloropicrin and drip-applied formulations of either pic alone or 1,3-D/Pic with or without a follow-up treatment of metham sodium (Porter *et al.* 2004a). In California, for example, the area of strawberry production treated with alternative fumigants (1,3-D, 1,3-D/Pic, chloropicrin alone, metham sodium) increased from 248 ha in 2000 to about 2077 ha in 2002. The California strawberry area treated with pic increased from 79 ha in 2000 to 590 ha in 2002. The area treated with 1,3-D formulations (including 1,3-D/Pic) increased from 42 ha in 2000 to an estimated 2176 ha in 2003 (Trout and Damodaran, 2004). In 2001, about 88% of the fumigated strawberry production area in California used MB, while about 12% used alternative fumigants (Trout and Damodaran, 2004). Adoption of alternatives has continued. In 2003, a survey by the California Strawberry Commission found that about 69% of the strawberry area used MB while about 31% used alternative fumigants (Legard, 2004).

A review of the average comparative performance of chemical alternatives relative to MB in the strawberry fruit sector in Australia identified relative yields of 123% for 1,3-D/Pic (TC35), 101% for pic, 97% for metham sodium, 101% for metham + pic, and 101% for dazomet, compared to 100% for MB and 84% average for the untreated controls. A similar review of studies on strawberry fruit in Spain reported relative yields of 103% for 1,3-D/Pic (TC35), 104% for pic alone, and lower yields for MS and dazomet alone, compared to 100% for MB and 78% for the untreated controls. A review of studies on strawberry fruit in the USA indicated average relative yields of

101% for 1,3-D/Pic (TC35), 108% for 1,3-D/Pic drip applied (InLine), 104% for pic EC, 98% for pic injected, 98% for dazomet, compared to 100% for MB and average of 68% for untreated controls. Whilst these data have not been subjected to a full meta-analysis, they demonstrate the broad spectrum control of soilborne pests that can be achieved with combinations of different fumigants. For example, 1,3-D/Pic, whether injected or drip applied, has been consistently effective across major production regions in USA, Spain and Australia and has already been successfully adopted for a substantial proportion of strawberry fruit production in each country (Porter *et al.* 2004a). In Victoria and Western Australia, for example, 1,3-D/Pic has been widely adopted in strawberry fruit (VDPI, 2005). A few instances of phytotoxicity were reported initially. The problem appears to be associated with small planting holes in the plastic, whereas larger holes (~ 10 cm) show no problems (VDPI, 2005). As a result of its successful adoption in strawberry fruit production in Australia, no application for a CUE was made for use in this sector in 2006.

The combination of chloropicrin and metham, applied sequentially, has gained new interest, particularly in regions where use of 1,3-D is limited by regulatory restrictions. Previous research has shown that sequential application of metham sodium after reduced rates of 1,3-D/Pic (InLine) or chloropicrin controlled soil pests in strawberry fruit and produced fruit yields equivalent to standard MB/Pic fumigation (Ajwa *et al.* 2004). Demonstration trials confirmed earlier research that metham can be used to reduce application rates of InLine and pic without a loss in yield in strawberry fruit in California, even though pathogen pressure was severe (Ajwa *et al.* 2004).

In China the good efficacy of chloropicrin for strawberry fruit production is accepted by growers, and chloropicrin and dazomet are being extended as MB alternatives in this sector, so the consumption of chloropicrin is increasing gradually in strawberry in China.

Among the chemical products that are not registered, methyl iodide, ethanedinitrile (EDN), propylene oxide, and sodium azide show promise (Mattner *et al.* 2003; Norton 2003, 2004). A review of 18 studies in the US indicated that the average yield from methyl iodide was similar to MB (average 101% for methyl iodide, compared to 100% for MB) (Porter *et al.* 2004a).

#### *Non-chemical alternatives in strawberry fruit sector*

Strawberry production in substrates accounts for 5% of world production, but their suitability is limited mainly to greenhouse production and cool climates with short cropping cycles, targeting early season markets or niche markets. The Netherlands, Japan, Italy, New Zealand, UK and China are some of the key producers using substrates for strawberry fruit production.



In northern Europe, substrate systems typically use peat and coir, producing about 45% more strawberry fruit per year than crops in MB-fumigated soil (Nuyten, 2000). Case studies indicate that the substrate systems cost approximately 60% more than production in soil with MB in northern Europe, but the substrate system is more profitable from the third year onwards (Nuyten, 2000). In southern Europe the substrate materials usually used for strawberry fruit production include peat, coir, rockwool, perlite, grape bagasse and cork, used singly or as mixtures. Some materials, such as coir, are easier to use than others. Studies in Huelva, the main strawberry production region of Spain, concluded that coir provides earlier yields and greater total yields than conventional soil-grown strawberries. In this region substrates allow the growing season to be extended and allow harvesting at a time when fruit prices are better (López-Medina *et al.* 2004). The initial investment cost for the cheapest strawberry fruit substrate system in Huelva is about 5-7 Euro/m<sup>2</sup>; however the net revenue from substrates is 9-10 Euro/m<sup>2</sup> compared to 1-2 Euro/m<sup>2</sup> for conventional soil production (López-Medina *et al.* 2004). Efforts to reduce initial set up costs for substrate systems are expected to increase their adoption as a MB alternative world-wide.

Solarisation in hot climatic conditions offers an effective alternative for soil disinfestations for strawberry fruit production providing that periods of hot conditions fit within the crop rotation. Solarisation alone or combined with IPM (organic amendments) is used as a MB alternative in several arid regions (e.g. Jordan), but has varied effectiveness in other regions (Porter *et al.* 2004a). Solarisation is up to 80% cheaper to apply than MB and provided it is used with a suitable crop rotation can produce acceptable yields (Batchelor, 2000).

#### *Combination of chemical and non-chemical treatments in strawberry fruit sector*

Between 20-30% of the world's strawberries are grown without MB fumigation using a range of IPM techniques (Porter *et al.* 2004a). The key components include clean mother and runner stock, good crop rotation, biofumigation, fungicide dips, herbicides and strategic use of organic amendments (Batchelor, 2000). Although many of these methods are not a direct replacement for MB, knowledge of how to optimise their use for strawberry crops can dramatically improve pest and disease control and yields (Bull *et al.* 2002; Mattner *et al.* 2004).

#### *Strawberry nurseries sector*

For strawberry nursery production regions that have traditionally relied heavily on MB more work is generally required to achieve results that are equal to MB. Preliminary trials with EDN and methyl iodide in Australia resulted in significantly higher nursery yields (i.e. numbers of runners per metre of bed) compared to MB (Porter *et al.* 2004b). A number of trials with

methyl iodide/Pic in Australia indicate that such products may offer better results than other alternatives tested to date (Mattner *et al.* 2004).

Some progress has been made in the trialling and adoption of MB alternatives in strawberry nurseries. In 2003, for example, strawberry nursery industries in Victoria, Australia commercially scaled up the use of 1,3 D/Pic on approximately 10% of the acreage, and 30% used biofumigation in the crop rotation with strawberry runners (VDPI, 2005).

### ***Tobacco sector***

The tobacco sector has made very substantial progress in phasing out MB. For tobacco, one type of alternative, floating tray systems (FTS), are the most widely accepted substitute technology for small and large farmers alike, in both non-Article 5(1) and Article 5(1) countries. Adoption continues to increase in the world's most important tobacco producers such as Brazil, Zimbabwe and Argentina (Sibanda and Way, 2004; PROZONO, 2003) In China, for example, FTS have been adopted widely in place of MB. MB consumption in the tobacco sector in China is declining rapidly, and it is estimated that MB will be completely phased out in the tobacco sector in China in the next two or three years. In Article 5(1) countries the Floating Trays System (FTS) has prevailed over the other alternatives because of several factors:

- Despite the initial investment required for set-up, FTS was found to be the most cost-effective, reliable and sustainable alternative technology in both demonstration trials and actual commercial practice.
- The FTS technology was developed in the early 1990s followed by a very rapid expansion process in the main tobacco growing industrialised countries. For Article 5(1) countries the MLF projects provided an opportunity first to demonstrate the system, and then, through investment projects, to remove the main barriers for widespread adoption, i.e. the high initial costs of inputs and the need for tobacco growers to acquire the relevant know-how.
- Tobacco companies strongly support the change to FTS due to advantages such as increased productivity, less use of chemicals, and because the need to use pelleted seeds allows companies to better control the varieties used by growers.

### ***Tomato and Vegetables Sector***

A number of developing countries have tested alternatives during MLF demonstration projects and are now implementing MB phase-out projects. In Lebanon, for example, 97% of the MB used for vegetable production has been phased out using soil solarisation, biofumigation, grafting and 1,3-D (Besri, 2004; Hafez *et al.* 2003). In Turkey, MB is due to be phased out in 2008 by

adopting non-chemical methods (biofumigation, solarisation, biological control, substrates and chemicals such as 1,3-D, metham sodium and dazomet (Besri, 2004; Ozturk *et al.* 2002)).

Progress has also been made in several developed countries. The vegetable sector in Bundaberg, once Australia's main user of MB, has almost phased out its use; in 2004 only 5% of growers still used MB (VDPI, 2005). The main crops which used MB heavily included tomato and bell peppers. These crops successfully adopted a wide range of alternatives such as the following:

- Metham sodium is now used extensively, and is applied either by direct injection or trickle application
- 1,3-D/Pic
- Various nematicides, which are used in conjunction with testing and monitoring
- Herbicides that have been evaluated and used in a range of crops, however additional controls for nutsedge are needed
- Cultural practices such as disease-resistant varieties and wider crop rotations (e.g. leasing fields from other growers who produce unrelated crops such as sugar cane)

A substantial number of chemical and non-chemical alternatives presently used commercially have proved to be as effective as MB for controlling tomato soilborne pathogens in many developed countries such as Belgium, Spain, Italy, Greece and France (Besri, 2004). These include combinations of chemicals (e.g. 1,3-D, chloropicrin, metham sodium and dazomet) and non-chemical methods (e.g. substrates, grafting, resistant varieties, biofumigation, solarisation) (Besri, 2004). In northern Europe the main alternative to MB in tomato production is soilless culture (often in association with other alternatives e.g. resistant cultivars and grafting), while in Southern Europe and the Mediterranean a much more diverse range of alternatives is used, selected according to their suitability to the cropping system and environmental conditions (Besri, 2004).

### ***Cucurbit Sector***

In Europe, grafted cucurbits are widely used in many countries because they offer a range of commercial benefits. When combined with other treatments, grafted plants can avoid the need for MB fumigation (De Miguel, 2004b). In Italy, for example, grafted plants are used with alternative fumigants (e.g. 1,3-D or Pic) as MB alternatives (Spotti, 2003, 2004). Applicability of grafted plants may be limited by availability of rootstocks tolerant to local pests and diseases.

In the Mediterranean region, grafting is one of the most commonly used MB alternatives in cucurbits (watermelon, melon and cucumber). Resistant rootstocks are available for pests and pathogens such as *Meloidogyne* sp. and *Fusarium oxysporum* in melon, watermelon and cucumber, *Monosporascus cannonballus* in melon, and *Phomopsis sclerotiodes* in cucumber (De Miguel 2004ac). In France grafting is used on 1000 ha of melon, where grafting has been found to be as effective as MB fumigation for *Phomopsis sclerotiodes*. Grafting is an important tool in dealing with *Fusarium oxysporum* in cucumber in Greece, and in melon in Turkey. Grafting combined with other practices replaced the use of MB in watermelon in Spain, where about 30 million plants are grafted annually, covering an area of about 12,000 ha (mainly in Almería, Valencia and Murcia). Grafting is used for 5-6 million melon plants and about 20 million watermelon plants in Italy. The practice of grafting is also spreading in cucurbit production in Jordan and Israel (De Miguel, 2004a). Grafting is commonly used in Japan and South Korea for cucurbits (Lee, 2003). Grafting combined with calcium cyanamide has been found to be an efficient alternative to methyl bromide for the control of fusarium wilt in melons (Blestos *et al.* 2005).

In the USA the main focus has been on alternative fumigants, combined with additional weed control when necessary, and grafted plants have not played a significant role as MB alternatives.

### 7.3 Alternatives for postharvest and structural treatments - update

The main alternatives to the disinfestation of flour mills and food processing premises are sulfuryl fluoride (sold in some countries under the Dow AgroScience trade name ProFume) and heat. Phosphine in fast generating gas forms has also made good progress and become an important alternative in some applications. There has been progress in the adoption of each of these alternatives.

#### *Sulfuryl fluoride*

ProFume (a sulfuryl fluoride formulation owned by Dow AgroSciences LLC and designed for food premises and food products) received US EPA Section 3 federal registration in January 2004. Following the federal registration, the product was registered by many states during 2004 and 2005, notably excepting California and New York. ProFume, however, has already been registered in California for several key uses in the dried fruit and tree nut industry. Dow AgroSciences has been working for several years with the Dried Fruit Association to make this alternative fumigant product available to the industry.

Dow AgroSciences reported to MBTOC that since the federal registration approval, millers, food processors and fumigators have completed 50 commercial fumigations at 30 facilities in the US. Numerous other research

fumigations have also been conducted in the US as part of an extensive training process for licensed pest control fumigators. Dow reports that as many as 30% of facilities are choosing ProFume in their ongoing pest management program (Dow AgroSciences, 2005).

In Europe ProFume was first registered for empty flour mills in Switzerland in July 2003, followed by registrations in Italy (April 2004) and the UK (July, 2004) (Bell, 2004). Progress in Europe has continued with the training of fumigators, research fumigations and commercial adoption. This process was somewhat slowed by the problem of the regulatory requirement for the mill to be completely empty of flour, since there was no minimum residue limit established for flour.

Germany, however, has made progress with this issue. Sulfuryl fluoride received registration in Germany in December 2004 for empty space and structure disinfestation and for the treatment of dried fruits. In the first quarter of 2005, the registration authority accepted a fluoride residue value for grain and flour in the range of about 5-10mg/kg which offers the opportunity to treat spaces in food factories which may contain grain or flour in gas tightly separated silo bins (Reichmuth, 2005). In recent research, Reichmuth et al (2003) reported the results of trials with SF in flour mills. CT-Products of 1860 to 2255 gh/m<sup>3</sup> were effective to control (>99%) various stored product pest insects in flour mills within 36 -49 hours. The temperature was elevated with heaters to 25 - 30°C.

A practical evaluation of results of US mills fumigated with sulfuryl fluoride indicates that continued work to adapt, understand, and evaluate the technical and economic effectiveness of sulfuryl fluoride is required for full commercial acceptance. A report of the treatment of Miller Milling of Winchester Virginia and submitted to MBTOC indicated mill infestation 8 weeks after a sulfuryl fluoride treatment (Ball, 2004). In this trial, later lab research established that eggs in the flour in the mill had not been killed by the treatment, resulting in the later infestation. Mill disinfestation by any means, chemical fumigants, MB or heat, has to be done with strong knowledge of the product, and the specific facility. Otherwise any disinfestation treatment could fail. A case study on marketing sulfuryl fluoride as a methyl bromide alternative examined and reviewed answers to some of the questions from millers and fumigations about the use of sulfuryl fluoride and noted that demonstrating SF effectiveness and economic viability to millers is ongoing (Marcotte, 2004).

In Japan, where imported timber has to be treated to protect the health of Japanese trees, sulfuryl fluoride has recently been registered as a treatment to control pests on imported timber (Notice of 16-967 from Ministry of Agriculture, Forestry and Fisheries of Japanese government issued as of December 28, 2004) (Tateya and Mizobuchi, 2005).

### ***Heat treatments***

There has been considerable research and commercial phase-in trials of heat treatment in mills and other food processing facilities in the past couple of years. Very little is covered in any published literature. Manufacturers of heat treatment equipment have advanced with systems designed for flour mills, and adapted heat equipment originally designed for uses in the construction industry for food processing uses. One heat equipment manufacturer, Temp-Air, in materials sent to MBTOC reported several commercial trials of its equipment in mills and food processing facilities (Temp-Air, 2005). Fields (2004), in work done with Canadian flour mills tested two types of heat equipment with varying results, and with an economic analysis that indicated heat treatment was considerably more costly, at least in Canadian circumstances.

Several trials and increasing use of heat treatments have been reported in Germany. Heat treatments of about 55°C to disinfest empty flour mills and similar premises within about 2 to 3 days were reported by Hofmeir (2002) and Segur-Cabanac and Enispieler (2004). A system of using electric mobile heaters to heat mills up to about 55°C for about two days is recommended for disinfestation of empty spaces in Germany (Kassel, 2004). The limitation still seems to be the size. A size of more than about 40,000m<sup>3</sup> is said to be too large for an economically feasible treatment in one campaign (Hofmeir summary). The next approach to be tried is to separate the premise into parts of less than 40,000m<sup>3</sup>, which will be treated subsequently. Millers, however, are concerned that this approach will allow the insects to leave the treated parts of the building and come back later. The repercussion for this is that an effective heat treatment of a mill will take many more days than usual, with very substantial lost-business costs for the millers.

### ***Phosphine***

Alternatives for durable commodities include phosphine (usually now used in fast generating gas forms) and ethyl formate. Phosphine has largely taken the market for disinfestation of dried fruit when a fast treatment is not required.

The California, pistachio processors are in the process of converting the fumigation of their product from solid phosphine products and methyl bromide to cylinderised phosphine. Most of the nuts are fumigated in chambers or large storage silos. The largest processor, which accounts for 65% of the pistachio production, is currently using cylinderised phosphine on 80% of their product. The commercial adoption of this alternative has taken place over the past two years. There are plans in place for the construction of additional chambers and silos to add storage space to allow for the longer exposure period when using cylinderised phosphine. The additions should be completed in the next two years and will significantly reduce or eliminate the need for methyl bromide. The industry is concerned about reports of export

shipments of nuts being rejected in Europe if they were fumigated with methyl bromide.

A new box apparatus has been developed in Germany for the rapid release of phosphine gas from solid formulations (e.g. magnesium phosphide). The gas is pumped into the treated area from outside. This apparatus appears suitable for the treatment of bag stacks of cocoa and similar (Jakob and Schmidt, 2003). Furthermore, gas formulations of phosphine are now being used at major ports to disinfest incoming grains. Recently, in Japan phosphine gas generation acceleration apparatus, installed outside of grain elevators, was developed and registered for use for the control of non-quarantine pests in imported wheat. Currently, this technology is used in 22 Japanese ports (Tateya and Mizobuchi, 2005).

#### ***Ethyl formate***

Ethyl formate in CO<sub>2</sub> (sold in Australia under the BOC Ltd trade name Vapormate) was recently registered in Australia for disinfestation of stored grains, oilseeds, grain storage premises and equipment and horticultural produce. Its action is as rapid as methyl bromide against adult pests.

#### ***Methyl iodide***

Controlling pests in imported timber remains an important requirement for methyl bromide. In Japan, where imported timber has to be treated to protect the health of Japanese trees, methyl iodide has recently been registered as a treatment against pests on imported timber, and a fumigation schedule for use as a quarantine treatment is now in preparation (Tateya and Mizobuchi, 2005).

#### ***Mixture of methyl isothiocyanate and sulfuryl fluoride***

In Japan, a mixture of methyl isothiocyanate and sulfuryl fluoride has recently been registered as a treatment against pests on imported timber, and a fumigation schedule for use as a quarantine treatment is now in preparation (Tateya and Mizobuchi, 2005).

### **7.4 Overview of alternatives in Article 5(1) countries**

Methyl bromide consumption in Article 5(1) regions fell to about 11,858 tonnes in 2003 from a peak of about 18,140 tonnes in 1998 (calculated from Ozone Secretariat data of April 2005). Substantial reductions are being achieved through MLF phase-out projects. In the floriculture sector for example, over 60% of the consumption reported for 2001 will be phased out through projects by the year 2008, well before the 2015 deadline set by the protocol (MLF, 2004).

Ozone Secretariat data indicates that almost all Article 5(1) countries achieved compliance with the freeze in consumption in 2002 required under Article 2H and most countries had achieved, by 2003, the 20% reduction step that is scheduled for 2005 (refer to Table 1 in section 1.4 for details).

However, several external factors threaten the considerable progress in MB reductions achieved to date in Article 5(1) countries. Progress is becoming slower in some projects due to marketing of methyl bromide and project administration problems, rather than technical issues, and there is a genuine risk that MB consumption may start to increase in some countries due to recent circumstances. Article 5(1) countries have reported the following reasons for slow progress in some instances: (a) the large Critical Use Exemptions requested by some MB users in non-Article 5(1) countries creating a competitive disadvantage for the alternatives, (b) the continued promotion of MB products (as noted in previous reports of TEAP), and (c) the global over-supply of MB, leading to falling prices of MB in some Article 5(1) countries.

For example, the price of MB in Argentina has fallen about 10% recently, making it more attractive to users. The cost of MB fumigation is also relatively low in Morocco (1250 US\$/ha), representing only 2 % of the farm production costs for tomato (61,585 US\$/ha) (Besri, 2003). The cost of treating one hectare of land with MB in Guatemala and Honduras was found to be US\$2430, while in comparison grafting costs \$3142, metham sodium \$3350 and 1,3-D/ Pic \$3400 (UNIDO, 2005cd). In Ecuador the cost of MB was reported at US\$4,100 per hectare (World Bank, 2005) and although there are no economic analyses that compare cost of alternatives in Ecuador at this time it is to be expected that these are more expensive (as a point of reference, treating one hectare with dazomet in Colombia is estimated at US\$5,850 and with 1,3- D at US\$8,600, Trujillo 2004, pers. comm.).

#### *7.4.1 Adoption of Alternatives*

Commercial adoption of alternatives to MB continues to increase in Article 5(1) countries, often assisted by MLF investment projects. In Ecuador for example, 56% of the country consumption, which was used in rose nurseries has been phased out, with the growers involved converting to substrate “mini-plant” production (World Bank, 2005). In Honduras and Guatemala, grafting and 1,3-D/Pic are replacing MB in the melon and watermelon sectors with the aid of UNIDO projects, with 22% MB reduction achieved in the 2004-2005 season for Honduras (UNIDO, 2005d). In Costa Rica, large melon growers have been using solarisation for 4-5 years with very positive results; this alternative is now implemented in an estimated 2000 Ha of the cropping area. Metham sodium and 1,3-dichloropropene/chloropicrin are also reported as efficient alternatives for this sector (UNDP, 2005). Three of the world's largest tobacco producers – Brazil, China and Zimbabwe – have made substantial advances in phasing out MB in this sector through the adoption of



the floating tray system for seedling production (Sibanda and Way, 2004; PROZONO, 2003; UNIDO, 2005a). In Peru, use of MB for the tobacco, paprika and onion sectors has been completely phased out and new potential uses (e.g. in strawberries and artichokes) are being prevented through the NOU and the MLF projects (OTO Peru, 2003, 2005). Other important examples are cited in previous sections of this report.

Commercial adoption of alternatives has also occurred as a result of efforts at the grower/ private level and national activities. In some Article 5(1) countries, MB use is being prohibited or restricted by national legislation. In a few cases (e.g. Brazil, Costa Rica) increases in MB price have led to alternatives becoming more competitive. In Brazil, for example, flower growers are using wood-fuelled boilers to steam sterilize soils and substrates (wood for burning comes from commercial *Eucalyptus* plantings and is thus a renewable resource); in Argentina, strawberry growers are using boilers that run on gas (UNIDO, 2005b). Soil-less or substrate production is increasing, also in floriculture in Uganda, Kenya, Ecuador, Brazil and Colombia among others (Pizano, 2004b, 2005). Some expansion of solarisation predates the investment and demonstration projects of alternatives in the melon sector of Costa Rica (UNDP, 2005). In many instances however, MB is not an expensive fumigant when compared to alternatives in Article 5(1) countries (UNIDO, 2005bcd; World Bank, 2005; UNDP, 2005)

#### 7.4.2 *Emission and dosage reduction*

Although there is wide variation in MB dosages used in Article 5(1) countries with high rates often in use, there is an evident trend towards rate reduction through use of VIF. Film of this kind is now available and in use in many Article 5(1) countries for example Brazil, Uruguay, Costa Rica, Argentina, Honduras and Guatemala and is readily used by growers who find an economic advantage in reducing amounts of MB needed. This is an efficient transitional strategy. As an added advantage, it has been shown that VIF also increases efficiency of alternative soil fumigants such as 1,3-D/Pic and metham sodium (Gilreath *et al.* 2003, Fennimore, 2004; Fennimore *et al.* 2003).

Frequently, the only formulation of MB registered in Article 5(1) countries is 98:2, which makes formulations with higher chloropicrin content and less MB – also used as a transitional measure - unavailable. Disposable canisters of MB (usually about 454 gr) are still commonly found in many Article 5(1) countries. Some Article 5(1) and most non-Article 5(1) countries no longer permit their use, e.g. Kenya, South Africa, usually on safety grounds. Though requiring very little technology and investment, the system is a relatively inefficient way of applying methyl bromide. However, application of many in-kind (fumigant) alternatives tends to be more difficult than the use of disposable cans of methyl bromide. Development of a direct and simple replacement for the disposable can system of MB for small scale use presents

a challenge. In China, however, the registration and recent commercial adoption of encapsulated chloropicrin has provided an example of an innovative alternative product that is relatively simple for small-scale farmers to use.

#### 7.4.3 *Constraints to adoption and lessons learned*

One constraint to adoption of chemical alternatives is lack of registration. This is particularly true in the case of 1,3-D/Pic (e.g. Telone, Agrocelhone). This potential alternative is not registered in several Article 5(1) countries e.g. Brazil, Peru, Ecuador and Zimbabwe.

Other constraints to adoption relate to market windows – particularly in the cucurbits sector and sometimes floriculture – where longer plant-back periods found necessary with alternative chemicals, can alter harvest times significantly and adjustments to planting schedules may be technically or economically difficult in some cases.

The following points summarise lessons learned from experience with MB phase-out in Article (5)1 countries:

- Efficient alternatives to MB have been found in the vast majority of cases. These work best when used within an IPM framework and training in this respect is essential (MBTOC, 2002).
- The capability to adapt to local conditions is essential to the success of any alternative. This is presently evidenced for example by use of locally sourced, cheap substrates for soilless production (UNIDO, 2004) and locally manufactured boilers for steaming that can be run on cheaper fuel options such as gas or wood (UNIDO, 2005ab; Barel, 2005). Alternatives evaluated can be introduced to developing countries within periods of 2-3 years. In fact, demonstration projects have led larger or more technically prepared growers to adopt alternatives on their own initiative (e.g. Kenya, Costa Rica, and Ecuador) (UNDP, 2004, 2005; World Bank, 2005). Large numbers of growers have been trained in relatively short periods of time in some MLF projects (e.g. about 2760 small-scale growers were trained to use not-in-kind alternatives in the first year of a project in Argentina (Valeiro, 2003)).

## 7.5 **Registration and Reregistration of Alternatives**

### 7.5.1 *Registration status of soil alternatives*

A full report on registration, reregistration and deregistration of in-kind methyl bromide alternatives is to be included in the report of TEAP/MBTOC of October 2005, in conformity with Decisions Ex. I/4(i) and Ex. I/4(j). Some preliminary information is given here.

Table 7-2 (below) presents available data on the registration status of leading chemical alternatives for the control of soilborne pests and diseases. It indicates that metham sodium and dazomet are widely registered, and 1,3-dichloropropene (1,3-D) and chloropicrin are also registered in a number of countries. Sodium tetrathiocarbonate (enzone) is registered in only a few countries. Registration of mixtures of fumigants (particularly 1,3-D + pic) is increasing. In addition to the countries listed in table 2, 1,3-D/Pic has been registered in Article 5(1) countries such as Chile, Costa Rica, Cuba and Morocco, and registration is being sought in countries such as Jordan, Argentina and China (Carrera *et al.* 2004). In some countries fumigants must be registered as a mixture if they are to be applied simultaneously; while in other countries fumigants can be simultaneously applied (co-applied) without the need for additional registration.

The US EPA has recently registered several products for the control of weeds, including *Cyperus* spp. These include halosulfuron methyl (Sanda) for use in fruiting vegetables and cucurbits, and trifloxysulfuron sodium (Envoke) for tomato (Norton, 2004).

The following soil fumigants are reported to be in the process of registration: iodomethane in USA (for peppers, tomatoes, strawberries and ornamentals), dazomet in USA (for strawberries and tomatoes), furfural in USA (for protected and open field ornamentals), sodium azide in USA (for turf and golf courses), mixture of 1,3-D/chloropicrin in Italy, chloropicrin in France, dazomet in Hungary, ethane dinitrile (cyanogen) in Australia, and dimethyldisulphide (DMDS) in France.

In the USA and European Union, a number of soil fumigants are undergoing re-registration. Metham sodium and chloropicrin, as well as MB, are going through re-registration in the USA at present, and decisions are scheduled to be completed in 2006. To date, 1,3-D is the only soil fumigant that has completed the re-registration process in the US. The US EPA is also carrying out a 'cluster analysis' on soil fumigants (metham sodium, iodomethane, chloropicrin, 1,3-D, dazomet and MB), which aims (a) to ensure a level playing field by evaluating the soil fumigant alternatives concurrently and consistently and (b) to ensure that risk management decisions do not result in risk/benefit tradeoffs that neither improve safety nor help agriculture.

Biological control products normally require registration but are not listed in Table 7-2 because they are not normally considered as MB alternatives due to their narrow spectrum of activity, although they can play a useful role as adjuncts to alternatives such as fumigants, steam or substrates. It should be noted that many non-chemical treatments do not require registration under the European Union's legislation on pesticide products; this applies to treatments such as steam, heat, substrates, grafted plants, resistant varieties and other cultural practices (Smeets, 2004). Many other countries also do not require

non-chemical treatments to be registered; as a result non-chemical products are more immediately available than new chemical products.

*Table 7-2: Registration status of chemical soil alternatives*

This table is compiled from databases on registration and available alternatives submitted by Parties to the Ozone Secretariat (European Commission, 2005a), and information provided in critical use nominations. Local conditions of use and requirements may render a registered fumigant unavailable for specific crops or locations, although registered in general.

Country	Fumigant products							Non-fumigant products		
	13D	Daz	met	pic	Enz	13D +pic	13D + MIT	ne m	fun	her
Australia	R	R	R	R		R		R	R	R
Belgium	R	R	R	R				R	R	R
Canada (a)	R (b)	R	R			R	R			
France	R	R	R		R			R	R	R
Greece	R	R	R	R (d)	R			R	R	R
Ireland	R	R	R	R						
Italy	R	R	R	R				R	R	R
Poland		R	R					R	R	R
Portugal	R	R	R			R (d)		R	R	R
Spain	R	R	R	R	R	R (d)		R	R	R
UK	R	R	R	R				R	R	R
USA	R (b)	R (c)	R	R		R		R	R	R (e)

NB. In some cases the fumigants are registered for specific crops, while in other cases they are registered for soil fumigation in general. (a) Registration information relates to strawberry runners only. (b) not permitted in some areas. (c) registered for non-food crops. (d) provisional at present pending finalisation of re-registration of fumigants in the EU. (e) for certain types of weeds only.

R	registered
13D	1,3-dichloropropene
daz	dazomet
met	metam sodium and/or metam potassium
pic	chloropicrin
enz	sodium tetrathiocarbonate (enzone)
MIT	methyl isothiocyanate
nem	various nematicide products, e.g. oxamyl
fun	various fungicide products – normally specific to certain groups of fungi
her	various herbicides – normally specific to certain types of weeds

### 7.5.2 *Registration status of postharvest and structural alternatives*

Table 7-3 (below) presents available data on the registration status of leading chemical alternatives for the control of stored product pests in commodities and/or structures. Phosphine (solid formulations) is registered in many countries. Registration of gaseous forms of phosphine (cylinderised) and sulfuryl fluoride is increasing. Some countries registered sulfuryl fluoride (SF) a number of years ago for non-food structures such as historic buildings in some European countries, or domestic dwellings (replacing a large volume of MB) in the USA. More recently sulfuryl fluoride formulations designed for certain commodities or empty mills have been registered in USA and parts of Europe. Sulfuryl fluoride is reported to be in the registration process in France, Benelux and Spain (Lange, 2004), and in Canada.

Two registered fumigants, MITC and iodomethane, are not included in the table below. Apparently MITC is registered in Canada for flour mills, according to a list of registered alternatives submitted by Canada to the Ozone Secretariat recently. Iodomethane has recently been registered in Japan for broad-spectrum insect control on imported timber (UNEP, 2004).

Most postharvest fumigants (active ingredients), except for sulfuryl fluoride, are undergoing re-registration in the European Union.

Table 7-3: Registration status of postharvest alternatives

The table was compiled from databases on registration and available alternatives submitted by Parties to the Ozone Secretariat (European Commission, 2005b), information provided in critical use nominations, and other sources.

Country	Fumigant products						Other treatments	
	EF	HC N	PH3 solid	PH 3 ga s	PPO	SF	ins	Irr
Australia	R		R	R			R	R (g)
Austria		R (b)	R			R (a)	R	
Belgium			R				R	R (e)
Canada			R	R			R	R (e h)
Denmark			R	R			R	R (e)
France		R (i)	R				R	R (e h f)
Germany			R	R		R (a b f)	R	R (e)
Greece			R				R	R (e)
Ireland			R				R	R (e)
Italy			R			R (b)	R	R (e)
Poland			R				R	R (e)
Spain		R	R				R	R (e)
Sweden			R			R (a)	R	R (e)
Switzerland			R			R (b)	R	
UK			R			R (b)	R	R (e)
USA			R	R	R (d)	R (a b c)	R	R (e h g f)

(a) non-food structures, e.g. historic buildings. (b) empty food structures e.g. mills. (c) dried fruits, tree nuts, cereal grains. (d) stored agricultural commodities: nutmeats, cocoa, spices; PPO mixed with CO<sub>2</sub> is registered for stored nuts. (e) permitted for herbs and spices. (f) dried fruit (g) some fresh fruits and vegetables for disinfestation. (h) some grains and cereals or flour (i) aircraft.

R	registered
EF	ethyl formate
HCN	hydrogen cyanide, calcium or sodium cyanides
PH3 solid	phosphine (solid formulations)
PH3 gas	gaseous phosphine in carbon dioxide or nitrogen (cylinders)
PPO	propylene oxide
SF	sulfuryl fluoride
ins	residual or aerosol insecticides suitable for use in IPM programmes
irr	irradiation

### 7.5.3 Re-registration and review of MB

In the European Union, MB is being evaluated for re-registration as part of the EC's general review of pesticides (active ingredients). The reviews include scientific assessments of safety and environmental data submitted by applicants. Under the EC Plant Protection Products Directive (91/414/EC) a

dossier on MB is being reviewed and a decision is due to be taken, by the end of 2008 at the latest, for pesticide uses that are regulated under this Directive. Under the Biocides Directive (98/8/EC) MB has been “identified” which means that biocidal products containing MB can only be placed on the EU market until 1 September 2006 at the latest, according to Article 4(2) of Regulation 2032/2003 (Arash, pers. comm. 2005). It is not clear whether a ban on the use of MB in the EC would result in a ban on import of products grown or treated with MB and it has not yet determined how significantly this would affect global MB use.

In the USA MB is undergoing re-registration at this time, and a decision is scheduled to be completed in 2006. MB is also included with the other fumigants in a “cluster analysis”, as described above.

A review of MB’s toxicity and environmental effects is provided in IPCS/WHO (1995).

## **7.6 Recapture, recycling and destruction.**

There continues to be only limited adoption of recapture technology that could lead to reduction of methyl bromide emissions to the ozone layer where methyl bromide continues to be used or for QPS applications. Where it is adopted, the investment in recapture systems is typically driven by local environmental or occupational health and safety concerns.

The Nordiko recapture/destruction system is now in commercial operation in several different situations in Australia (Brash, 2005). The systems are attached to ‘under sheet’ fumigations, to permanent fumigation chambers, and as clip-on units to containers under fumigation. The system involves recapture on active carbon, destruction of the sorbed methyl bromide with sodium thiosulphate and washing and drying the treated carbon for reuse.

## 7.7

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## **8 Methyl Bromide - Quarantine and Pre-shipment Task Force - First Report**

### **8.1 Background**

In paragraph 4 of decision XI/13, the Parties requested the Technology and Economic Assessment Panel (TEAP) to evaluate the technical and economic feasibility of alternative treatments and procedures that could replace methyl bromide for quarantine and pre-shipment (QPS) treatment and to estimate the volume of methyl bromide that would be replaced by the implementation of technically and economically feasible alternatives for quarantine and pre-shipment treatment, reported by commodity and/or application.

This preliminary report of the QPS Task Force introduces the quarantine and pre-shipment issue and releases survey results and modifications to the survey to date. The issue is a complex and diverse one, with a multitude of different applications of methyl bromide coming under the category of QPS usage. In many countries, records of QPS usage by application are not routinely kept or easily assessed. This has necessitated a survey approach to the gathering of data to provide a basis for response to Dec. XI/13(4). Paragraph 6 of decision XI/13 urges the Parties to implement procedures to monitor the uses of methyl bromide by commodity and quantity for quarantine and pre-shipment uses. Additionally, reporting of quantities of methyl bromide used in QPS applications has only recently become required of the Parties (Beijing Amendment, Art. 1, para. O). Hitherto, quantities of methyl bromide used in QPS have been estimated from a variety of sources.

The scope of the QPS exemption has been defined in decisions of the Protocol relating to the scope of the terms “Quarantine” and “Pre-shipment”.

The Seventh Meeting of the Parties decided in Decision VII/5 that:

- (a) “Quarantine applications”, with respect to methyl bromide, are treatments to prevent the introduction, establishment and/or spread of quarantine pests (including diseases), or to ensure their official control, where:
  - (i) Official control is that performed by, or authorised by, a national plant, animal or environmental protection or health authority;
  - (ii) Quarantine pests are pests of potential importance to the areas endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.
  
- (b) "Pre-shipment applications" are those treatments applied directly preceding and in relation to export, to meet the phytosanitary or sanitary

requirements of the importing country or existing phytosanitary or sanitary requirements of the exporting country;

The Eleventh Meeting of the Parties decided in decision XI/12 that pre-shipment applications are those non-quarantine applications applied within 21 days prior to export to meet the official requirements of the importing country or existing official requirements of the exporting country. Official requirements are those, which are performed by, or authorised by a national plant, animal, environmental, health or stored product authority.

TEAP and its MBTOC reported on this issue in its 2003 progress report and noted that individual tonnages for uses of methyl bromide for quarantine and pre-shipment treatment of particular commodities were not available on a world-wide basis, though specific surveys were available for several countries. TEAP and its MBTOC further noted that a survey had been commissioned by the European Community and the report of the survey was scheduled to be available for 2004. The survey was actually started in 2004 and the Parties have been requested, through the Ozone Secretariat, to provide data and information on QPS uses and their alternatives by 30 June 2004.

At its twenty-fourth meeting, July 2004, the Open-ended Working Group discussed the feasibility of completing the survey by the 30 June deadline in view of the detailed nature of the survey and the ability of the Parties to answer all the survey questions. Recognising the importance of the data and the heavy workload already borne by MBTOC, various suggestions were made as to how the work could be carried forward.

Australia, on behalf of Canada, Switzerland and the United States of America, presented a proposal to the July 2004 Open-ended Working Group, but no agreement was reached. Australia stated its intention to hold inter-sessional discussions on the issue with a view to presenting a revised proposal to the Sixteenth Meeting of the Parties in November 2004.

At the Sixteenth Meeting of the Parties, Australia submitted a new proposal on the issue explaining that the proposed decision had been prompted by a concern that, given the short deadline for submission of data, some Parties would simply be unable to comply with the deadline and that any reported data hastily compiled might be incomplete and unreliable. The Parties then adopted Decision XVI/10, which set a new schedule for completing the study called for by Decision XI/13 with a view to ensuring the provision of reliable and robust information by the Parties. Decision XVI/10 states:

**“Decision XVI/10. Reporting of information relating to quarantine and pre-shipment uses of methyl bromide**

*Recalling* the tasks assigned to the Technology and Economic Assessment Panel under decision XI/13 paragraphs 4 (a) and (b) regarding quarantine and pre-shipment uses of methyl bromide,

*Recognising* that in order to complete both of these tasks, the Panel will require better data on the nature of each Party's quarantine and pre-shipment uses and on the availability in each Party of technically and economically feasible alternatives to methyl bromide for these uses,

*Noting* the advice of some Parties that they would require additional time in order to provide useful and robust data to inform the Panel's work on this issue, particularly on the availability of technically and economically feasible alternatives in their jurisdictions,

*Desiring* that the Technology and Economic Assessment Panel's implementation of decision XI/13, paragraph 4, should nevertheless take place in as timely and reasonable a manner as possible,

*Noting* with appreciation that some Parties have already submitted partial data to inform the Panel's work on this issue,

*Noting* that, given the nature of quarantine and pre-shipment applications, quarantine and pre-shipment uses of methyl bromide and its alternatives can vary considerably from year to year,

*Noting* that the introduction of standard 15 of the International Standards for Phytosanitary Measures, of March 2002, of the International Plant Protection Convention of the Food and Agriculture Organization of the United Nations, may create a growing demand for the quarantine and pre-shipment uses of methyl bromide, despite the availability of heat treatment as a non-methyl bromide option in the standard;

*Noting* the current workload of the Methyl Bromide Technical Options Committee and its request at the twenty-fourth meeting of the Open-ended Working Group for additional expertise in some quarantine and pre-shipment applications,

*Noting* that quarantine and pre-shipment treatments, according to decisions VII/5 and XI/12, are authorised or performed by national plant, animal, health or stored product authorities,

1. To request the Panel to establish a task force, with the assistance of the Parties in identifying suitably qualified members, to prepare the report requested by the Parties under decision XI/13 paragraph 4;
2. To request Parties that have not yet submitted data to the Panel on this issue to provide best available data to the task force before 31 March 2005, identifying as available all known uses of methyl bromide for quarantine and pre-shipment, by commodity and application;
3. In responding to the request under paragraph 2, to request the Parties to use best available data for the year 2002 or data considered by the Party to be representative of a calendar year period;

4. To request the task force to report the data submitted by the Parties under paragraphs 2 and 3, or previously submitted by other Parties in response to the 14 April 2004 methyl bromide quarantine and pre-shipment survey, by 31 May 2005, for the information of the Open-ended Working Group at its twenty-fifth session;
5. Also to request the task force, in reporting pursuant to paragraph 4, to present the data in a written report in a format aggregated by commodity and application so as to provide a global use pattern overview, and to include available information on potential alternatives for those uses identified by the Parties' submitted data;
6. To request the Parties to provide information to the task force, as available and based on best available data, on the availability and technical and economic feasibility of applying in their national circumstances the alternatives identified in paragraph 5, focusing in particular on the Parties' own uses, for the calendar year period reported under paragraphs 2 and 3, by 30 November 2005, constituting either:
  - (a) More than 10 per cent of their own total annual methyl bromide consumption for quarantine and pre-shipment consumption; or
  - (b) In the absence of uses over 10 per cent, which constitute their five highest volume uses; or
  - (c) Where data is available to the Party, all their known uses;
7. To request the Panel, on the basis of information contained in paragraph 6, to report to the Parties in accordance with decision XI/13, paragraph 4, by 31 May 2006; ”

Development of methyl bromide alternatives for QPS applications continues to be a difficult process exacerbated by the multitude of commodities being treated, the diverse situations where treatments are applied and a constantly changing trade and regulatory landscape. A variety of technologies are potentially suitable as replacements for some commodities and some circumstances. In many cases, uncertainty about phytotoxic effects and effectiveness against the target pests constrain use of alternatives. There will be considerable cost, effort and time required to gain the registrations and approvals that are required for many quarantine uses. At this time, it is not clear how or if this will happen. Changing quarantine regulations and bilateral quarantine agreements will have to be the responsibility of governmental agencies but pesticide registrations are in the private sector. In the past, pesticide companies have been reluctant to invest money to register and market pesticides for small markets represented by many of these quarantine uses. Alternatives that do not require registration such as heat, cold and inert gases would be more easily adapted in cases where their use is appropriate to the commodity, situation and where they show sufficient efficacy.

QPS uses are currently lumped together by the Parties. The Task Force sees an advantage to considering quarantine and preshipment issues separately. They differ markedly in their ability to adopt alternatives. The standard of efficacy for quarantine uses is extremely high because the consequences of exotic pests surviving treatments can be catastrophic to countries where the new pest becomes established. Preshipment uses on the other hand, are usually for cosmopolitan pests that are already found in the importing country. Consequently, the efficacy standard does not need to be as severe as in the case of quarantine and research requirements to establish efficacy can be less rigorous as well. It would appear that there are many fewer obstacles to adopting alternatives for preshipment methyl bromide uses.

## **8.2 Result of the Survey**

The survey responses were directly sent by the Parties to the contractor engaged by the European Commission to organise and report on the results. An interim report was prepared by the contractor for presentation to the Lisbon Conference on Alternatives to Methyl Bromide, 27-30 September 2004. The interim report is attached as Annex I to this chapter.

The survey sought data for the calendar year 2002. As reported in the attached interim report, forty-two Parties had responded to the survey questionnaires. Fifteen of the respondents advised that their use of methyl bromide for QPS was zero. The quantity of methyl bromide used for QPS reported by the respondents totalled 1,611.062 metric tonnes which represents approximately 15% of the QPS usage that was estimated for 2000 by MBTOC in its 2002 Assessment Report.

Since the Lisbon Conference, one other Party (Kazakhstan) reported 1.58 tonnes of methyl bromide use for QPS.

While the total reported quantity only represented a small part of total estimated QPS usage, the interim report notes some general themes and trends, which are also consistent with other available studies. The interim report concludes that much more methyl bromide could be replaced by adoption of available alternatives and that there needs to be greater awareness of the scope of the QPS exemption.

## **8.3 Progress on the Implementation of Decision XVI/10**

As of 1 April 2005, ten Parties responded to paragraphs 2 and 3 of Decision XVI/10. Summary of the data and information submitted are shown in Table 8-1. Data by commodity and application are provided where the Parties submitted such data.

TEAP and its MBTOC, in its May 2004 Progress Report, reported that more than 11,245 tonnes of methyl bromide was used for QPS purposes according

to data reported by the Parties to the Ozone Secretariat. TEAP noted that the data reported by the Parties was not complete. The total additional QPS use reported by the Parties since the attached interim report was prepared amounts to 291.823 tonnes (including Kazakhstan's 1.58 tonnes and excluding Egypt). The total QPS use in 2002 reported to date since the 14 April 2004 QPS survey is 1,902.885 tonnes, representing approximately 17% of the total reported QPS use of 11,245 tonnes. TEAP and the QPS Task Force felt that the additional information and data received since the preparation of the interim report do not merit a re-analysis of the results contained in the interim report, including of the global use pattern overview.

The information provided by the Parties did not include information on the potential alternatives. Some information on this issue is provided in the attached interim report. Further information on alternatives will be forthcoming in the TEAP Progress Report of this year. The next periodic assessment under Article 6 of the Montreal Protocol will be prepared for consideration of the Parties in 2006. MBTOC's 2006 Assessment Report will also provide further information on alternatives for QPS.

#### **8.4 Establishment of the QPS Task Force and continuation of the work**

Pursuant to paragraph 1 of Decision XVI/10, TEAP established a small group consisting of six members to function as the core group of the QPS Task Force. The members are drawn from MBTOC. The QPS Task Force is still being constituted and any nominations from Governments are still welcome.

The six members of the core group are as follows:

Jonathan Banks	Australia
Mokhtarud-Din Bin Husain	Malaysia
Darka Hamel	Croatia
Mitsusada Mizobuchi	Japan
David Okioga	Kenya
Ken Vick	USA

The Terms of Reference of the QPS Task Force are attached as Annex II to this chapter.

In accordance with paragraph 6 of Decision XVI/10, Parties are expected to submit further information. The QPS Task Force and TEAP will continue to assess the information submitted by the Parties and report the final result to the Parties by 31 May 2006 as required by paragraph 6 of the same decision.

Table 8-1: Summary of data and information provided by the Parties as of 1 April 2005, pursuant to Decision XVI/10 (3) and (4)

Party	Total MB Used for QPS		Commodities treated (for 2002 only)		Information on alternatives	Comments
	Year	Quantities (metric tonnes or kg)	Type	Quantities		
Bhutan		0				
Canada		42,833 kg	Seeds for planting Fresh Fruit and vegetables Wooden and other packaging material Dried food stuffs Wood Whole logs Equipment and shipping containers Christmas trees Potato field (soil)	575 kg 550 kg 26,716kg 9 kg 14 kg 3,716 kg 6,209 kg 889 kg 4,155 kg	Yes Under evaluation Yes Yes Yes Yes Yes Yes Yes	Information on legislation also provided.
Croatia	2002 2003 2004	58 kg 89.9 kg 122.5 kg	Pallets (wood packaging material)	58 kg	Not provided	
Dominica		0				
Egypt						Informed that information was submitted directly to the contractor.

Party	Total MB Used for QPS		Commodities treated (for 2002 only)		Information on alternatives	Comments
	Year	Quantities (metric tonnes or kg)	Type	Quantities		
Georgia	2000 2001 2002	13 t 13 t 13 t	Wood Dried food stuffs Wooden packing material Fresh Fruit and vegetables Equipment and shipping containers Personal effects, furniture, crafts, etc. Cut flowers Bulb, corms, tubers, rhizomes Nursery stock Cotton and other fiber crops Whole logs Hay, straw, dried animal fodder	2,000 kg 1,000 kg 300 kg 2,000 kg 500 kg 1,000 kg 500 kg 900 kg 2,000 kg 500 kg 2,000 kg 300 kg	Not provided	
Moldova	2002 2003 2004	1,192 kg 359 kg 222 kg	Not provided	Not provided (total 1,192kg)	Not provided	Information on legislation also provided.
Sri Lanka	2002	4.56 t	Wood packaging material (export) Foliage (export) Coir products (export) Ship and containers (export) Foliage (import) Grains (import)	2.26 t 0.3 t 0.3 t 1.50 t 0.10 t 0.10 t	Not provided	
Thailand	2002	228.6 t	Tapioca, starch, rice flour Rice Other post-harvest (wheat, feed, maize, etc.) Cut flowers	109.2 t 69.6 t 36.0 t 13.8 t	Not provided	



Party	Total MB Used for QPS		Commodities treated (for 2002 only)		Information on alternatives	Comments
	Year	Quantities (metric tonnes or kg)	Type	Quantities		
USA		Not provided	Asparagus, ceramic tile, cherries, citrus, cotton, equipment (soil disinfection), forest seedlings, fruit (various), grapes, herbs, kiwi, logs, non-plant commodities, nut trees, nuts, various, ornamentals, pallets, plant material (various), raspberries, rice milling facilities, roses, seed (various), soil, spices, stonefruit trees, strawberry runners, turf, unmanufactured wood, vegetables, walnuts, wood packing material, yams	Not provided	Not provided	US is seeking additional information to supplement the information reported on the categories reported so far.
<b>Total</b>				<b>290.243 t</b>		



## ANNEX I (8-1)

### PRELIMINARY RESULTS OF AN INTERNATIONAL SURVEY ON THE USE METHYL BROMIDE FOR QUARANTINE AND PRE-SHIPMENT

S.C. OGDEN

*Market Access Solutionz Ltd., Wellington, New Zealand*

[stephen@solutionz.co.nz](mailto:stephen@solutionz.co.nz)

#### ABSTRACT

An international survey was carried out to determine the volumes of methyl bromide (MB) that were used for quarantine and pre-shipment (QPS) purposes in 2002. Preliminary results are presented in this paper. Forty-two Parties responded to the survey and reported that 1,611 tonnes of MB was used for QPS. Of this, just over half was used to treat cereals, grains and dried foodstuffs and a further 28% to treat wood packaging, wood and logs. Parties reported widespread availability of alternative treatments, but that cost, location of facilities, and lack of acceptance by trading partners are impediments to their implementation. Although the survey represents a small sample of estimated QPS MB use, the survey has identified the main uses and those uses for which respondents report alternatives are available but not in use. The survey also identified a need for greater awareness of the scope and definition of the quarantine and pre-shipment exemption.

#### INTRODUCTION

Applications of methyl bromide (MB) for quarantine and pre-shipment (QPS) purposes are exempt from the phase-out provisions of the Montreal Protocol. Quarantine applications are treatments to prevent the introduction, establishment and/or spread of quarantine pests<sup>1</sup> (including diseases), or to ensure their official control<sup>2</sup>. Pre-shipment applications are non-quarantine applications applied within 21 days prior to export to meet the official requirements<sup>3</sup> of the importing country or existing official requirements of the exporting country.

The Eleventh Meeting of the Parties to the Montreal Protocol instructed the Technical and Economic Assessment Panel (TEAP) “to estimate the volume of

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<sup>1</sup> Pests of potential importance to the areas endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.

<sup>2</sup> Control performed by, or authorised by, a national plant, animal or environmental protection or health authority.

<sup>3</sup> Those which are performed by, or authorised by, a national plant, animal, environmental, health or stored product authority.

*methyl bromide that would be replaced by the implementation of technically and economically feasible alternatives for quarantine and pre-shipment, reported by commodity and/or application” (Decision XI/12). Due to TEAP workload and other priorities the report requested by the Parties could not be completed. Instead, an international survey on the use of MB for QPS purposes was commissioned to assist TEAP in this work. This paper presents preliminary results of the survey.*

## **METHODS**

In order to standardise data reporting a survey form was developed to gather data from the Parties. In the survey form the broad range of commodities and articles that might be treated with MB for QPS purposes were grouped under 16 headings:

*Bulbs, corms, tubers and rhizomes (intended for planting);*  
*Cut flowers and branches (including foliage);*  
*Fresh fruit and fresh vegetables;*  
*Grain and cereals for consumption including rice (not intended for planting);*  
*Dried foodstuffs (including herbs, nuts, dried fruit, coffee, cocoa);*  
*Nursery stock (plants intended for planting other than seed);*  
*Seeds (intended for planting);*  
*Wooden packaging materials, other packaging materials including cardboard, pallets and dunnage;*  
*Wood (including round sawn, sawn wood, wood chips);*  
*Whole logs (with or without bark);*  
*Hay, straw, dried animal fodder (other than grains and cereals listed above);*  
*Cotton and other fibre crops and products;*  
*Buildings (including dwellings, factories, storage facilities);*  
*Equipment (including used agricultural machinery & vehicles) and empty shipping containers;*  
*Personal effects, furniture, crafts, artefacts, hides, fur and skins;*  
*Other.*

For each of these major groups, Parties were asked to identify the quantities of MB used for QPS, the reasons for treatment (associated pests, legislative basis for treatment) and the availability of alternative treatments in their country. The survey sought data for the 2002 calendar year as this is the most recent period for which Parties are required to have reported their total MB consumption (including total QPS) to the United Nations Environment Programme (UNEP). The survey form was made available for download from the website of the UNEP Ozone Secretariat from April. The Ozone Secretariat contacted all Parties to the Montreal Protocol and requested that they co-operate in the completion of the survey and that responses be received by 30 June 2004.

## RESULTS OF THE SURVEY

### Volume of methyl bromide used for quarantine and pre-shipment purposes in 2002

Forty-two of the 188 Parties to the Montreal Protocol responded to the survey, reporting a total of 1,611,062 kg of MB used for QPS (Table A8-1-1). Fifteen of these respondents advised that their use of MB for QPS was zero in 2002 (Colombia<sup>1</sup>, Cyprus<sup>1,3</sup>, Czech Republic<sup>3</sup>, Denmark<sup>2</sup>, Dominica<sup>1</sup>, Luxembourg<sup>2</sup>, Macedonia, Mongolia<sup>1</sup>, Namibia<sup>1</sup>, Oman<sup>1</sup>, Slovakia<sup>3</sup>, Slovenia<sup>3</sup>, Sweden<sup>2</sup>, Togo<sup>1</sup>, Uganda<sup>1</sup>). Twenty of the responding Parties operate under Article 5(1) of the Montreal Protocol, and 22 are non-Article 5(1) countries. Responding Article 5(1) countries used 76% of the total MB reported for QPS purposes. Several Parties at the Open-Ended Meeting of the Parties in July 2004 reported that more time was required to complete the survey (Anon, 2004).

Table A8-1-1: Amount (kg) of methyl bromide used by responding Parties for QPS purposes in 2002

Name of Party	Total MB (kg) for QPS use	MB (kg) replaceable by alternative technologies	Name of Party	Total MB (kg) for QPS use	MB (kg) replaceable by alternative technologies
Bahrain <sup>1</sup>	2,000	0	Myanmar <sup>1</sup>	61,373	61,373
Belarus	948	0	Netherlands <sup>2</sup>	1,470	750
Belgium <sup>2</sup>	25,660	25,660	New Zealand	100,100	0
Bulgaria	5,000	5,000	Nigeria <sup>1</sup>	300	0
Cameroon <sup>1</sup>	13,500	13,500	Pakistan <sup>1</sup>	31,000	0
Canada	18,958	8,495	Peru <sup>1</sup>	36	0
Egypt <sup>1</sup>	224,342	142,132	Poland <sup>3</sup>	34,779	0
Estonia <sup>3</sup>	100	100	Portugal <sup>2</sup>	5,000	5,000
European Union <sup>4</sup>	265,346	164,377	South Africa <sup>1</sup>	44,630	9,023
Greece <sup>2</sup>	29,828	29,828	Spain <sup>2</sup>	131,068	72,998
Hungary <sup>3</sup>	3,000	3,000	Turkey <sup>1,5</sup>		
Italy <sup>2</sup>	41	41	United Kingdom <sup>2</sup>	34,400	27,000
Jamaica <sup>1</sup>	2,828	648	Uruguay <sup>1</sup>	600	431
Mexico <sup>1</sup>	284,200		Vietnam <sup>1</sup>	555,900	457,300
Total Article 5(1) Parties	1,220,709	684,407	<b>Notes</b> <sup>1</sup> Operating under Article 5(1) of the Montreal Protocol. <sup>2</sup> Member State of the European Union in 2002. <sup>3</sup> Current EU Member State, but not a member in 2002. <sup>4</sup> Total of data submitted by current European Union Member States, including those Parties that were not Member States in 2002. <sup>5</sup> Some aspects of the data provided are currently being clarified, so are not reported here.		
Total non-Article 5(1) Parties	390,352	177,872			
TOTAL	1,611,062	862,279			

Of the total volume of MB reported for QPS, approximately 75% was used for quarantine (Q) purposes and only 2.7% could be identified as pre-shipment (PS) use. The breakdown between Q and PS use was very similar when totals for Article 5(1) Parties (74% Q, 3% PS) and non-Article 5(1) Parties (77% Q, 3% PS) were calculated. The remaining percentages could not be accurately allocated to either category due to ambiguity in the data provided. These figures should be considered preliminary as some survey responses are being clarified with the responding Parties.

### **Major sectors using methyl bromide for quarantine and pre-shipment**

Just over half of the MB used for QPS in 2002 (Table A8-1-2) was used to treat durable food products in the categories of grains and cereals (40.2%) and dried foodstuffs (11.5%). Responding Parties suggested that most of this use of MB (89% and 77% respectively, or 590.8 tonnes) could be replaced by the implementation of alternative technology that is currently available, but not used, in their countries.

The next largest category for QPS use of MB (28.0% or 371.7 tonnes) was for timber and timber products (wood packaging, sawn wood, whole logs), followed by cotton and fibre (6.5% or 86.2 tonnes), and perishable plant products (fresh fruit and vegetables and flowers) at 3.1% or 41.4 tonnes. The category of “other”, the specifics of which were generally not detailed by Parties, represented 6.2% of QPS use.

*TABLE A8-1-2: Quarantine and pre-shipment use of methyl bromide by use category, including quantities that could be replaced by the implementation of available alternative technology.*

Category (categories are described fully in methods)	MB (kg)	% MB used by sector	MB (kg) for QPS replaceable by alternatives	% MB used for QPS replaceable by alternate technology
Bulbs, corms, tubers and rhizomes	3,035.50	0.23	0.00	0.00
Cut flowers and branches	2,731.30	0.21	2,010.00	73.59
Fresh fruit and fresh vegetables	38,682.95	2.92	16,046.75	41.48
Grain and cereals for consumption	533,479.55	40.21	473,214.00	88.70
Dried foodstuffs	152,440.14	11.49	117,575.00	77.13
Nursery stock	64.04	0.00	0.00	0.00
Seeds for planting	618.39	0.05	400.00	64.68
Wooden packaging materials, pallets, dunnage, other packaging	204,612.16	15.42	119,549.44	58.43
Wood	107,791.90	8.12	100,850.40	93.56
Whole logs	59,330.45	4.47	3,957.80	6.67
Hay, stray, dried animal fodder	2,345.00	0.18	0.00	0.00
Cotton and fibre	86,198.00	6.50	13,500.00	15.66
Buildings	0.00	0.00	0.00	0.00
Equipment	35,360.26	2.66	14,813.00	41.89
Personal effects	18,298.65	1.38	362.25	1.98
Other	81,873.50	6.17	0.00	0.00
<b>TOTAL<sup>1</sup></b>	<b>1,326,861.79</b>	<b>100.00</b>	<b>862,278.64</b>	<b>64.99</b>

<sup>1</sup> Note these totals differ from Table A8-1-1 totals, because some survey respondents did not allocate total MB into specific categories. Percentages in Table 2 are percentages MB allocated to categories.

### **Methyl bromide alternatives**

Most Parties reported that MB alternatives were commercially available in their countries. The totals presented in Table A8-2-2 suggest that 65% of the MB currently used for QPS purposes could be replaced by technologies that are commercially available in the responding countries. Article 5(1) Parties estimated that 73% of QPS MB use could be replaced by alternative technologies and non-Article 5(1) Parties reported that 46% could be replaced.

The volumes of MB that could be replaced by alternative technologies within each of the survey categories are presented in Table A8-1-2. Responding parties also identified the MB replacement technologies that were available in their countries. For grains, cereals, and dried foodstuffs the available alternatives included phosphine, aluminium phosphide, magnesium phosphide, hot water treatment, heat treatment, controlled atmosphere, and combination hot water and dry air. For timber and timber products alternatives were heat treatment, heat + low O<sub>2</sub>, phosphine, aluminium phosphide, ethyl formate, sulfuryl fluoride, debarking, insecticides, pest free areas, and inspection. For cotton and fibre, the only alternative reported was

phosphine. For perishable plant products alternatives included pyrethroids, cold treatment, hot water treatment, and alternative phytosanitary procedures (pre-clearance programmes, systems approach, pest free areas, inspection). Principle reasons why these alternatives have not been adopted are cost (relative to MB), location of heat treatment facilities, lack of application to packed shipping containers, and their lack of acceptance by importing countries.

### **Pests treated with methyl bromide for quarantine and pre-shipment purposes**

For each of the major groups of commodities treated with MB for QPS, the pests that were treated are listed in Table A8-1-3, as are the export destination countries that required these treatments to be carried out. The species listed in Table A8-1-3 are those specified by responding Parties, however many responses were non-specific (e.g., “various insects”). Similarly, the list of countries requiring MB treatment includes all of those countries listed by the responding parties, however in many cases only very general destinations were stated (e.g., “many countries”, “Asia”, “West Africa”). Some Parties expressed concerns that providing details of export destinations was commercially sensitive to some export sectors.

In addition to the export destinations, many QPS treatments were applied by importing countries in response to the detection of quarantine pests during import inspection. These importing countries are not listed in Table 3 as they do not require mandatory MB treatment – the treatments were only applied in response to the detection of specified quarantine pests.



Table A8-1-3: Key pests treated with methyl bromide for quarantine and pre-shipment purposes in major use categories, and the countries requiring this treatment (2002 data)

Category	Key pests treated	Countries requiring MB treatment for these commodities <sup>1</sup>
Grain, cereals & dried foodstuffs	<i>Acarus siro</i> , <i>Ahasverus advena</i> , <i>Araecerus fasciatus</i> , <i>Botrytis</i> spp., <i>Carpophilus dimidiatus</i> , <i>C. hemipterus</i> , <i>Curculio elephas</i> , <i>C. splendana</i> , <i>Cydia</i> sp., <i>Ephestia cautella</i> , <i>Ephestia figulilella</i> , <i>Ephestia kuehniella</i> , <i>Ephestia</i> spp., <i>Fusarium</i> spp., <i>Lasioderma serricorne</i> , <i>Lolium temulentum</i> , <i>Necrobia rufipes</i> , <i>Oryzaephilus surinamensis</i> , <i>Phoma</i> spp., <i>Plodia interpunctella</i> , <i>Ptinus</i> spp., <i>Rhyzopertha dominica</i> , <i>Sitophilus granarius</i> , <i>Sitophilus oryzae</i> , <i>Tilletia indica</i> , <i>Tribolium confusum</i> , <i>Tribolium</i> sp., <i>Trogoderma granarium</i> , <i>Trogoderma inclusum</i> , <i>Typhaea stercorea</i> , weed seeds, mites.	Angola, Bahrain, Bangladesh, Canada, China, European Union, Germany, India, Indonesia, Japan, Korea, Macau, Malaysia, Mexico, USA.
Timber products (packaging material, sawn timber, logs)	<i>Agrilus planipennis</i> , <i>Anobium rufipes</i> , <i>Anoplophora chinensis</i> , <i>Anoplophora glabripennis</i> , <i>Bursaphelenchus xylophilus</i> , <i>Callidium violaceum</i> , <i>Callipogon relictus</i> , <i>Erwinia salicis</i> , <i>Heterobostrychus</i> sp., <i>Hylastes ater</i> , <i>Ips typographus</i> , <i>Lyctus</i> sp., <i>Lymantria dispar</i> Asian biotype, <i>Lymantria monacha</i> , <i>Lymantria mathura</i> , <i>Monochamus alternatus</i> , <i>Monochamus</i> sp., <i>Ophiostoma ulmi</i> , <i>O. novo-ulmi</i> , <i>Phytophthora</i> sp., <i>Phytophthora ramorum</i> , <i>Ptilinus fuscus</i> , <i>Priobium carpini</i> , <i>Sirex noctilio</i> , <i>Tetropium castaneum</i> , <i>Tetropium fuscum</i> , <i>Tomicus piniperda</i> , <i>Trichoferus campestris</i> , <i>Tyroglyphus farinae</i> , <i>Xanthomonas populi</i> , <i>Zeuzera pyrina</i> , Anobiidae, Bostrichidae, Buprestidae, Cerambycidae, Curculionidae, Isoptera, Lyctidae, Oedemeridae, Scolytidae, Siricidae, nematodes, wood boring insects, warehouse pests, white ants.	Australia, Brazil, Canada, Chile, China, Cuba, Egypt, Fiji, India, Iran, Ivory Coast, Netherlands, New Caledonia, Mexico, New Zealand, South Africa, Singapore, Spain, Tanzania, Turkey, USA.
Cotton and fibre	<i>Anthonomus grandis</i> .	European Union, Pakistan
Perishable plant products (fresh fruit & vegetables, cut flowers & branches)	<i>Anastrepha fraterculus</i> , <i>Artipus</i> sp, <i>Aspidiotus hartii</i> , <i>Brachycera</i> sp., <i>Ceratitidis capitata</i> , <i>Contarinia</i> sp., <i>Cydia pomonella</i> , <i>Dypressa ulula</i> , <i>Dysmicoccus neobrevipes</i> , <i>Eriosoma lanigerum</i> , <i>Lepidosaphes ulmi</i> , <i>Palaeopus costicollis</i> , <i>Panonychus ulmi</i> , <i>Planococcus lilacinus</i> , <i>Planococcus pacificus</i> , <i>Pseudococcus citri</i> , <i>Pyrausta</i> sp., <i>Quadraspidiotus perniciosus</i> , <i>Tribolium</i> sp., Bruchidae, aphids, spider mites, thrips, whitefly.	Bahrain, Brazil, Dubai, Egypt, Japan, Jordan, USA, Yemen.

<sup>1</sup> As stated by survey respondents

## DISCUSSION

The total amount of MB reported from this survey is approximately 15% of the QPS usage that was estimated for 2000 by MBTOC (2002).

Unfortunately, some large users of MB have yet to respond to the survey, so the results need to be interpreted with caution. However there are some general themes worthy of note and which are consistent with the findings of other studies.

The major uses of MB for QPS are for treatment of durable commodities, such as grains, cereals and dried foodstuffs and wooden packaging materials, wood, and logs. Banks (2001) found that these uses were amongst the main QPS uses of MB in Australia in 2000. Similarly, MBTOC (2002) reported that the second largest use of MB (including QPS) after soil fumigation was to treat durable commodities. Most parties reported that alternatives are commercially available for these major groups of durable commodities; however they are yet to be fully implemented. The main impediments to their adoption are cost, location of facilities, and lack of acceptance by trading partners.

Amongst the timber products treated for QPS, wooden packaging is a major area of MB usage. In 2002, an International Standard “Guidelines for Regulating Wood Packaging Material in International Trade” (FAO, 2002) was published. The purpose of the guideline is “to reduce the risk of introduction and/or spread of quarantine pests associated with wood packaging material (including dunnage)” (FAO, 2002) by requiring that such materials are treated before export and marked to indicate that they have been treated. The guideline currently approves only two treatments for this purpose – MB fumigation and heat treatment. Many countries have subsequently acted to harmonise their import requirements with the guideline and it is likely that use of MB for treatment of wood packaging materials will have increased since 2002.

Several responding parties appeared to be unaware of the scope of the exemption for QPS use of MB – 290 tonnes of MB were categorised as QPS when the notes and explanations that were provided by survey respondents indicated that the use was not QPS (e.g., fumigation of flour mills, golf courses and nurseries, requirement of letter of credit). Other Parties reported fumigating export consignments when unaware of the pests being treated or of importing country legislation requiring treatment with MB. Some of these treatments appeared to be prophylactic treatments aimed at ensuring smooth clearance of import inspection procedures, rather than to treat specific quarantine pests.

Although these preliminary results represent a small sample of QPS use of MB, the survey has identified the main uses of MB for QPS, has determined that much more MB could be replaced by the adoption of available alternatives, and that there needs to be greater awareness of the scope of the QPS exemption.

## REFERENCES

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## ACKNOWLEDGEMENTS

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## ADDENDA

Subsequent to the presentation of this paper we have received further information and clarifications as follows:

- Italy has clarified that its use of MB for QPS was 41 tonnes, not 41kg as reported in Table 1.
- Turkey has clarified its figures, and confirm a total of 12.9 tonnes of MB for QPS.
- Kazakhstan has reported the use of 1.58 tonnes of MB for QPS.



## **ANNEX II (8-2)**

### **TERMS OF REFERENCE FOR THE TEAP QPS TASK FORCE**

The TEAP QPS Task Force will undertake the following tasks:

1. Report the data submitted by the Parties under paragraphs 2\* and 3\*\* of Decision XVI/10, or previously submitted by other Parties in response to the 14 April 2004 methyl bromide quarantine and pre-shipment survey.
  - The data will be presented in a written report in a format aggregated by commodity and application so as to provide a global use pattern overview, and to include available information on potential alternatives for those uses identified by the Parties' submitted data;
  - The report will be prepared by 31 May 2005, for the information of the Open-ended Working Group at its twenty-fifth session.
2. On the basis of information and data submitted by the Parties pursuant to paragraph 6\*\*\* of Decision XVI/10, and in accordance with paragraph 4 of XI/13, report to the Parties on the following:
  - (a) Evaluation of the technical and economic feasibility of alternative treatments and procedures that can replace methyl bromide for quarantine and pre-shipment;
  - (b) Estimation of the volume of methyl bromide that would be replaced by the implementation of technically and economically feasible alternatives for quarantine and pre-shipment, reported by commodity and/or application;
  - The report will be prepared by 31 May 2006.

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\* (Para 2, Decision XVI/10) To request Parties that have not yet submitted data to the Panel on this issue to provide best available data to the task force before 31 March 2005, identifying as available all known uses of methyl bromide for quarantine and pre-shipment, by commodity and application;

\*\* (Para. 3, Decision XVI/10) In responding to the request under paragraph 2, to request the Parties to use best available data for the year 2002 or data considered by the Party to be representative of a calendar year period (para.3, Decision XVI/10);

\*\*\* (Para.6, Decision XVI/10) To request the Parties to provide information to the task force, as available and based on best available data, on the availability and technical and economic feasibility of applying in their national circumstances the alternatives identified in paragraph 5, focusing in particular on the Parties' own uses, for the calendar year period reported under paragraphs 2 and 3, by 30 November 2005, constituting either:

- (a) More than 10 per cent of their own total annual methyl bromide consumption for quarantine and pre-shipment consumption; or

- (b) In the absence of uses over 10 per cent, which constitute their five highest volume uses; or
- (c) Where data is available to the Party, all their known uses.

## 9 Critical Use Nominations for Methyl Bromide

### 9.1 Introduction to MBTOC Evaluation of Critical Use Exemptions

#### 9.1.1 Mandate

Under Article 2H of the Montreal Protocol the production and consumption (defined as production plus imports minus exports) of methyl bromide is to be phased out in Parties not operating under Article 5(1) of the Protocol by 1 January 2005. However, the Parties agreed to a provision enabling exemptions for those uses of methyl bromide that qualify as critical. Parties established criteria, under Decision IX/6 of the Protocol, which all such uses need to meet in order to be granted an exemption. The Decision IX/6 states that:

*1. To apply the following criteria and procedure in assessing a critical methyl bromide use for the purposes of control measures in Article 2 of the Protocol:*

- (a) That a use of methyl bromide should qualify as “critical” only if the nominating Party determines that:*
  - (i) The specific use is critical because the lack of availability of methyl bromide for that use would result in a significant market disruption; and*
  - (ii) There are no technically and economically feasible alternatives or substitutes available to the user that are acceptable from the standpoint of environment and health and are suitable to the crops and circumstances of the nomination;*
- (b) That production and consumption, if any, of methyl bromide for critical uses should be permitted only if:*
  - (i) All technically and economically feasible steps have been taken to minimise the critical use and any associated emission of methyl bromide;*
  - (ii) Methyl bromide is not available in sufficient quantity and quality from existing stocks of banked or recycled methyl bromide, also bearing in mind the developing countries’ need for methyl bromide;*
  - (iii) It is demonstrated that an appropriate effort is being made to evaluate, commercialise and secure national regulatory approval of alternatives and substitutes, taking into consideration the circumstances of the particular nomination and the special needs of Article 5 Parties, including lack of financial and expert resources, institutional capacity, and information. Non-Article 5 Parties must demonstrate that research programmes are in place to develop and deploy alternatives and substitutes. Article 5 Parties must*

*demonstrate that feasible alternatives shall be adopted as soon as they are confirmed as suitable to the Party's specific conditions and/or that they have applied to the Multilateral Fund or other sources for assistance in identifying, evaluating, adapting and demonstrating such options;*

*2. To request the Technology and Economic Assessment Panel to review nominations and make recommendations based on the criteria established in paragraphs 1 (a) (ii) and 1 (b) of the present decision;*

*3. That the present decision will apply to Parties operating under Article 5 and Parties not so operating only after the phase-out date applicable to those Parties.*

Para. 2 of Decision IX/6 does not assign TEAP the responsibility for determining the existence of "significant market disruption" specified in paragraph 1(a)(i).

TEAP assigned its Methyl Bromide Technical Options Committee (MBTOC) to determine whether there are *no technically and economically feasible alternatives or substitutes available to the user that are acceptable from the standpoint of environment and health and are suitable to the crops and circumstances of the nomination*, and to address the criteria listed in Decision IX/6 1(b).

MBTOC/TEAP reviewed CUNs submitted in 2005 for 2006 and 2007.

In addition to the criteria for the evaluation provided in Decision IX/6, the Parties have given further guidance for the review of CUNs in Annex 1 of 16 MOP meeting report. Inter alia, this requires that TEAP and MBTOC to provide a clear description of why any part of the CUN is not recommended, including references to the relevant studies used as the basis for such a decision. Para. 32 emphasizes that exemptions must fully comply with Decision IX/6 and other relevant decisions, and are intended to be limited to the levels needed for critical-use exemptions, being temporary derogations from the phase-out of methyl bromide in that they are to apply only until there are technically and economically feasible alternatives that otherwise meet the criteria in Decision IX/6, and that MBTOC should take a precise and transparent approach to the application of the criteria, having regard, especially, to paragraphs 4 and 20 of Annex 1.

Paragraphs 4 and 20 read:

*4. Although the burden of proof remains with the Party to justify a request for a critical-use exemption, MBTOC will provide in its report a clear explanation of its operation with respect to the process of making determinations for its recommendations, and clearly state the approach, assumptions and reasoning used in the evaluation of the critical-use nominations. When cuts or denials are proposed, the*



*description should include citations and also indicate where alternatives are technically and economically feasible in circumstances similar to those in the nomination, as described in decision Ex.1/5, paragraph 8.*

*20. In line with paragraph 4 above, in any case in which a Party makes a nomination which relies on the economic criteria of decision IX/6, MBTOC should, in its report, explicitly state the central basis for the Party's economic argument and explicitly explain how it addressed that factor, and, in cases in which MBTOC recommends a cut; MBTOC should also provide an explanation of its economic feasibility.*

### 9.1.2 *Scope of this chapter*

This chapter provides MBTOC/TEAP evaluations on

- on new and supplemental CUNs submitted in 2005 for 2006, and
- on new CUNs submitted in 2005 for 2007.

This chapter also contains preliminary discussion of the important issue of registration and reregistration of MB alternatives, as a precursor to a comprehensive response to Decisions Ex.I/4(9i) and Ex.I/4(9j) which will be made in a later report.

Additionally, in accordance with para. 2 of Annex 1 referred to in Decision XVI/ 4, this chapter presents the standard presumptions used in making the evaluations of CUNs in this round. These are as used previously in the evaluations of CUNs by MBTOC/TEAP in their October 2004 report (TEAP 2004). It also foreshadows proposed changes and additions to these presumptions that are to be used in the evaluations of CUNs submitted in 2006, subject to approval of the Parties at 17MOP.

### 9.1.3 *MBTOC and TEAP process for consideration of CUNs*

Some Parties submitted nominations to the Ozone Secretariat by the prescribed 24 January 2005 deadline, while other Parties submitted nominations slightly later, by agreement with the Secretariat. The Secretariat supported a password protected Internet site for access by MBTOC members in electronic form, and placed the nominations and other needed documents on the site in preparation for the MBTOC meeting. Following an initial review, MBTOC sought additional information or clarification from nominating Parties on most nominations. This initial set of clarifications was as anticipated in the timetable for consideration of CUNs given in Annex 1 of 16MOP meeting report.

MBTOC received responses to its questions from most Parties shortly before its 11-15 April 2005 meeting in Buenos Aires, Argentina. This meeting was held as required by the time schedule for considerations of CUNs given in Annex 1 of the 16th MOP meeting report. Nominations were categorized as 'unable-to-assess' in this report where responses were not received in time for

consideration or where the full review determined that the nomination and any supplementary information was inadequate to accurately assess the nomination.

In addition to the normal Disclosure of Interest required under the TEAP/TOC terms of reference, MBTOC members made an additional disclosure relating specifically to their level of national, regional or enterprise involvement in the CUN process. This was required to ensure that those with a high level of involvement and interest in developing a particular nomination did not bias the process of evaluation through participation in the detailed review. A few MBTOC members were disqualified from review of specific nominations as a result of this process.

A soil subcommittee in MBTOC considered the nominations relating to use of MB for soil fumigation, while a postharvest subcommittee considered the nominations relating to the use of MB for fumigation of commodities, structures and objects. Drafts arising from the subcommittees were considered in plenary where consensus decisions were made.

As part of internal process of MBTOC, checklist style evaluation forms were generated to allow the Committee to assess the large number of nominations efficiently and equitably. These evaluation forms include reference to the basis for the questions asked as part of the evaluation and specifically relevant sections of Decision IX/6 or the Handbook (August 2003 version). All nominations were treated similarly, independent of the size of the exemption requested.

The CUEs approved by 16MOP and 1EMOP for 2005 use were the baseline data when considering CUNs for 2006. For CUNs relating to 2007, MBTOC used the approvals given in Section IIA of Decision XVI/2 as baseline data, together with those (unapproved) recommendations in the report relating to Section III of Decision XVI/2 (TEAP 2005). Nominations in the 2005 round were prepared by Parties and submitted to the Ozone Secretariat prior to 2EMOP, and thus could not take into account decisions made at that meeting.

The European Commission submitted CUNs on behalf of the various Parties applying for CUEs that were member states of the European Union. The EC provided analysis of the nominations additional to that given by the Party and adjusted proposed methyl bromide quantities in some of the nominations. The EC nominated quantities formed a basis for the consideration of these CUNs by MBTOC.

Bilateral discussions were held during the MBTOC meeting of 11 – 15 April 2005 with the only Party (USA) that made a request for such a meeting under Decision XVI/2(7,b). Some MBTOC members also visited Florida, USA on 19-22 April 2005 to investigate regional issues relating to CUNs. These

bilateral meetings were of considerable assistance in clarifying for MBTOC some issues with the complex CUNs from that Party.

## **9.2 Critical Use Nominations Review**

In considering the CUNs submitted in 2005 MBTOC applied the standards contained in Annex 1 of 16MOP. In particular MBTOC sought to provide consistent treatment of CUNs within and between Parties while at the same time taking local circumstances into consideration for specific crops and situations, and to provide transparency in its processes and conclusions.

### *9.2.1 Consideration of alternatives*

In considering alternatives to methyl bromide, MBTOC used the guidance given in Annex 1 where 'Alternatives' were defined as any practice or treatment that can be used in place of methyl bromide. 'Existing alternatives' are those alternatives in present or past use in some regions. 'Potential alternatives' are those alternatives in the process of investigation or development. MBTOC also used information on the suitability of alternatives for a nomination by considering the commercial adoption of alternatives in regions nominating for CUNs. Also, adoption in regions with similar climatic zone and cropping practices was used as an indication of the feasibility (technical and economic) of an alternative in a particular region. For example, 1,3-dichloropropene/chloropicrin (1,3-D/Pic), metham alone or in combination with chloropicrin, dazomet, substrates and the use of resistant varieties (for solanaceous crops, melons and cucurbits) have been adopted to replace MB for several crops and in several regions where MB was once used. MBTOC is 'unable to assess' nominations that do not explain why these major alternatives are unsuitable for the circumstances of a nomination.

In evaluating the CUNs for soil treatments, MBTOC assumed that a technically feasible alternative to MB would need to provide sufficient pest and weed control for continued production of that crop to existing market standards. For commodity and structural applications, it was assumed that a technically feasible alternative would provide disinfestation to a level that met the objectives of a MB treatment, e.g. meeting infestation standards in finished product from a mill. Technically and economically feasible alternatives do not necessarily provide superior pest control results than are achieved in practice by MB.

### *9.2.2 Period of nominations*

All Parties submitting nominations in this round confined their nominations to 2006 and/or 2007, with no nomination for other years. The EC foreshadowed that it would submit nominations for 2007 in January 2006.

### 9.2.3 *New or recently increased uses of MB*

As in previous CUN rounds, there was little consistency between CUNs with regard to treatment of projected increases in crop area, structural or commodity volume potentially requiring MB. One Party, as in previous CUN rounds, specifically excluded any new areas from its nominations while some other Parties increased their request to allow new production areas. MBTOC used the figures as provided by the nominating Party in its analyses irrespective of whether or not they represented increases in acreage over previous years. However, MBTOC evaluated whether the Party submitted adequate justification for increased use of MB.

### 9.2.4 *Plans to develop, register and deploy alternatives*

To qualify for a CUE, Decision IX/6 in part states that Parties must demonstrate that “...an appropriate effort is being made to evaluate, commercialise and secure national regulatory approval of alternatives and substitutes, taking into consideration the circumstances of the particular nomination...” and “...must demonstrate that research programmes are in place to develop and deploy alternatives and substitutes...”

In many nominations in the 2005 round, as in previous rounds, plans to identify alternatives were often not adequate and future plans to phase out MB were not given. As with the 2004 round, MBTOC did not use lack of phase-out plans as a basis to ‘not recommend’ a nomination.

Decision Ex. I/4 requires Parties that make “a critical-use nomination after 2005 to submit a national management strategy for phase-out of critical uses of methyl bromide to the Ozone Secretariat before 1 February 2006”. MBTOC awaits these reports. In this round of nominations, some Parties identified alternatives and reduced their nominations to allow for phase-in of alternatives. MBTOC did not reduce a Party’s requested amount for phase-in of alternatives without technical and economic evaluation and suitable justification.

MB is a mature technology and a considerable knowledge base exists for its use. On the other hand, many alternatives need continued efforts for correct and efficacious use and adaptation to local commercial circumstances. This leads to difficulties in true comparison of the feasibility of alternatives as the newer alternatives and their application may not be fully developed, may not have achieved economies of scale, and may have fewer years of documented pest control success. Some latitude is needed in evaluating the feasibility of alternatives to take this problem into account.

### 9.2.5 *Registration and regulatory restrictions*

Decision Ex. I/4(j) directs MBTOC to *report annually on the status of registration of alternatives and substitutes for methyl bromide, with particular*

*emphasis on possible regulatory actions that will increase or decrease dependence on methyl bromide. Decision Ex. I/4(i) directs MBTOC to report annually on the status of re-registration and review of methyl bromide uses for the applications reflected in the critical-use exemptions, including any information on health effects and environmental acceptability*

Information on registration status of alternatives was supplied by one Party under Decision Ex. I/4(j) in April 2005. MBTOC is currently awaiting information from other Parties to progress preparation of the report requested by the Parties. The report is to be completed and included in the TEAP report of October 2005.

MBTOC is seeking information on current registration status of the potential and existing in-kind alternatives given below:

*for soil treatment*

*Methyl bromide/chloropicrin mixtures*

*1,3 - dichloropropene*

*1,3 - dichloropropene/chloropicrin mixtures*

*Chloropicrin*

*Methyl iodide*

*Metham sodium, metham potassium and metham ammonium*

*Dazomet*

*Cyanogen*

*Sodium azide*

*Furfural*

*Propargyl bromide*

*Ethylene dibromide*

*Carbon disulphide (bisulphide)*

*'Dazitol'*

*For commodity or structural treatment*

*Phosphine*

*Ethyl formate*

*Sulphuryl fluoride*

*Carbonyl sulphide*

*Carbon disulphide (bisulphide)*

*Hydrogen cyanide*

*Methyl iodide*

*Cyanogen*

Details of formulations and restrictions (e.g. maximum dosage rate, buffer zones), in summary, are also requested.

While there are efforts to develop and deploy non-chemical and other sustainable alternatives to MB, chemical treatments including fumigation remain the principal alternatives at this time. Chemical treatments require registration by national, and sometimes by regional authorities. The

registration of new alternatives and re-registration of existing key alternatives are necessary for the methyl bromide phase-out.

Progress is slow on the registration of new alternatives, but at least one new alternative has made considerable progress in new registrations (sulphuryl fluoride as a structural and commodity fumigant). Slow progress in registration of alternatives continues to restrict the ability of applicants to switch to alternatives.

Several countries are in the process of re-registration of existing alternatives, in particular the key alternatives of chloropicrin and 1,3-D as soil fumigants, and phosphine in post-harvest. Loss of currently registered methyl bromide alternatives, and particularly these fumigants, would be a very significant risk to methyl bromide phase-out. It is likely that such a loss would result in pressure to revert to methyl bromide use in many areas now utilizing these alternatives, given the lack of further recognized, economically feasible alternatives.

Chloropicrin is a particularly effective fumigant against soilborne plant diseases, but with weaker activity against nematodes and weeds. Almost all existing in-kind alternatives to MB require application in conjunction with chloropicrin to obtain the full spectrum of activity required in some soil fumigations. Examples are combination treatments of 1,3-D and chloropicrin, and metham sodium and chloropicrin.

Furthermore, MB/Pic mixtures are more effective than MB alone in many situations, allowing reduction in the quantity of MB applied for the same level of effect. At present, there is no registered or proposed fumigant alternative that provides the complementary activity of chloropicrin to other fumigants.

It is notable that the European Community is planning to cancel the registration of methyl bromide in 2008 and that the re-registration process in the United States may prohibit or further restrict the use of methyl bromide. Furthermore, some Parties already do not permit use of chloropicrin as an active ingredient of soil fumigants and chloropicrin is to undergo a re-registration process in both the EU and USA in 2005, with the possibility that regulatory actions may result in further restrictions in use of chloropicrin or even loss of Pic for some or all fumigation uses in these regions. Some CUNs for soil uses submitted by Parties for 2005 had the choice of alternatives restricted because chloropicrin was not permitted in the particular country. In post-harvest commodity applications, phosphine has become the leading methyl bromide alternative. Virtually all the phase-out of methyl bromide accomplished for commodity uses has been due to the switch to phosphine. Loss of phosphine availability, either as a result of loss of registration or phosphine resistance, would result in a very significant increased need for methyl bromide.

Additionally, because chemical treatments always require registration, more emphasis has been placed on their evaluation and approval. However, some physical treatments also may require approval by regulatory authorities. Irradiation, a physical treatment for post-harvest commodities and particularly useful for quarantine applications, requires approval. Generally, all quarantine treatments, chemical and physical require prior approval before use. As the approval of quarantine treatments is particularly demanding, Parties should investigate their required treatment approvals for physical treatments that are methyl bromide alternatives.

The cost of registration relative to projected profits in smaller countries or countries with a small market for post harvest durable and structural treatments is a major constraint. Even in Europe, there is not yet harmonisation in place, which would facilitate the transfer of registration from one country to the other. In North America, US/Canada government memorandums of understanding for joint reviews have not yet caused companies to pursue joint registration of fumigants.

MBTOC recognises that registration and local regulations can be constraints on the availability of particular chemical alternatives to the end user, in the sense of Decision IX/6, and are thus grounds for recommending a CUE if no other suitable alternatives are available.

Registration status of chemical alternatives varies from country to country, although some alternatives are widely registered. Registration may also vary within countries. The differing registration status of two specific key chemical alternatives, 1,3-dichloropropene (1,3-D) and chloropicrin (Pic), sometimes resulted in different recommendations in otherwise similar nominations from different Parties.

In certain countries, states or regions, regulatory restrictions such as buffer zones or township caps apply to some chemical fumigants. In cases where buffer zones are the same size for both MB and alternatives, the buffer zones are not relevant to the consideration of CUEs. However, MBTOC considers the continued use of methyl bromide justified under the criteria in Decision IX/6 in a few cases where buffer zones are larger for an alternative fumigant than for MB, provided that no other effective alternatives can be used in this situation. The same reasoning applies to township caps.

Legislation from some Parties requires that MB be applied at specific label rates only, whereas some other countries give a range of rates on the label.

Uncertainties in the registration status and long term availability of both MB and some key chemical alternatives and potential impact on nominations for CUEs have been discussed previously (TEAP 2003a, 2003b, 2004). The combination of these possible actions will have implications to the methyl bromide phase-out under the Montreal Protocol.

### 9.2.6 *Fulfilment of Decision IX/6*

Decision XVI/2 directed MBTOC to indicate whether all CUNs fully met the requirements of Decision IX/6. When the requirements of Decision IX/6 were met, MBTOC recommended the full amount of the request. Where some of the conditions were not fully met, MBTOC recommended a decreased amount, depending on its technical and economic evaluation. MBTOC reduced a nomination when a technical alternative was considered effective or when the Party had failed to show that it was not effective. Where the criteria of Decision IX/6 were not satisfied to a substantial extent, MBTOC did not recommend the nomination. In many instances, MBTOC addressed further questions to the Parties to assist its determination at a later date.

There are two sections of Decision IX/6 that MBTOC evaluated with less stringency. These are use of stockpiles (para. 1 (b) (ii)) and the need for the Party to conduct sufficient research on alternatives (para. 1 (b) (iii) in part)). MBTOC or the Ozone Secretariat has not collected data on level of stocks or stockpiles present in various countries and Parties did not provide such data for individual nominations. Thus, MBTOC did not use that element in our evaluation. MBTOC also found some applicants did not, themselves, conduct sufficient research to fully meet Decision IX/6. However, sometimes a Party reviewed and reported on similar or pertinent research in other countries or situations. MBTOC also found, in far fewer instances, and generally only where the applicant was a small operator, no research was conducted, usually reflecting inability on the part of the applicant to do so because of cost. In those instances, MBTOC relied more heavily on its own knowledge of the research and on developments and usages in related crops or situations.

### 9.2.7 *Sustainable Alternatives*

In most CUNs, the most appropriate alternatives are often chemical fumigant alternatives, which themselves have issues related to their long term suitability for use. MBTOC urges Parties to consider the long term sustainability of treatments adopted as alternatives to MB.

### 9.2.8 *Frequency*

In the CUN round for 2005, reductions in MB for both preplant soil and postharvest use could be achieved in some nominations where effective alternatives were identified by reducing the frequency of MB. In some countries, present regulations already restrict the frequency of use of MB (i.e. every second year) on similar crops and circumstances to those nominated by other Parties. MBTOC suggests that in these and other instances MB only be required every 2, 3 or 4 years and suggests that Parties further consider reductions were appropriate. Alternation of control measures may also help provide end user confidence and experience in alternatives. New control



measures may also be good agricultural practice, reducing risk of development of tolerance and providing control of a wider spectrum of pests.

#### 9.2.9 *Standard presumptions used in assessment of nominated quantities*

The table below is an explicit statement of standard presumptions applied by MBTOC/TEAP in assessing this round of CUNs, and both the 2004 and 2005 round of CUNs, where continued methyl bromide use is sought. Previous statements of these presumptions have been given in TEAP (2004).

The rates and practices adopted by MBTOC are, in general, conservative. For soil treatments, the dosage levels of methyl bromide given in these presumptions exceed that required in good agricultural practice in all but exceptional circumstance, particularly when used in conjunction with low permeability barrier films, e.g. VIF or equivalent. To assist the adoption of lower dosage rates, researchers and extension specialists need to continue to build grower confidence in the effectiveness of lower dosage levels and optimise the methods for application of barrier films, VIF or equivalent, in the field. Proposed changes to these standard presumptions with supporting documentation will be provided in a later report in conformity with para. 2 of Annex 1 referred to in Decision XVI/ 4 for consideration at the 17th MOP.

Table 9-1: Standard presumptions used in assessment of CUNs – soil treatments

	<b>Comment</b>	<b>CUN adjustment</b>	<b>Exceptions</b>
<b>1. Dosage rates</b>	Maximum guideline rates for MB:Pic 98:2 - 45g/m <sup>2</sup> (cold, heavy soils) or 35g/m <sup>2</sup> (sandy soils), both with barrier films (VIF or equivalent); for MB/Pic 67:33 - 20gMB/m <sup>2</sup> , under barrier films. Exceptionally, where VIF or equivalent is not feasible, maximum guideline rates for MB:Pic 98:2 – 60 g/m <sup>2</sup> . All rates on a ‘per treated hectare’ basis.	Amount adjusted to maximum guideline rates. Maximum rates set dependent on formulation and soil type and film availability.	Higher rates accepted if specified under national legislation or where the Party had justified otherwise.
<b>2. Barrier films</b>	All treatments to be carried out under barrier film (e.g. VIF)	Nomination reduced proportionately to conform to barrier film use.	Where VIF prohibited or restricted by legislative or regulatory reasons
<b>3. MB/Pic Formulation: Pathogen control</b>	Unless otherwise specified, MB/Pic 50:50 (or similar) was considered to be the standard effective formulation for pathogen control, as a transitional strategy to replace MB/Pic 98:2.	Nominated amount adjusted for use with MB/Pic 50:50 (or similar).	Where MB/Pic 50:50 is not registered, or chloropicrin is not registered
<b>4. MB/Pic Formulation: Weeds/nutgrass control</b>	Unless otherwise specified, MB/Pic 67:33 (or similar) was used as the standard effective formulation for control of resistant (tolerant) weeds, as a transitional strategy to replace MB/Pic 98:2.	Nominated amount adjusted for use with MB/Pic 67:33 (or similar).	Where chloropicrin or chloropicrin-containing mixtures are not registered
<b>5. Strip vs. Broadacre</b>	Fumigation with MB and mixtures to be carried out under strip	Where rates were shown in broadacre hectares, the CUN was adjusted to the MB rate relative to strip treatment (i.e. treated area). If not specified, the area under strip treatment was considered to represent 67% of the total area.	Where strip treatment was not feasible e.g. some protected cultivation or open field production of high health propagative material

*Table 9-2: Standard presumptions used in assessment of CUNs – post-harvest treatments*

	Comment	CUN Adjustment	Exception
Dosage rate - structural	20g/m <sup>3</sup>	Nominations using higher dosage rates were reduced proportionally	Where approved label rates require higher dosage rate or where substantiated by the Party
Dosage rate – commodities	EPPO standard, as given in MBTOC (1994, 1998)	Nominations using higher dosage rates were reduced proportionally	Where approved label rates require higher dosage rates or where substantiated by the Party

#### *9.2.10 Adjustments for standard dosage rates*

MBTOC assessed CUNs for appropriate MB application rates and deployment of MB emission reduction technologies, such as use of barrier films or appropriate sealing techniques.

Decision IX/6 requires that critical uses should be permitted only if ‘all technically and economically feasible steps have been taken to minimise the critical use and any associated emission of methyl bromide.’ One key transitional strategy has been the adoption of MB:Pic formulations with lower concentrations of methyl bromide (e.g. MB:Pic 50:50 or less). These formulations are considered to be equally as effective in controlling soilborne pathogens as formulations containing higher quantities of methyl bromide (e.g. 98:2, 67:33), though control of some weeds may be reduced. These formulations have been adopted widely by non-Article 5(1) countries to meet Montreal Protocol restrictions where such formulations are registered or otherwise permitted. Their use can be achieved with application machinery, which allows co-injection of methyl bromide and chloropicrin or by use of premixed formulations.

In the soils sector, some CUNs still involve the use of MB with low or high density polyethylene sheeting (tarping). This process is known to lead to high rates of emission of MB in the absence of specific measures such as deep injection. MB use and emission rates can be reduced substantially through use of less pervious tarping (MBTOC, 2002), such as barrier films. Virtually Impermeable Film (VIF) or equivalent, allows increased retention of MB, extended effective exposure periods for the pests, and reduced MB application rates compared with use of conventional sheeting. It has been long recognised that the use of low permeability barrier films coupled with reduced dosages effectively reduces methyl bromide emissions (e.g. Wang et al. 1997). The use of low permeability barrier films (VIF or equivalent) has been mandated in the EU since 2000 and is in routine use in many countries.

In 2003 and 2004 (TEAP 2003, 2004), MBTOC/TEAP evaluations of CUNs used conservative maximum guideline dosage rates for use with standard films and barrier films (VIF or equivalent). Since then, high levels of success have been demonstrated in many countries at lower rates of methyl bromide with barrier films. For this reason, new guidelines for reduced effective use rates with barrier films and standard films will be proposed in the September 2005 TEAP report for consideration by the Parties at the 17MOP, as required by the Decision XIV/2.

As in the evaluations of the 2003 and 2004 nomination round, MBTOC reduced quantities of MB in particular nominations to a standard rate and expected that barrier films (VIF or barrier films) would be used to retain gas effectively and allow extended exposures. MBTOC considers the maximum MB application rate, for 100% MB and 98:2 MB:Pic, of either 350 kg/ha (warm sandy soils) or 450 kg/ha (heavier cool soils), in conjunction with barrier films, combined with extended exposure periods, as effective in most circumstances when well applied. In cases where use of high chloropicrin-containing mixtures (approximately MB:Pic 67:33) were feasible, maximum guideline dosage rates of 200 kg MB per treated hectare were regarded as acceptable.

The indicative rates used by MBTOC were maximum rates, for the purpose of calculation only. MBTOC recognises that the actual rate appropriate for a specific use may vary with local circumstances, soil conditions and the target pest situation. Some nominations were based on rates lower than these indicative rates, but did not use barrier film technology to reduce emissions.

Quantities in CUNs were recalculated to conform to these specifications, including use of barrier films where feasible. Reductions were not made if the Party provided a substantive argument otherwise (e.g. unusually tolerant pests) or where there were regulatory requirements to use specific rates.

As noted in TEAP (2004), use of barrier films results in better retention of methyl bromide compared with polyethylene tarps. Appropriate worker safety and other protective measures need to be in place to avoid unacceptable and unexpected exposures.

In some jurisdictions, use of barrier films is restricted. Most of the problems with use of these films described in the 2002 MBTOC Assessment Report have now been overcome. In those few applications where broadacre coverage is required (nematode control in covered floriculture for example), obtaining an effective glue and/or method for seam sealing may be difficult and require further work or trials to determine acceptable materials under some particular conditions.

In structures, it is feasible to reduce MB use and emissions by the use of improved sealing techniques, monitoring to ensure only the effective dose is

used, and longer exposure periods. The average dosage rates now quoted in the CUNs, typically around 20 g/m<sup>3</sup> for mills and similar structures, are reasonable.

In commodities, methyl bromide dosage rates vary with commodity temperature and by commodity sorption rates. Accordingly, MBTOC uses the dosage rates published by the European Plant Protection Organization (EPPO) and found in annexes to the MBTOC Assessment Reports published in 1994 and 1998. Parties are encouraged to use the lowest possible dosage rate appropriate for the circumstances and as allowed by the label.

#### *9.2.11 Rate of adoption of alternatives*

MBTOC recognises that time is needed to effect phase-in of alternatives and accepts this as a reasonable technical argument for lack of availability to the end user sensu Decision IX/6.

Some CUNs in the 2006 round argued that time was required to allow the relevant industry to transition to available alternatives or barrier film use. Some CUNs showed a reduction in nominated quantity requested from that of the preceding year, reflecting progressive adoption of alternatives; while others had the same or similar quantities of MB nominated to the preceding CUNs. In some cases alternatives at varying stages of readiness for adoption were identified in the CUN and in others they were identified by MBTOC.

There is limited guidance and data available on what is a reasonable rate of transition to existing and available alternatives.

### **9.3 Evaluations of CUNs – 2005 round for 2006 and 2007 exemptions**

MBTOC assessed 62 new or additional critical use nominations for 2006 and 27 nominations for 2007 totalling 324.68 and 8088.32 metric tonnes respectively.

Of the 89 new or supplementary CUNs considered during its meeting in Buenos Aires, MBTOC was unable to assess 26 nominations. Some of the larger and more complex nominations were in this category. It did not recommend two nominations.

Recommendations totalled 269.61 tonnes for 2006 and 873.19 tonnes for 2007.

Details of evaluations are given in Table 9-3.

In paragraph 20 of Annex 1 referred to in Decision XVI/4, Parties, inter alia, specifically requested that MBTOC explicitly state the central basis for the Party's economic argument relating to CUNs. Table 9-3 provides this information for each CUN.

MBTOC has sometimes suggested quantities of MB for 2006 or 2007 different from that nominated. Grounds used for these changes are given in detail after the relevant CUNs in Table 9-3. The adjustments follow the standard presumptions given in Tables 9-1 and 9-2, unless indicated otherwise.

In general, CUNs resulted mainly from the following issues: regulatory restrictions on alternatives, scale up of alternatives, and economic issues. For the most part technical alternatives exist, but often at a less developed state than methyl bromide. MBTOC has been unable to identify alternatives, or has very inadequate information for the following applications: fresh high-moisture dates, some seeds when rapid turn around is required for immediate planting, cheese stores, dry cure ham treatment, and unmovable historical artefacts especially where fungi is of concern. The Parties are requested to consider focusing some research on these applications to identify and, where required, register effective alternatives.

Table 9-3: Evaluations of new or supplemental CUNs submitted in 2005 for 2006 or 2007

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Australia	Rice (consumer packs)	6.15	6.15	6.15		6.15		U	MBTOC is unable to assess this nomination for 2007 at this time. A partial response from the Party was received on the questions sent by MBTOC. However MBTOC still requests further clarification on why phosphine is not an effective alternative for the final clean up of paddy rice (if that is the material fumigated). The Party is also requested to provide information on the following: how is the MB fumigation of bulk paddy rice carried out while in sheds, and what proportion of the requested MB is needed for packaged rice and what proportion is for use on paddy rice.	No economic data on alternatives given
Australia	Strawberry runners	35.75	30	7.5		35.75		U	MBTOC is unable to assess this nomination for 2007. MBTOC is awaiting confirmation of the certification information from the Party. The CUN states that MB is required to meet certification standards, however MBTOC is unclear if MB is mandatory. A key alternative, 1,3-D/Pic, is reported to have been phytotoxic due to the heavy and wet soil conditions. MBTOC still considers 1,3-D/Pic a possible alternatives but accepts that further research is required. The CUN states that plug plants are a technically feasible alternative but that the costs associated with this technology are regarded as too high. The Party is already using a lowered rate of MB, 250 kg/ha, and is examining the efficacy of 30:70 mixtures of MB/Pic. MBTOC suggests that the CUN should be scaled to a maximum dosage rate of 200 kgMB/ha with MB/Pic mixtures in conjunction with barrier films. MBTOC considers that difficulties in using barrier films on a broadacre basis to reduce emissions can be overcome, leading to further reduced usage of MB.	CUN states data is not yet available to enable an economic evaluation of alternatives.
Belgium	Antique structures and furniture	0.319			0.199		0.199		MBTOC recommends a CUE of 0.199 tonnes for these uses in 2006. This application is for the treatment of unmovable historical antiques and antique furniture. The Party has reduced the applicant's request in consideration of the partial availability of alternatives. Metal components and church location disallows the use of phosphine. SF is not registered.	CUN states nitrogen is not economic. Cost is 7.4 times cost of methyl bromide.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Belgium	Artefacts and structures	0.59			0.307		0.307		MBTOC recommends a CUE of 0.307 tonnes for this use in 2006. Metal components and church location disallow the use of phosphine. Additionally this application is for treatment of wood boring insects which requires a higher than usual dosage of MB.	CUN states phosphine and contact insecticides costs less but heat costs more than three times more than MB treatment, because of energy costs.
Belgium	Asparagus	0.63			0.225		0.225		MBTOC recommends that a CUE of 0.225 tonnes be approved in 2006 for this use. The MB requested is to be restricted to a small part of the total production (seedbeds and open fields) with recalcitrant pest problems, not controllable by other means. Alternatives are already in use where applicable (99.7 % of the cropping area). The nomination aims only where no alternatives are available because of technical and economical reasons. The need for high plant health of planting material is recognised, and at present MB is appropriate for this specific use (cool conditions, high pathogen incidence). The area is characterized by soil grown asparagus with high disease pressure, small size farms and high input from family capital. MBTOC suggests that the Party take steps to help these remaining growers to phase out use of MB by using the available alternatives.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.
Belgium	Berry fruit				0.621		0.621		MBTOC recommends that a CUE of 0.621 tonnes be approved in 2006 for this use. The MB requested is for treatment of Perennial Crop Replant Disorder in all berry fruit in open fields, except strawberries. The Party states that fumigants are used to establish new plantings once every 5 years, and that the key alternatives, metham sodium and 1,3-D, are used on approximately 20% of the crops, but that growers need MB to ensure that pathogens do not build up in soils. Only 8.3% of plantings are treated annually and MBTOC acknowledges that disease control is difficult as a key alternative, chloropicrin, is not registered yet with these alternatives. MB/Pic mixtures are registered, although further adoption may be limited because Party is concerned about crop damage to adjacent crops. MBTOC acknowledges the efforts made by the Member State to restrict MB use further by using strip fumigation and MB/Pic mixtures.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.



Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Belgium	Chicory	0.18			0.18		0.18		MBTOC recommends that a CUE of 0.180 tonnes be approved in 2006 for this use. Alternatives are already in use where applicable (99.7 % of the cropping area). The nomination aims only where alternatives are not available because of technical and economical reasons. The area is characterized by soil grown chicory with high disease pressure, small size farms and high input from family capital. . MBTOC suggests the Party take steps to help these remaining growers to phase out use of MB by using the available alternatives particularly substrates.	CUN notes high cost to convert to soilless systems. Except for steam, alternative soil treatments are less costly than methyl bromide. CUN states that in certain circumstances technical necessity leads to use of more costly methyl bromide.
Belgium	Churches, monuments and ships' quarters	0.15			0.059		0.059		MBTOC recommends a CUE of 0.059 t be approved for this use. The Party reduced this year's nomination to 30% of its request for 2005 by reducing dosage and in consideration of the potential to adopt alternatives. The applicant has conducted research on alternatives for this use finding that metal components disallows use of phosphine, inert gases were unsuccessful in some locations and that there was a risk to the antiques if heat was used in combination with MB in an attempt to reduce dosage. Good gastightness was reported with plans for further improvement. Sulfuryl fluoride is not registered for this use.	No economic data on alternatives given.
Belgium	Chrysanthemums	1.12			0.72		U		MBTOC is still unclear as to the exact nature of this CUN and is thus unable to assess it at this time. The Party is requested to specify whether it involves single stem chrysanthemums grown in mobile greenhouses, spray chrysanthemums grown in fixed greenhouses or both, and if the latter what percentages of each. In information on what proportion of the crop being affected by the critical need of MB is not suited for steaming is also requested, as well as reasons that prevent the use of substrates in older greenhouses. Although Party claims that no technical and economically feasible alternatives are available, this has not been validated. Further, efforts to investigate, register and deploy alternatives do not appear sufficient.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Belgium	Cucumber	0.61			0.545		0.545		MBTOC recommends that a CUE of 0.545 tonnes be approved in 2006 for this use. Alternatives are already in use where applicable. The nomination is only for uses where, according to the nomination, alternatives are not available because of technical and economic reasons. The area is characterised by soil grown cucumber with high disease pressure, small size farms and high input from family capital. MBTOC suggests that the Party take steps to help these remaining growers to phase out use of MB by using the available alternatives particularly substrates and grafting.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.
Belgium	Cut flowers	4			1.956		1.956		MBTOC recommends 1.956 tonnes for this nomination. The critical use is required because of restriction imposed by small farm size and mixed number of crops, and restrictions on alternative use because of cool soil temperatures and extended plant back times. MBTOC appreciates the additional information sent by the Party as it helps clarify the nature of this nomination. For future nominations, the Party is encouraged to collect and submit statistical information regarding technical and economical validation of alternatives for the critical uses involved in this nomination.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.
Belgium	Electronic equipment	0.1			0.035		0.035		MBTOC recommends a CUE of 0.035 tonnes for this use in 2006. Phosphine cannot be used in this situation and SF not registered. The Party reduced the applicant's request to ensure minimal emissions and uses the MBTOC standard dosage rate.	No economic data on alternatives given.
Belgium	Empty silo	0.05			0.043		0.043		MBTOC recommends a CUE of 0.043 tonnes for this use in 2006. The Party reduced the applicant's request to eliminate structures of poor gastightness. Contact pesticides, heat, cold, and heat plus MB are already in use. SF is not registered. Phosphine cannot be used in many facilities since they include corrodible equipment. Applicant has reduced MB use to very low levels and low frequency of fumigation	Energy costs for heat treatment are higher. Costs of IPM with pheromone trapping and spray treatment are greater than costs of methyl bromide.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Belgium	Endive				1.65		1.65		MBTOC recommends that a CUE of 1.65 tonnes be approved in 2006 for this use. The nominated quantity amount is less than the quantity used in 2003 (2.08 tonnes). Alternatives are already in use (98.1%) of the cropping area. The nomination is only for uses where, according to the nomination, alternatives are not available because of economic reasons. The endive area is characterized by soil grown crops grown in areas with high disease pressure, small size farms and high input from family capital. MBTOC suggests that the Party take steps to help these remaining growers to phase out use of MB.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.
Belgium	Flour mill				0.072		0.072		MBTOC recommends a CUE of 0.072 tonnes for this use in 2006. The applicant has reduced dosage, emissions and minimises MB use by using it during times of high ambient temperature. This applicant has reduced MB use and frequency to a very low level.	CUN reports heat will cost 2.63 times more than methyl bromide
Belgium	Flour mills				4.17		4.17		MBTOC recommends a CUE of 4.17 tonnes for this use in 2006. Party has reduced dosage to MBTOC standard for structural treatments and in consideration of use of alternatives and frequency of fumigation, and reduced the applicant's request in consideration of those mills that need improvement in gastightness. Party has taken measures to ensure good gastightness through mill improvements in some mills. SF not registered.	CUN reports phosphine will cost 50% more, heat will cost 6.5 times more and modified atmosphere will cost 10 times than methyl bromide. Sulfuryl fluoride treatment is more costly than methyl bromide.
Belgium	Food premises	0.3	0.3		0.03		0.03		MBTOC recommends a CUE of 0.030 tonnes for this use for 2006. This CUN relates to fumigation of 21 premises. Applicant has reduced MB use to very low levels and low frequency of fumigation.	No economic data on alternatives given.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Belgium	Food processing premises	0.03			0.03		0.03		MBTOC recommends a CUE of 0.030 tonnes for this use for 2006. Applicant has reduced MB use to very low levels and low frequency of fumigation.	CUN reports IPM will cost more than 3 times and sprays will cost 3 times more than MB; energy costs too high for heat treatment
Belgium	Food storage (dry) structure	0.12			0.12		0.12		MBTOC recommends a CUE of 0.120 tonnes for this use in 2006. The applicant has reduced MB use and frequency of fumigation to a very low level.	IPM alone will cost 3.7 times more than MB. Spray insecticides 3 times cost of methyl bromide.
Belgium	Leek & onion seeds	0.66			0.155		0.155		MBTOC recommends that a CUE of 0.155 tonnes be approved in 2006 for this use. Alternatives are already in use were applicable (99.7 % of the cropping area). The nomination is only for uses where, according to the nomination, alternatives are not available because of technical and economic reasons. The CUN is characterized by leek and onion seed crops grown in soils with high disease pressure, small size farms and high input from family capital. MBTOC suggests that the Party take steps to help the remaining growers to phase out use of MB by using the available alternatives, particularly substrates.	CUN notes alternative chemical treatments are less costly than methyl bromide but in cases of combined pest pressure, their technical performance is not assured. CUN states steam is not cost effective.
Belgium	Lettuce	25.19			22.425		U		MBTOC is unable to assess this nomination for 2006. Alternatives are already in use were applicable (98 % of the cropping areas). The nomination is only for uses where, according to the nomination, alternatives are not available because of technical, economic and regulatory constraints. The area is characterized by lettuce grown in soils with high disease pressure (combination of nematode and fungi), with small size farms and high input from family capital. MBTOC encourages the Party to take steps to help the remaining growers to phase out use of MB by using the available alternatives, particularly substrates.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Belgium	Mills				0.2		0.2		MBTOC recommends a CUE of 0.2 tonnes for this use in 2006. The Party has reduced dosage to MBTOC standard for structural treatments and reduced the applicant's request in consideration of those mills that need improvement in gastightness, use of alternatives and frequency of fumigation. Party has taken measures to ensure good gastightness through mill improvements in some mills. SF not registered.	IPM alone will cost 3.7 times more than MB
Belgium	Nursery	0.9			0.384		U		MBTOC is unable to assess this nomination for 2006. This nomination is for 0.384 tonnes to be used in less than one hectare. In consideration of the small area, the fact that annual seedling crops are involved and the Party's statement that technical feasibility is the parameter by which alternatives are selected, MBTOC is not clear why the crops involved in this nomination cannot be produced in substrates or as "plug plants", which is a well developed and implemented technique in many countries around the world (e.g. Styler and Koranski, 1997). Further, MBTOC requests clarification on the issue of chloropicrin fumigation burning nearby crops, including how close are these crops planted to the fumigated area, what are the conditions immediately following the fumigation that seem to favour burning of nearby crops, and how long are the tarps left on the soil after fumigating with chloropicrin.	CUN provides cost data for soil fumigation with methyl bromide and alternative chemicals and steam. No yield or price data were reported. CUN states the economic consequences of nursery stock that is not healthy and free of pathogens are dramatic loss of yield and revenue
Belgium	Old buildings				0.306		0.306		MBTOC recommends a CUE of 0.306 tonnes for this use in 2006. The Party reduced the applicant's request to ensure emissions controls were improved and to take into consideration use of MBTOC standard dosage rates and current available alternatives. Applicant notes that MB use is restricted to incidents where IPM has failed. SF is not registered	CUN reports high energy costs for heat or cold treatment. Phosphine marginally lower cost but presents technical problem.
Belgium	Old buildings				0.282		0.282		MBTOC recommends a CUE of 0.282 tonnes for this use in 2006. MB use is restricted to where IPM has failed. Phosphine cannot be used because of risk of damage to old materials. SF is not registered.	No economic data on alternatives given

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Belgium	Pepper & egg plant	3			1.35		1.35		MBTOC recommends that a CUE of 1.35 tonnes be approved in 2006 for this use. This recommendation is made on the basis of economic issues. Most production of this crop does not rely on methyl bromide. The remaining production of eggplant and pepper using methyl bromide is characterised by cropping in soils with high disease pressure, with small size farms and high input from family capital. MBTOC suggests that the Party help these remaining growers to transition out of MB use, using the available alternatives and, particularly, substrates.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.
Belgium	Strawberry runners	3.4			0.9		0.9		MBTOC recommends a CUE of 0.9 tonnes be approved for this use in 2006. The Party is requested to provide a copy of the Flemish certification handbook for strawberry runners. The nomination is based on the grounds that registered alternatives are not suitable for the specific pest combinations and conditions. The Party states that alternatives are used whenever feasible. MBTOC notes with concern that the Party states that in the last 10 years in Belgium there has been no research on soil fumigation and MB alternatives for strawberry runner production. The Party states that plug plants are currently not used, and that possibly in the future there will be a place for plug plants. MBTOC recognises the substantial MB reductions made in this sector recently, from 4.0 tonnes in 1998 to 0.9 tonnes in current nomination.	CUN provides cost data for soil fumigation with methyl bromide and alternative chemicals and steam. No yield or price data were reported. CUN states the economic consequences of nursery stock that is not healthy and free of pathogens are dramatic loss of yield and revenue
Belgium	Tomato (protected)	5.7			4.5		4.5		MBTOC recommends that a CUE of 4.5 tonnes be approved in 2006 for this use. This is similar to the amount of MB used in 2003 (4.6 tonnes). This recommendation is made on the basis of economic issues. Alternatives are already in use where applicable, predominantly soilless culture on 72% of the cropping area. The nomination is only for uses where, according to the nomination, alternatives are not available because of economic constraints. The production is characterised by growing in soils with high disease pressure, with small size farms and high input from family capital. MBTOC suggests that the Party help these remaining growers to transition out of MB use using the available alternatives, particularly substrates and grafting.	CUN provides a net revenue analysis showing decreased net revenue relative to methyl bromide if alternatives are used in situations where they are not suitable. CUN notes potential yield, quality, and market prices reductions when there are multiple or recalcitrant pest problems.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Belgium	Tree nursery	0.23			0.155		0.155		MBTOC recommends that a CUE of 0.155 tonnes be approved for 2006 for this use. Clean propagative material is recognised as important in the reduction of need for fumigation of production fields. Party is requesting 155 kg to treat 0.5 ha (1% of the tree nursery production area). This is a reduction of 33% from the amount approved for 2005. Dosage rates are consistent with MBTOC's guideline standards. MBTOC notes that, according to the Party (EC), lack of technical and economically feasible alternatives has not been validated and efforts to find, register and deploy alternatives have been insufficient.	CUN provides cost data for soil fumigation with methyl bromide and alternative chemicals and steam. No yield or price data were reported. CUN states the economic consequences of nursery stock that is not healthy and free of pathogens are dramatic loss of yield and revenue
Belgium	Woodworking premises	0.3			0.101		0.101		MBTOC recommends a CUE of 0.101 tonnes for this use in 2006. The Party has reduced the applicant's requested amount to use MB standard dosage rate and availability of alternatives. The amount nominated is already reduced to one third of the 2005 CUE.	CUN reports IPM and pheromone trapping will cost over 3 times and spray treatment will cost over twice the cost of methyl bromide
Canada	Flour mills	(a)	27.8	7.0		30.167		30.167	MBTOC recommends a CUE of 30.167 tonnes for this use in 2007. The Party has reduced its MB use over 2006 levels. Considerable research has allowed for a shift to heat treatments where possible. IPM improvements and full site heat trials are on going. MBTOC standard dosage is used. SF is not registered.	Research submitted indicates that heat is likely to be 2-6 times more expensive than MB treatment
Canada	Strawberry runners (PEI)	(a)		8.666(b)		7.995		7.995	MBTOC recommends a CUE of 7.995 tonnes for this use in 2007. This nomination is for strawberry runners for which national regulatory controls are in place in both the nominating Party and the Parties that receive shipment of this material. The Party has determined that the usage covered by this CUN does not fall under QPS. MBTOC acknowledges that the ban of 1,3-D in the nominated region is a significant impediment to the Party in the transition away from MB. The Party is urged to consider use of reduced rates of MB with barrier films as a transition strategy.	CUN provided no economic data. CUN based on technical feasibility reasons.

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Canada	Strawberry runners (Quebec)	(a)				1.826		1.826	MBTOC recommends a CUE of 1.826 tonnes for this use in 2007. This nomination is for strawberry runners for which national regulatory controls are in place in both the nominating Party and the Parties that receive shipment of this material. The Party has determined that the usage covered by this CUN does not fall under QPS. The Party is urged to consider use of reduced rates of MB with barrier films as a transition strategy.	CUN provided no economic data. CUN based on technical feasibility reasons.
Germany	Artefacts	0.25			0.1		0.1		MBTOC recommends a CUE of 0.1 tonnes for this use (control of fungi in immovable historical artefacts) in 2006. MBTOC does not know of any technically effective alternatives for this use under the particular circumstances.	No economic data on alternatives given
Germany	Mills and Processors	45			19.35		19.35		MBTOC recommends a CUE of 19.35 tonnes for this use in 2006. The Party reduced the applicant's requested amount to take into consideration that SF is newly registered, balanced by the consideration that there is no MRL for fluorine. This application is only for MB use when neither heat nor phosphine can be used.	SF costs for mills treatment are insufficiently known and heat treatment in large mills costs more and must be done more frequently for same level of control of MB.
Greece	Dried fruit	4.28			3.081		U		MBTOC is unable to assess this nomination for 2006 at this time. In general, there are alternatives available for postharvest treatment of dried figs and raisins. Further information is requested on the basis of this nomination particularly including important marketing timeframes and economic arguments to justify why slower treatments cannot be used in place of MB. It would be useful to have information separately for the two commodities since they have somewhat different requirements.	CUN reports direct costs of phosphine are lower than methyl bromide, but treatment takes much longer resulting in downtime or need for more chamber capacity. Party also reports installation and operating costs of cold treatment are high compared to methyl bromide.



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Greece	Cucurbits	30			19.2		19.2		MBTOC recommends that a CUE of 19.2 tonnes be approved in 2006 for this use. Alternatives are already in use were applicable (89.5 % of the cropping area). The nomination aims only where no alternatives are available because of economical reasons. The area is characterized by high disease pressure, small size farms and high input from family capital. MBTOC suggests that the Party take steps to help these remaining growers to phase out use of MB by using the available alternatives particularly chemicals, substrates and grafting.	CUN reports costs of chemical and non-chemical alternatives for methyl bromide. Partial budget analysis shows that chemical alternatives result in gross margin (net revenue) decreases of 50 percent or more compared to methyl bromide.
Greece	Cut flowers	14		14	6		U		MBTOC is unable to assess this nomination for 2006 at this time. Further information on several issues has been sought from the Party, including validation that no technical and economically feasible alternatives are available. Chloropicrin and mixtures thereof are not registered in Greece for cut flower production, limiting range of alternatives available. The Party states that although substrates (coco peat) are technically feasible they are expensive. Transition to substrate systems for rose growing is limited by investment costs, but 30% of the sector uses hydroponic production methods. The principal crops, carnations, roses and gypsophila, are produced without MB in many parts of the world under apparently similar conditions, suggesting transition should be feasible. Efforts to investigate, register and deploy alternatives do not appear sufficient.	CUN reports 30% yield loss with metham sodium or dazomet compared to methyl bromide. Party reports these alternatives will result in net revenue decreases of 16 to 27 percent compared to methyl bromide. Soilless production is in use for 25 percent of rose production. Initial cost of establishing soilless systems is a major constraint on further adoption.
Greece	Mills and Processors	23			16		15.445		MBTOC recommends a CUE of 15.445 tonnes for this use in 2006. The minimum label dosage rate in Greece is higher than the MBTOC standard dosage rate for fumigation of structures. No dosage adjustments are proposed, but the Party may wish to instruct fumigators to use the minimum dosage rates in the range given on the label to minimise emissions and MB usage. It is suggested that the Party continue research and development on heat treatments combined with IPM improvements as a priority.	CUN reports that phosphine costs 3 times more than MB treatment

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Greece	Rice and legumes				2.355		U		MBTOC is unable to assess this nomination for 2006 at this time. Further information is requested on the extent of commercial use of alternatives to MB for postharvest disinfestation of rice and legumes in a percentage of total production in Greece. A more detailed technical and economic justification for the critical need for MB is sought when it appears that alternatives are in extensive commercial use in Greece and neighbouring countries in apparently similar situations.	High capitol costs for modified atmosphere packaging equipment. Recent decreased cost of MB in comparison with phosphine. Lengthy time in phosphine treatment delays shipment.
Greece	Tomatoes	156			73.6		73.6		MBTOC recommends a CUE of 73.6 tonnes for this use in 2006. The Party states the nomination is restricted to where alternatives are not available because of economic reasons. Alternatives are already in use on 53-63 % of the cropping area. The area relating to the nomination is characterised by high disease pressure, with small size farms and high input from family capital. MBTOC suggests that the Party takes steps to help these remaining growers to phase out use of MB using the available alternatives, particularly 1,3 D+ Pic, substrates and grafting.	CUN reports costs of chemical and non-chemical alternatives for methyl bromide. Partial budget analysis shows that chemical alternatives result in gross margin (net revenue) decreases of 45 percent or more compared to methyl bromide.
Ireland	Mills				0.888		0.888		MBTOC recommends a CUE of 0.888 tonnes for this use in 2006. The Party reduced the applicant's request to adjust to MBTOC standard dosage rates. Full scale heat treatment trials are underway. Difficulty in achieving good pest control results with alternatives in larger mills has been observed.	CUN notes sulfuryl fluoride will be at least 2.5 times cost of methyl bromide. No accurate cost of heat available. Losses from additional downtime when alternatives are used.
Italy	Mills and Processors	160			130 (c)		U		In a letter dated 26 January 2005, the Party requested deferment of the assessment for their application pending their submission of a comprehensive response to MBTOC questions. MBTOC will consider this nomination at its August 2005 meeting. The Party is invited to submit the required information by August 1, 2005 for this to be considered at its August meeting.	Party deferred assessment.
Japan	Chestnuts	7.1	6.5		0.3	6.5	0.3	6.5	MBTOC recommends a supplemental CUE of 0.3 tonnes for this use in 2006 and a CUE of 6.5 tonnes for this use in 2007. MBTOC does not know of any alternatives for disinfestation of fresh chestnuts in shell. Japan is encouraged to continue research into alternatives.	No economic data on alternatives given

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Japan	Cucumber	88.3	87.6		1.2	72.4	1.2	72.4	MBTOC recommends a supplemental CUE of 1.2 tonnes for 2006 and a CUE of 72.4 tonnes for 2007 for this use. The supplemental CUN for 2006 is for areas of crop that did not apply in the previous nomination round. This is based on the recognition that both the cropping system and pathogen (Kyuri Green Mottle Mosaic Virus) targeted by methyl bromide are unique. Methyl bromide use permits multiple cropping within a year while managing risk of disease carryover. Several potential alternatives have been trialled, but have not performed adequately. Basic practices have been in place for many years, with farmers using low technology systems, including applying MB from small canisters. The latter system has been superseded in many developed countries on grounds of safety and efficacy. MBTOC acknowledges the effort to transition growers to use VIF. However, in spite of rates conforming with MBTOC guidelines, MBTOC urges the Party to consider further reductions in dosage rates, together with a more rapid transition to barrier films, as a transitional strategy while alternatives are developed.	CUN reports no economic data on alternatives. CUN states hydroponic systems are not economically feasible.
Japan	Ginger - field	119.4	119.4			112.2		N	MBTOC does not recommend a CUE for this use for 2007. The Party in their submission identified several very effective alternatives that exist (e.g. metalaxyl granules) for controlling this disease, although the Party stated that some may need further testing and refinement. Methyl bromide is no longer used in other developed countries producing ginger, indicating that alternatives are, in general, available. The key pathogen, Pythium, is easily controlled by various fungicides, e.g. metalaxyl, and also with cultural practices (e.g. Smith et al 1988).	CUN estimates higher costs and lower yield with Chloropicrin. Dazomet has lower cost than methyl bromide but also lower estimated yield. Estimated reduction in net revenue with alternatives is -22 to -30 percent.
Japan	Ginger - protected	22.9	22.9			14.8		N	MBTOC does not recommend a CUE for this use for 2007. The Party in their submission identified several very effective alternatives that exist (e.g. metalaxyl granules) for controlling this disease, although the Party stated that some may need further testing and refinement. Methyl bromide is no longer used in other developed countries producing ginger, indicating that alternatives are, in general, available. The key pathogen, Pythium, is easily controlled by various fungicides, e.g. metalaxyl, and also with cultural practices (e.g. Smith et al 1988).	CUN estimates higher costs and lower yield with Chloropicrin. Dazomet has lower cost than methyl bromide but also lower estimated yield. Estimated reduction in net revenue with alternatives is -22 to -30 percent.

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Japan	Melon	194.1	171.6		32.3	182.2	32.3	182.2	MBTOC recommends a supplemental CUE for 32.1 tonnes for 2006 and a CUE of 182.2 tonnes for 2007 for this use. The supplemental CUN for 2006 is for areas of crop that did not apply in the previous nomination round. This is based on the recognition that both the cropping system and pathogens (Melon necrotic spot virus and Cucumber green mottle mosaic virus) targeted by methyl bromide are unique. Methyl bromide use permits multiple cropping within a year while managing risk of disease carryover. Several potential alternatives have been trialled, but have not performed adequately. Basic practices have been in place for many years, with farmers using low technology systems, including applying MB from small canisters. The latter system has been superseded in many developed countries and grounds of safety and efficacy. MBTOC also acknowledges the effort to transition growers to use VIF. However, in spite of rates conforming with guideline standards, MBTOC urges the Party to consider further reductions in dosage rates, together with a more rapid transition to VIF or equivalent films, as a transitional strategy while alternatives are developed.	Technical reasons for CUN citing particular virus situation. No economic data on methyl bromide alternatives.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Japan	Peppers (green and hot)	187.2	112.3	74.9	13.5	169.4	13.5	156.7	MBTOC recommends that a supplementary CUE for 13.5 tonnes for 2006 and a reduced CUE of 156.7 tonnes for 2007. The nomination is based on the stated need to control a particular virus of peppers. Pepper mild mottle tobamovirus is transmitted by mechanical inoculation, grafting and contact between plants and by seeds, and can survive in crop debris, especially in fumigated soils. The problem appears to exist because of continuous cropping with peppers and is controlled in other countries by appropriate crop rotation, better crop sanitation and use of pathogen free seeds. The virus has been reported in many countries. In spite of the high severity of this virus in most of these countries, MB has never been used or requested for its control. MBTOC recognises the unique farming system used for peppers in Japan in place for many years. MB treatment is apparently essential to economic health of these growers. MBTOC notes that the cultural practices adopted for pepper production in Japan result in need for MB for this virus and that no other country is using MB to control this virus. The Party is urged to demonstrate progress in developing strategies to eradicate the pathogen, particularly from the crop debris. VIF technology is currently being introduced. The Party claims that the minimum rate of adoption of VIF is 5% per year and is achievable, although a higher rate may be possible. Based on the Party statement, MBTOC sees that by 2007, 15% of the growers will be adopting VIF at a dosage of 200 kg/ha for those currently using high rates of 400 kg/ha. A 7.5 % reduction of the nomination for 2007 is thus recommended.	Technical reasons for CUN citing particular virus situation. No economic data on methyl bromide alternatives.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Japan	Watermelon	129.0	60.9		38	94.2	38	94.2	MBTOC recommends a supplemental CUE of 38 tonnes for 2006 and a CUE of 94.2 tonnes for 2007 for this use. The supplemental CUN for 2006 is for areas of crop that did not apply in the previous nomination round. This is based on the recognition that both the cropping system and pathogen (Cucumber green mottle mosaic virus) targeted by methyl bromide are unique. Methyl bromide use permits multiple cropping within a year while managing risk of disease carryover. Several potential alternatives have been trialled, but have not performed adequately. Basic practices have been in place for many years, with farmers are using low technology systems, including applying MB from small canisters. The latter system has been superseded in many developed countries on grounds of safety and efficacy. MBTOC acknowledges the effort to transition growers to use VIF. However, in spite of rates conforming with standards, MBTOC urges the Party to consider further reductions in dosage rates, together with a more rapid transition to VIF films, as a transitional strategy while alternatives are developed.	Technical reasons for CUN citing particular virus situation. No economic data on methyl bromide alternatives.
Latvia	Grains				2,502		U		MBTOC is unable to assess this nomination for 2006. Further information has been sought on appropriate dosage rates and frequency of application, details of application methodology and emission control, applicability of recognised alternatives and the need for increased usage over historical trends.	CUN reports phosphine costs twice as much, and the additional costs for improved ventilation equipment to allow use of phosphine would be prohibitive.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Malta	Cucumber				0.127		0.127		MBTOC recommends a CUE of 0.127 tonnes of MB in 2006 for this use. MBTOC recognises that farmers in Malta intend to transition to alternatives as suggested by the Party by 2007 (dazomet, metham sodium and solarisation) and that any stocks of methyl bromide would be used for any remaining critical uses.	The CUN reports one set of economic information in a single CUN for cucumber, eggplant, strawberry and tomatoes. The CUN reports costs of methyl bromide treatment, steam, and solarisation. Gross and net revenues for methyl bromide, steam, and solarisation are reported. Significantly lower net revenues result from the alternatives. However, because the data are not crop specific, it is not possible to evaluate the economic feasibility of the alternatives.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Malta	Eggplant				0.17		0.17		MBTOC recommends a CUE of 0.170 tonnes of MB in 2006 for this use. MBTOC recognises that farmers in Malta intend to transition to alternatives suggested by the Party by 2007 (dazomet, metham sodium and solarisation) and that any stocks of methyl bromide would be used for any remaining critical uses.	The CUN reports one set of economic information in a single CUN for cucumber, eggplant, strawberry and tomatoes. The CUN reports costs of methyl bromide treatment, steam, and solarisation. Gross and net revenues for methyl bromide, steam, and solarisation are reported. Significantly lower net revenues result from the alternatives. However, because the data are not crop specific, it is not possible to evaluate the economic feasibility of the alternatives.



Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Malta	Strawberry				0.212		0.212		MBTOC recommends 0.212 tonnes for 2006 of MB in 2006 for these uses for open field and greenhouse. MBTOC recognises that farmers in Malta intend to transition to alternatives suggested by the Party by 2007 (metham sodium combined with resistant cultivars, metham sodium + short solarisation and low cost substrates) and that any stocks of methyl bromide would be used for any remaining critical uses.	The CUN reports one set of economic information in a single CUN for cucumber, eggplant, strawberry and tomatoes. The CUN reports costs of methyl bromide treatment, steam, and solarisation. Gross and net revenues for methyl bromide, steam, and solarisation are reported. Significantly lower net revenues result from the alternatives. However, because the data are not crop specific, it is not possible to evaluate the economic feasibility of the alternatives.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Malta	Tomatoes				0.594		0.594		MBTOC recommends a CUE of 0.594 tonnes of MB in 2006 for this use. MBTOC recognises that farmers in Malta intend to transition to alternatives suggested by the Party by 2000 (metham sodium combined with resistant cultivars, metham sodium + short solarisation and low cost substrates) and that any stocks of methyl bromide would be used for any remaining critical uses.	The CUN reports one set of economic information in a single CUN for cucumber, eggplant, strawberry and tomatoes. The CUN reports costs of methyl bromide treatment, steam, and solarisation. Gross and net revenues for methyl bromide, steam, and solarisation are reported. Significantly lower net revenues result from the alternatives. However, because the data are not crop specific, it is not possible to evaluate the economic feasibility of the alternatives.
Netherlands	Strawberry runners - postharvest	0.12			0.12		0.12		MBTOC recommends a CUE of 0.120 tonnes for 2006 for this use (control of bacteria in bare root strawberry plantlets). The applicant has stated there are complete MB capture systems in place and as a result there are no MB emissions. To date control has not been achieved through alternatives. Party is encouraged to continue its research program.	No economic data on alternatives given
Poland	Coffee & cocoa beans				2.160		2.160		MBTOC recommends a CUE of 2.160 tonnes for this use (control of mites in 2006 in imported cocoa and coffee beans). MBTOC recognises that controlling mites is more difficult than other pests and the need for dockside treatment at cold temperatures further complicates treatment. The Party has reduced the applicant's request to account for lower dosage rates, and the applicant has plans to reduce their dosage rates even further. The Party is encouraged to continue their investigation and/or adoption of rapidly generated forms of phosphine gas.	No economic data given on alternatives, but CUN indicates capitol costs for fast generating phosphine machines (a technically effective alternative), and cold are too expensive.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
Portugal	Cut flowers	50			8.75		8.75		MBTOC recommends that a CUE of 8.75 tonnes of MB for 2006 for this use. MBTOC appreciates the new information sent by the Party to further clarify the nature of this nomination. For any future submissions MBTOC requests that the Party more explicitly state the pests and pathogens or environmental conditions that make MB critical for the portion of the cropping area where alternatives have been difficult to adopt. MBTOC notes that, according to the Party (EC), lack of technical and economically feasible alternatives has not been validated and efforts to find, register and deploy alternatives have been insufficient.	CUN reports lower costs for dichloropropene alone and in combination with metham sodium with accompanying yield losses of 50 to 90 percent compared to methyl bromide. Steam effective but near 3 times the cost of methyl bromide. Emphasis on technical basis for CUN.
Spain	Rice				?		U		MBTOC is unable to assess this nomination for 2006 at this time. The Party (EC) has not provided a nominated amount of MB for this use. Further information has been sought on processes used, rationale for exceptionally high dosage rates used, and whether allowance has been made for the adoption of alternatives resulting from the current construction programme of fumigation facilities.	Phosphine fumigant costs equivalent to MB, but requires longer treatment times. Modified atmosphere chambers capital costs high. Vacuum packaging treatment (technically effective alternative) increases consumer costs \$0.20/kg of rice
UK	Cereal processing plants	(a)			8.131		8.131		MBTOC recommends a CUE of 8.131 tonnes for this use in 2006. The Party is quickly adopting heat and SF where possible, but SF is not registered for silos that are integral to the flour mills in the case of the structures within this CUN. The applicant should be encouraged to change logistics to enable emptying of silos before fumigation to allow for increased use of SF.	CUN reports that heat or SF would cost 200% more than MB treatment
UK	Cheese stores	1.6			1.248		1.248		MBTOC recommends a CUE of 1.248 tonnes this use (traditional cheese stores with cheese in situ) in 2006. MBTOC knows no alternatives for mites in cheese under these conditions. The applicant has made significant efforts in improving gastightness and is continuing a research programme.	CUN states there are no economically feasible alternatives based on lack of technically feasible alternatives. CUN presents no economic data or analysis.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
UK	Cut flowers				7.56		U		MBTOC is unable to assess this nomination at this time. Clarification of some issues relating to this CUN have been sought from the Party. MBTOC is not clear why Party is requiring MB to control Mycosphaerella and thrips on flowers, as both are considered foliar pests (although thrips have a soil stage MB is not the customary means of control for this pest). Further to the questions already submitted, the Party is requested to provide information on what % of the UK flower production in glasshouses is resistance to azoxystrobin now present, rendering this material ineffective and if this material can be alternated with another compound to achieve acceptable control, but reduce the likelihood of developing resistant strains. Also, the Party states that Fusarium-resistant carnations are available, but not grown in the UK; clarification is requested as to why these varieties are not suited to the UK growing conditions or UK markets. MBTOC notes that, according to the Party (EC), lack of technical and economically feasible alternatives has not been validated and efforts to find, register and deploy alternatives have been insufficient.	CUN yield losses with alternatives dazomet and metham sodium, but no yield loss with steam. Steam alternative is reportedly too costly compared to methyl bromide. The CUN presents a partial budget analysis showing dazomet results in a 95 percent decrease in Gross Margin (net revenue) compared to methyl bromide.
UK	Dried commodities (rice, fruits and nuts) Whitworths	2.4			1.256		1.256		MBTOC recommends a CUE of 1.256 tonnes for this use in 2006. The Party indicated that VIF in stack fumigation and chambers are used to reduce emissions. The applicant is encouraged to assess how changed marketing logistics will allow a higher percentage to be treated with phosphine thereby reducing MB use. MBTOC also notes that SF is not approved for these commodities.	CUN presents no economic information on methyl bromide or alternatives. The Party's response to EC notes discussed economic costs of phosphine.
UK	Herbs and spices	0.035			0.037		0.037		MBTOC recommends a CUE of 0.037 tonnes for this use in 2006. The Party has reduced the applicant's request to encourage adoption of alternatives and IPM. MBTOC suggests that improvements in IPM practices, together with pest management prior to import be continued so as to reduce the need for MB for this nomination.	CUN states that phosphine or CO2 would cost 5 times and irradiation would cost 7 times the cost of MB treatment, CUN notes losses would result from additional downtime when alternatives are used.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
UK	Mills (NABIM)	(a)			10.195		10.195		MBTOC recommends a CUE of 10.195 tonnes for this use in 2006. The Party has reduced the applicant's request by 60 percent to encourage faster adoption of alternatives. Given the difficulties identified in the adoption of alternatives, specifically heat, in large mills, no further reductions are suggested.	CUN reports heat will cost 2.5 times more than MB and although costs of SF are unclear at this time, it is estimated to cost 2.5 - 6 times the MB treatment costs.
UK	Mills and Processors (biscuits)	2.525			1.787		1.787		MBTOC recommends a CUE of 1.787 tonnes for this use in 2006. The Party has reduced the application to account for potential to use alternatives. The applicant has also made improvements in facility gastightness, reduced dosage rates to MBTOC standards and upgraded IPM practices to enable decreased fumigation frequency. The applicant also has an active research programme. SF is not registered for this purpose.	CUN states that SF would cost 200-300% more and heat would cost 200-400% than MB treatment.
UK	Structures (herbs and spices)	3.0			1.872		1.872		MBTOC recommends a CUE of 1.872 tonnes for this use in 2006. The Party has reduced the nomination to account for the potential to continue adoption of heat treatment. SF is not registered for this purpose.	CUN states heat or SF treatment would cost 200% more than MB treatment.
UK	Structures, processors and storage (Whitworth's)	1.1			0.880		0.880		MBTOC recommends a CUE of 0.880 tonnes for this use in 2006. The Party is encouraged to develop industry standards for efficacy of heat treatments sufficient to comply with UK food safety legislation and to continue to develop alternatives such as appropriate packaging and phosphine treatment.	CUN reports no economic data on alternatives. Party's response to EC states costs for SF would be up to 5 times the costs of methyl bromide.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Cucurbits - field	1187.8	747.839			598.927		U	<p>MBTOC is unable to assess this nomination in total at this time, but recommends CUEs for the following component of this CUN: 26.592 tonnes for Michigan for 2007. In Michigan, the key pests are Phytophthora capsici and Fusarium. The Party states that 1,3-D/chloropicrin may be an effective alternative but growers will miss the optimal market window due to longer plant back times with this alternative. This argument is economic and is recommended on this basis. There may be scope for avoiding this problem through treatments in autumn preceding the crop. The CUN was based on limited trial data, and MBTOC requires further information to assess the other regions, in particular the relevance of recent trial results in SE USA, especially those using low permeability barrier films (Gilreath et al 2005a) and new application methods for alternatives (on cucurbits or similar crops from relevant production regions). MBTOC also seeks the current registration status and use rates of MB/Pic mixtures with lower MB than currently used (especially 30:70, 50:50) for control of the key pests in the nomination and also results of their technical efficacy. The nomination indicates that MB is often not applied before cucurbits, but before the preceding crop as part of a double cropping process. MBTOC requests further clarification on how the proportion of the total crop area where MB is used immediately prior to cucurbits is determined. In SE and Georgia, the key pest is nutsedge. The Party states that potential alternatives, 1,3-D/Pic combinations and metham sodium, result in yield loss estimates of 29%. Estimates of yield differences are a determining factor in the relative economics of MB and the next best alternative. The Party refers to an old study on tomato production for yield data (Locascio 1997) and further information is requested to support the yield loss estimates relative to MB resulting from 1,3-D/chloropicrin combinations and metham sodium, with or without Pic, and other combinations such as 1,3-D + trifluralin + chloropicrin + napropamide. Recent references available to MBTOC demonstrate effective alternatives (metham sodium, with and without Pic) for moderate to heavy nutgrass control and further clarification is required on their suitability to karst and non karst areas (Johnson and Webster, 2001; Gilreath et al 2005b,c). Yields were similar to methyl bromide, however there was no data presented on plantback effects for cucurbits.</p>	<p>CUN states next best alternative in all regions is 1,3-D with chloropicrin with expected yield losses of 6 percent in Michigan and 29 percent in Southeastern States and Georgia. CUN states 1,3-D with chloropicrin is considered technically feasible in Michigan. However, CUN noted that for Michigan in addition to the yield loss, delayed planting and harvest with the alternatives results lower average price received from missed market windows and negative net revenue. In remaining regions yield losses significantly reduce net revenues. CUN notes other regions may also experience lower prices because of missed market windows.</p>

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Dried beans				7.07			U	MBTOC is unable to assess this nomination for 2006 at this time, pending further information from the Party. MBTOC notes that this application is specifically for the State of California where the pest (cowpea weevil) is not listed on the phosphine label, but beans are listed on the same label. An interpretation is requested to determine if phosphine could be used on beans in California, Cowpea weevil is the main pest of beans, and phosphine is used for its control in other parts of the US.	No economic data on alternatives given.
USA	Dried fruit and nuts (walnuts, pistachios, dried fruit and dates and dried beans)	89.166	80.649			91.279		U	MBTOC is unable to assess this nomination in total at this time, but recommends reduced CUEs for the following components of this CUN: walnuts (55.178 tonnes), dried fruit (18.218 tonnes) for 2007 with a CUE for associated research of 0.020 tonnes. The amounts have been reduced to their 2006 levels in the absence of a justification for the increased amount of MB requested for these commodities. Although phosphine is used to treat a large percentage of US walnuts, the Party reported that CUN for walnuts is largely for in-shell nuts which require a longer treatment time for phosphine. The longer treatment time would affect the key holiday market window and there is not yet sufficient treatment chamber capacity. MBTOC is seeking further information from the Party on the use of MB on dates, specifically the condition of the dates at time of treatment and whether both fumigations are equally time-limited. MBTOC recognises that there are no alternatives for fresh dates but that there are alternatives for dry dates, though these may take some days for effectiveness. MBTOC is unable to assess the quantities required for pistachios in consideration of the recent extensive conversion of pistachio treatment by the largest processor to rapidly generated gas forms of phosphine. MBTOC requests the Party to provide further information on its critical methyl bromide needs for pistachios. MBTOC is also unable to assess the nomination for dried beans for 2007 pending a clarification from the Party on a California label issue. Cowpea weevil is the main pest of beans, and phosphine is used for its control in parts of the US.	Economic data on alternatives given for walnuts, pistachio and dried fruit other than dates. Phosphine fumigant costs 10-30% higher but problem is phosphine takes longer to accomplish and its use would not allow sellers to reach December holiday export market window since product is harvested in autumn. CUN states walnuts, pistachio, and dried fruit all experience substantial additional downtime and subsequent lost revenues if phosphine is used.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Dry commodities/ structures (cocoa beans)	61.519	46.139	15.38		46.139		U	MBTOC is unable to assess this nomination for 2007 at this time. This nomination refers to cocoa beans for 2007 and has been disaggregated by MBTOC from the US CUN that includes other dry commodities. A recent case study (Marcotte and Sansone 2005) and an examination of US import statistics indicates that as much as 25 percent of US cocoa imports are treated with MB as required by US FDA for official sanitation control. MBTOC is therefore unsure if part of the requested amount may be for a QPS use. MBTOC also invites the Party to determine if a percentage of cocoa beans that are stored in separate long term storage warehouses are suitable for phosphine treatment and if fumigation logistics could accommodate use of phosphine in that part of cocoa bean sector. If so, could the percentages suitable for phosphine treatment be supplied by the Party? Phosphine is the usual treatment for cocoa beans in other countries.	No data on costs of alternatives. CUN notes additional fumigation time needed with phosphine, and costs of retrofitting facilities for heat treatment.



Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Dry commodities/ structures (processed foods, herbs and spices, dried milk and cheese processing facilities)	83.344	56.253	27.091		56.253		U	MBTOC is unable to assess this nomination in total at this time, but recommends CUEs for the following components of this CUN: 2.996 tonnes for cheese processing facilities for 2007. MBTOC is not aware of any registered alternatives for mites in cheese stores. The Party is encouraged to continue research on this sector. The largest requested use in this CUN is for processed foods (74.884 t), which also includes bakeries. Some bakeries are also included in another CUN where increased MB is being requested. MBTOC continues to have questions on the potential for further adoption of heat treatments in bakeries and other food processing facilities by 2007. MBTOC finds obstacles to treatment of bakery ingredients by heat reported in the CUN to be the same as for MB: ingredients such as fats cannot be heat treated, but neither can they be MB treated. Bakeries have access to heat equipment and MBTOC needs to understand the obstacles to increased adoption of heat treatment. MBTOC's questions were raised in the light of the increased MB request for bakeries in another US CUN and what seems to be an increase in the request for facilities including bakery in this CUN. The CUN does not currently adequately justify the extent of MB use in this sector. The Party is also invited to report whether the amount of MB requested for herbs and spices (4.891 t) is for facilities and equipment or for herb and spice commodity. Several alternatives are available for herb and spices as commodities, but the CUN is unclear for the need of MB in this sector. MBTOC also needs to know more about the requirement for MB in the category "other" (467 kg). Is this an import situation where fast fumigation is necessary? Phosphine could possibly treat some of the commodities listed under this category.	No data on costs of alternatives. CUN notes additional fumigation time needed with phosphine, and costs of retrofitting facilities for heat treatment.
USA	Dry Cured Ham (building and product)	67.907			40.854 (c)	40.854		U	MBTOC is unable to assess this use for 2007. MBTOC has not identified any alternatives for this specific and specialised use, where fumigations are conducted in the presence of curing hams. The nomination did not indicate any research to develop alternatives. The Party is requested to gather use data to support this nomination and to adjust the quantity nominated for any unused allocations from previous CUEs. MBTOC has concerns over the lack of emission controls in this use.	No economic data on alternatives given.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Eggplant - field	76.721	81.253	20.933		96.48		U	<p>MBTOC is unable to assess this nomination in total at this time, but recommends CUEs for the following component of this CUN: 3,799 tonnes for Michigan for 2007. In Michigan, the key pests are Phytophthora capsici and Verticillium. The Party states that 1,3-D/chloropicrin may be an effective alternative, but growers will miss the optimal market window due to delayed plantback times. Recommended on the basis of this economic argument. The CUN was based on limited trial data, and MBTOC requests further information to assess the other regions, in particular the relevance of recent trial results in SE USA especially those using low permeability barrier films (Gilreath et al 2005a) and new application methods for alternatives on cucurbits or similar crops from relevant production regions. MBTOC also seeks the current registration status and use rates of MB/Pic mixtures with lower MB than currently used (especially 30:70, 50:50) for control of the key pests in the nomination and also results of their technical efficacy. The nomination indicates that MB is often not applied directly before eggplant, but before the preceding crop. MBTOC requests further clarification on how the proportion of the total crop area where MB is used immediately prior to eggplants is determined. In Georgia and Florida, nematodes, soil borne fungi and nutsedge are the key pests. The Party states that 1,3-D + chloropicrin + trifluralin + napropamide is an effective alternative in Florida except in areas of karst topography which comprise 40% of the growing acreage. 1,3-D/chloropicrin is effective against nematodes, but not nutsedge. Although not controlling nutsedge as well as MB, this combination provided equivalent yields in spring and fall crops in Tifton GA (Culpepper and Langston, 2004). An effective strategy for controlling nematodes, pathogens and nutsedge has been demonstrated in Florida as described above. Also, recent references available to MBTOC demonstrate effective alternatives (metham sodium, with and without Pic) for moderate to heavy nutgrass control in similar regions for non-karst and karst areas (Johnson and Webster, 2001; Gilreath et al. 2005b and c). Yields were similar to methyl bromide, however there was no data presented on plantback effects for eggplants. It is not clear why this combination cannot be used in 92% of Georgia nomination where karst topography is not a concern. Yield differences are the principal factor in economic analyses on economic feasibility of technically suitable alternatives for these regions. These yield differences are estimated for eggplant on the basis of some tomato data including Locascio (1997)</p>	<p>CUN states next best alternative in all regions is 1,3-D with chloropicrin with expected yield losses of 6 percent in Michigan and 29 percent in Georgia and Florida. CUN states 1,3-D with chloropicrin is considered technically feasible in Michigan. However, CUN noted that for Michigan in addition to the yield loss, delayed planting and harvest with the alternatives results lower average price received from missed market windows and negative net revenue. In Florida and Georgia yield losses significantly reduce net revenues. CUN notes Florida and Georgia producers may also experience lower prices because of missed market windows.</p>

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Forest nursery seedlings	192.515	157.694			152.629		U	<p>MBTOC recommends a CUE of 18.456 tonnes be approved for Regions C (Illinois), E (Weyerhaeuser NW), and G (Michigan Forest Seedlings) for forest nursery use in 2007, but is unable to assess the remaining part of the nomination. The CUN is based on economic infeasibility of using substrates and the lack of effective alternatives for control of nutsedge and a range of fungal pathogens. It covers certified seedling production in 7 forest nursery regions and one region in Michigan growing herbaceous perennials. Certification requires that seedlings must be pest/pathogen free. The Party states that all regions use broadacre fumigation, but with different mixtures and rates of MB/Pic. MBTOC recommends 1.911, 9.637 and 6.908 tonnes respectively for the nominations from regions C,E and G which use MB/Pic mixtures of 67:33. MBTOC is unclear why regions A, B, D and F, which presently use MB/Pic 98:2 or MB/Pic 90:10 cannot use MB/Pic 67:33 as is used in Regions C, E, and G and requests further clarification on this issue. Research is ongoing to determine if Pic with metham, 1,3-D and /or herbicides can provide acceptable control of high levels of nutsedge. To date, metham sodium and chloropicrin in combination showed promising results, but when used without plastic sheeting caused severe crop injury. MBTOC considers that this treatment (and others) covered with plastic films, particularly low permeability barrier films, may provide an effective technical alternative and avoid crop injury, but MBTOC accepts that gluing some barrier films is presently problematic for broadacre tarping under some conditions. MBTOC also requests further information on whether 1,3-D/Pic + metham sodium (or glyphosate) can be used in place of MB/Pic formulations to control nutsedge (Culpepper and Langston, 2004). MBTOC further requests clarification from the Party of the availability and effects of VIF films used with MB/Pic mixtures or alternatives to control persistent targets (e.g. nutgrass) as this can further reduce rates (Gilreath et al 2005a). The nomination states that containerised plants are not economically feasible for regions A through G. MBTOC considers substrates to be an effective technical alternative for most forest nurseries, however understands that present costs (\$US0.12 vs. \$0.04 per seedling) make this practice economically infeasible at the present time. The Party</p>	<p>Alternatives have 3-5% decrease in yield and higher costs resulting in estimated decreases in net revenue that varied from 6 percent to 42 percent with the next best alternative. CUN states numerical analysis does not include additional impact of quality losses and indirect yield losses resulting from lengthening the production cycle.</p>

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
									states that substrates cannot be used for Region H (Michigan herbaceous seedlings) because roots will freeze, but clarification is requested on whether this could be avoided by use of polyethylene tunnels or in greenhouses where plug plants are raised successfully for many crops in many regions (Styler and Koranski, 1997). As the herbaceous seedlings portion of the nomination (region H) has more similarities to the Ornamentals sector than to Forest Seedlings, it is suggested that this nomination could be included in the Ornamentals CUN for any future nominations	
USA	Mills and Processors	483	394.843	111.139		401.889		U	<p>MBTOC is unable to assess this nomination for 2007 at this time. MBTOC believes that the reduction in the Party's MB nomination in 2007 over the 2006 requested amount reasonably represents the likely adoption of alternatives in flour mills. MBTOC however continues to have concerns for the component of this CUN on rice mills, particularly relating to the potential adoption of SF in rice mills in light of the regulatory situation in mid 2005. MBTOC also needs further information on the potential for adoption of heat treatments and other IPM practices in bakeries and pet food establishments.</p> <p>MBTOC finds obstacles to treatment of bakery ingredients by heat reported in the CUN to be the same as for MB itself: ingredients such as fats cannot be heat treated, but neither can they be MB treated. Bakeries have access to heat equipment and MBTOC needs to understand more fully the obstacles to increased adoption of heat treatment. The CUN notes that 20 percent of US pet food establishments use heat and MBTOC would like a better understanding of further potential for heat adoption by 2007. MBTOC's questions were raised in the light of the increased amount of MB requested for bakeries, and the essentially same amount requested for pet food for 2007 as was requested in 2006. The CUN does not currently adequately justify the extent of MB use in these sectors. MBTOC also observes that some bakeries were included in the CUN on dry food commodities, which further contributed to queries about the extent of use of MB in bakery sector.</p>	The CUN reports heat will cost 1.5 times and sulfuryl fluoride costs 1.3 times the cost of MB treatment. Heat treatment is reported to result in lost operating days and thus lower throughput and gross revenues.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Nursery stock - fruit trees, raspberries, roses	45.800	64.528			6.485		U	MBTOC is unable to assess this nomination for 2007 at this time. MBTOC acknowledges receipt of the letter sent by the Party stating that the amounts requested for this CUN has been revised downward to a total of 6.485 tonnes (Western Raspberries 2.738 tonnes, Roses 0.227 tonnes and Fruit and Nut Tree 3.52 tonnes). The nomination is for certified propagative material. Certification is mandatory for California and is voluntary in Washington, but stock exported to European and S. American markets are required by law in the importing country to participate in the certification program. The crop has no value if it is not certified. In CA, the standards require the propagative material to be "commercially clean" and lists approved methods for meeting this standard. In WA, the tolerance is 0.1% incidence for nematodes and "practically free" for disease. Studies to show certified nursery level of control are on going. Party has indicated that a revised nomination and BUNI will be submitted.	CUN cites lack of technically feasible alternatives. CUN notes most economic losses cannot be quantified. CUN notes certification requirements that would result in yield losses of up to 100 percent if nursery stock cannot be certified as pest free and subsequent economic consequences. CUN notes potential increase in pesticide use and potential lower yields of fruits and nuts from plants and trees placed in production.
USA	Orchard replant	706.176	527.6	300.4		405.4		U	MBTOC is unable to assess this nomination at this time. The CUN is for 3 situations: Orchard/vineyard replant disorder of unknown aetiology; heavy soils or soils which cannot be dried to a sufficient depth to effectively use the reduced rates of 1,3-D now allowed in California; and areas in which Township caps do not allow use of 1,3-D. In bilateral discussions with the Party on April 13, 2005, the Party indicated it needed to further check calculations in all nominations in which strip treatments are used. This nomination indicates strip treatments are used for stone fruit and for almond. MBTOC awaits the confirmation of the calculations in order to complete this evaluation. MBTOC notes that the nominated amount is a 24% reduction from the amount recommended by MBTOC for 2006. The amount recommended in 2006 was a reduction of 25% from the amount recommended in 2005.	CUN cites lack of technically feasible alternatives. CUN notes most economic losses cannot be quantified and lists factors that contribute to losses including delayed planting, tree loss, additional use of herbicides, yield losses of fruit or nuts.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Ornamentals	154			162.817(c)	149.965		137.835	<p>MBTOC recommends a reduced CUE of 137.835 tonnes in total for this nomination, being 75.145 tonnes for California and a reduced CUE of 58.63 tonnes for Florida, and 4.06 tonnes for associated research. MBTOC recognises the effort made by the Party in submitting more complete information; this is essential in understanding the specific circumstances of the complex and diverse US ornamental industry, particularly the fact that uses have now been disaggregated by region. 52% of this nomination is for California and corresponds to areas impacted by regulatory issues (township caps). There are no available in-kind alternatives for these areas. 48% of the nomination is for Florida. Of this, 40% is impacted by karst topography, denying use of 1,3-D and is recommended by MBTOC on the basis of lack of feasible alternatives. It is suggested that the dosage for this part of the nomination be reduced from 350 to 200 kg/ha in line with MBTOC presumptions for MB:Pic 67:33, but the remainder of the Florida nomination (60%) exceptionally be left at the high rate for treatment of soils of very high organic matter content. There is scope for reduction of the MB used using barrier films, provided the fumigation sheets can be joined satisfactorily. The Party states that the alternatives are not economically feasible because the decline in yields in all nominated regions leads to a substantial reduction in net revenue. This is based on the assumption that the quoted reduction in yields is technically realistic.</p>	<p>CUN reports yield losses of 20-25 percent with alternatives. Operating costs were assumed same as with methyl bromide. CUN reports substantial decreases in gross and net revenues. Negative net revenues predicted for calla lilies and bulbs in California and for caladiums in Florida.</p>

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Peppers - field	1094.782	806.877	694.497		1151.751		U	<p>MBTOC recommends 11.396 tonnes for Michigan for use in 2007, does not recommend the component for California, and is unable to assess the component of this nomination from the SE USA, Georgia and Florida. In Michigan, the key pests are Phytophthora capsici and Verticillium. The Party states that 1,3-D/chloropicrin may be an effective alternative, but growers will miss the optimal market window due to delayed planting under cold spring conditions. There appears to be scope for avoiding this problem by treatment in autumn prior to planting, possibly with chloropicrin alone. The principal argument for a critical use here is economic. In SE US, Georgia and Florida, nematodes, soilborne fungi and nutsedge are key pests. The Party states that 1,3-D + chloropicrin + trifluralin + napropamide is the best alternative strategy, but further testing required. This is restricted to areas without karst topography and the Party states that several large scale trials are in progress. The CUN was based on limited research results, and MBTOC seeks further discussion on recent trial results in SE USA, especially those using low permeability barrier films (Gilreath et al 2005a) and new application methods for alternatives on peppers. Recent references available to MBTOC, demonstrate effective alternatives (metham sodium, with and without Pic) for moderate to heavy nutgrass control in similar regions to the nomination and for non-karst and karst areas (Johnson and Webster, 2001; Gilreath et al 2005b,c). Yields were similar to methyl bromide, however there was no data presented on plantback effects for peppers. MBTOC also requests the Party provide the registration status and use rates available for use with MB/Pic mixtures and verify that mixtures with less MB (especially 30:70, 50:50) are unsuitable for control of the key pests in the nomination. Also it is requested that economic data be provided for the two most appropriate alternatives for all circumstances of the nomination. An adjustment is suggested for dosages for Florida (*200/237) and the rest of SE US (*200/223) to conform with MBTOC guideline rates. There appears to be scope for substantial reduction in MB use in this area through adoption of barrier film technology together with reduced MB dosages. For California, the key pests are nematodes and soilborne fungi. According to 2003 data available from the California Department of Pesticide Regulation, metham sodium is used on nearly as many acres as methyl bromide for peppers in California, indicating this is a viable alternative in areas affected by township caps, where another alternative, 1,3-D/Pic is not available. Economic analyses were not provided for this alternative for California.</p>	<p>CUN states next best alternative in all regions is 1,3-D with chloropicrin with expected yield losses of 6 percent in California and Michigan and 29 percent in other regions. CUN states 1,3-D with chloropicrin is considered technically feasible in California and Michigan. CUN noted that for California the distribution of yield loss across individual growers and the yield risk associated with alternatives was not accounted for the numerical economic assessment. Numerical assessment showed 14 percent decrease in net revenue. In Michigan delayed planting and harvest with the alternatives results lower average price received from missed market windows and negative net revenue. In remaining regions yield losses significantly reduce net revenues.</p>

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Strawberry fruit – field	2052.846	1523.180	397.597		1733.901		U	<p>MBTOC is unable to assess this nomination for 2007 at this time. The Party has nominated a total of 1731.524 tonnes for strawberry fruit, comprising 1267.88 tonnes for California, 165.735 tonnes for Eastern states, 297.909 tonnes for Florida and 2.377 tonnes for research. In California, the nomination is based on the grounds that township caps limit further adoption of 1,3-D, and hilly terrain prevents the use of drip-applied alternatives. In the case of township caps, alternatives that do not contain 1,3-D (such as Pic and Pic + metham applied sequentially) are technically feasible in at least part of this area (Ajwa et al 2002, 2004; Haar et al. 2001; Nelson et al. 2001a,b). The CUN noted that producers of day-neutral cultivars like Diamonte could miss early market windows due to longer equipment set-up time for drip application and/or reduced harvest period. However, the Party noted that this is not a serious problem for short day cultivars, such as Camarosa. MBTOC notes that chloropicrin alone and chloropicrin mixtures are being adopted for strawberry fruit, particularly in the south, where short day cultivars are grown (PUR data cited in Trout and Damodaran 2004; California Strawberry Commission 2005). There may be scope for additional adoption of chloropicrin and/or chloropicrin + metham for short day cultivars. Regarding hilly terrain, MBTOC acknowledges that current methods of drip application may not be appropriate. MBTOC is aware that pressure-compensated drip application systems are used in parts of the world, and encourages the Party to examine if there is any scope to adopt pressure-compensated drip application systems on some parts of the hilly terrain. Adoption of low permeability barrier films is proving effective in reducing application rates of MB in many industries and MBTOC acknowledges that there are regulatory constraints on use of VIF in California. In eastern US, the nomination is based on moderate to severe pest pressure (Meloidogyne spp., Pythium, Rhizoctonia, Phytophthora cactorum, Cyperus esculentus, C. rotundus, Lolium spp.) affecting 30-40% of the crop area, and small farm buffer zones on 40% of the crop area which affects use of 1,3-D formulations. MBTOC considers that alternatives appear to be available for some part of the buffer zones which are not subject to heavy nutsedge pressure (e.g. Pic formulations, metham + Pic), so is seeking further information about the potential area that could adopt such alternatives. For Florida, the Party states that at moderate to severe pest pressure (primarily nutsedge on 30-40% of area), protocols for commercial application of alternatives have not been sufficiently developed to be implemented for the 2007 season.</p>	CUN reports costs of alternatives for three next best alternatives for California, Florida, and Eastern United States. 1,3-D with chloropicrin is reported to reduce yield by 14 percent. Resulting lower production leads to lower net revenue. Planting and harvesting delays with alternatives are reported to lead to lower average prices received in all regions, but is only shown in the revenue analysis for California.



Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
									<p>However, no recent trial data was provided to MBTOC to substantiate the information. The CUN is also based on inability to use 1,3-D on 40% of the strawberry crop area because of karst topology. MBTOC considers some alternatives appear to be available for some part of the karst area that is not subject to heavy nutsedge pressure (e.g. Pic formulations, metham + Pic) and is seeking further information about the potential area that could potentially adopt such alternatives. MBTOC acknowledges karst topography limits the area that 1,3-D can be used but considers that other alternatives (Pic EC, metham + Pic) appear to be available for some part of this area, and asks the Party to provide further information about the potential area that could adopt such alternatives prior to and during 2007. Party is requested to clarify the registration of all MB/Pic formulations. There may be scope for both improving effectiveness of alternatives (Fennimore et al. 2003, Gilreath et al. 2003) and reducing MB use by adoption of low permeability barrier films e.g. VIF, Canslit, Pliant, etc. in all regions where available (Gilreath 2005a). MBTOC seeks further information about the potential area that could adopt barrier films, an estimate of the rate of adoption and the potential for lowering application rates of methyl bromide to 10g/m2 or less.</p>	

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Strawberry runners	54.988	56.291			4.483		4.483	<p>MBTOC recommends a CUE of 4.483 tonnes for this use, comprising 2.654 tonnes for southeastern states, 1.375 tonnes for California, and an associated research amount of 0.454 tonnes for 2007. A high proportion, 94% of runner production covered by this CUN has been exempted by the Party from critical use nomination under QPS. In future nominations, a copy of the certification requirements is requested from the Party. In the Southeastern states the nomination is based on the grounds that MB is needed to meet the strict requirements for producing pest free nursery stock. For California, the nomination says that the state mandatory certification program has strict requirements for control of disease and nematodes, which amount to near complete control of the key pests. MBTOC recognizes the need to produce planting stock of high health status to minimise spread of diseases and pests. The Party states that key alternatives are 1,3-D/Pic, 1,3-D/Pic + metham, and 1,3-D + metham, and that dazomet + Pic or 1,3-D is also a possible alternative. The Party notes that these chemicals, in addition to other strategies, such as use of high density tarps, may ultimately reduce or replace MB. Technical data provided with the submission indicates that several alternatives (e.g. metham + Pic) provide effective disease control but further trials are required to validate disease tolerance. The CUN section for California stated that research trials on metham sodium incorporated with a tractor-mounted tillovator provides good results but most growers do not have this equipment. Iodomethane is in the registration process. Party states that substrates/plugin plants are currently being produced and sold in the southeast and to a very limited extent in California, but would require expensive retooling of the industry and additional pest control measures. Formulations of 67:33 MB:Pic are applied broadcast under HDPE in many cases, at 350 kg/ha in southeastern states and 263 kg/ha in California. Use of VIF is restricted in California, but low permeability barrier films (VIF or equivalent) could potentially be adopted in southeastern states with associated reduction of dosage.</p>	CUN identifies 1,3-D with chloropicrin as the next best alternative with a 10-percent yield loss in California and the Southeastern States. Operating costs with 1,3-D plus chloropicrin are marginally higher in the Southeast and marginally lower in California. In both regions the alternative is predicted to result in a 46-percent decrease in net revenues.

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USA	Tomato - field	2876.046	2222.934	627.552		2334.047		U	<p>MBTOC is unable to assess this nomination for 2007 at this time. The Party provided limited information on recent trials conducted in the US especially those using VIF films and new application methods for alternatives. MBTOC also requests the Party to review the use rates used with MB/Pic mixtures and verify that mixtures with less MB (especially 30:70 and 50:50) are unsuitable for control of the key pests in the nomination. Also it is requested that economic data be provided for the two most appropriate alternatives for all circumstances of the nomination. In Michigan, the key pests are Phytophthora capsici and Verticillium. The Party states that 1,3-D/chloropicrin may be an effective alternative but growers will miss the optimal market window. The Party is requested to clarify why this problem cannot be overcome by scheduling fumigations in autumn prior to the crop. In California, the key pests are nematodes and soilborne fungi. The CUN is restricted to cultivation on hillsides. According to 2003 data available from the California Department of Pesticide Regulation, metham sodium is used on nearly as many acres as methyl bromide for tomatoes in California. It thus appears to be a viable alternative for hillsides and in areas affected by township caps where drip-applied fumigants, e.g. 1,3-D mixtures, cannot be used. Shank applied 1,3-D mixtures also appear suitable for hillside applications, but have a higher impact on township calculations than drip-applied formulations. In the Southeast, including Florida, nematodes, soil borne fungi and nutsedge are the key pests. The Party states that a combination of 1,3-D + chloropicrin + herbicides (trifluralin, napropamide, halosulfuron, S-metolachlor) is the best alternative strategy but further testing is required. However, the Party estimates yield losses of 6.2% and</p>	CUN reports yield losses ranging from 17 to 22 percent. Net revenue declines reported for all regions. Missed market windows cited in Michigan and Southeastern States. California estimate of gross and net revenue losses do not account for distribution of yield loss across individual growers and yield risk with alternatives.

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
									<p>market window losses of 14% due to delays in plant back after treatment. This combination is not available to areas with karst topography (32% of the production). Owing to the lack of data from recent trials in the south east region provided with the nomination, MBTOC cannot fully evaluate the effectiveness of alternatives for moderate to heavy nutgrass infestations. Recent references available to MBTOC, demonstrate effective alternatives (metham sodium, with and without Pic) for moderate to heavy nutgrass control in similar regions to the nomination and for non-karst and karst areas (Johnson and Webster, 2001; Gilreath et al 2005b,c). As yields were similar to methyl bromide, further clarification is required on their suitability for commercial use. For all areas the dosage range is close to or below MBTOC guideline rates. Growers may be able to reduce dosages to about 100 kg/ha under strips by adoption of low permeability barrier films (VIF or equivalent) and by adopting formulations of MB/Pic with less MB (i.e. 50:50). MBTOC also needs clarification if alternatives can be applied every alternate year as a transitional strategy for MB phase-out.</p>	

Party	Industry	Total CUEs for 2005 as approved by 1EMOP and 16MOP.	Approved for 2006 by 16 MOP under Sect IIA Dec. XVI/2	Approved (interim) for 2006 by 16 MOP under Sect 111 Dec. XVI/2	Nominated in 2005 for 2006	Nominated in 2005 for 2007	Recommended by MBTOC for 2006	Recommended by MBTOC for 2007	MBTOC comments	Economic reasoning provided by the Party and considered by MBTOC.
USA	Turfgrass	206.827	131.6			78.04		78.04	MBTOC recommends a CUE of 78.040 tonnes in 2007 for this use, including 1.9 tonnes for associated research. The Party has reduced the amount requested to 59% from that recommended by MBTOC in 2006. All of this nomination is for production of certified propagative material. MBTOC recognises the importance of producing clean propagative material. Historically the industry has used a rate of 500 kg/ha, but has recently reduced the rate to 300 kg/ha of 98:2 MB. Trials with mixtures of MB with chloropicrin indicate inconclusive results in pest and pathogen control. MBTOC suggests that further rate reductions can be achieved with the use of low permeability barrier films (VIF or equivalent) and the use of 67:33 or 50:50 MB/Pic formulations. Further validation of their effectiveness is sought in future nominations. Although dazomet is used effectively in other countries for this use, it has not yet proven effective in trials in USA (Unruh et al. 2002). Trial use of this product with barrier films is suggested. New fumigant alternatives, sodium and potassium azide, iodomethane have shown excellent weed control (Unruh et al 2002). These chemicals at present lack registration.	CUN is for turf production intended to be sold as certified sod. CUN identifies dazomet as next best alternative to methyl bromide and states quality losses with dazomet would exclude much of production from certified market leading to substantial losses in gross and net revenue. CUN states price for non-certified sod is 75 percent lower than price for certified sod.

*Footnotes:*

*All quantities given in metric tonnes, unless otherwise stated.*

- (a) No specific CUE quantity approved for this use. Quantity approved included with other uses*
- (b) CUE includes exemptions for both Quebec and PEI growing regions*
- (c) Categorised as 'unable-to-assess in the TEAP Report of October 2004. To be reconsidered at the Second EMOP*

## 9.4

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## 10 TEAP/TOC Organisation Issues

TEAP has made progress in increasing the participation of experts from CEIT and Article 5(1) countries and is looking for qualified nominations for TEAP and all its TOCs. There is a particularly urgent need for agricultural pest control practitioners, QPS experts, and agricultural economists for the Methyl Bromide Technical Options Committee and for chemists, chemical engineers, laboratory and analytical experts, and experts in destruction for the new CTOC. There are many openings for qualified experts including openings for Co-Chairs of the CTOC and HTOC. Nominations of experts from Article 5(1) countries are particularly welcome.

In 2005, TEAP implemented the “Chemicals Technical Options Committee” (CTOC) to integrate topics including process agents and feedstocks, destruction, laboratory and analytical uses, non-medical aerosol products, solvents, and CTC. TEAP appointed Dr. Masaaki Yamabe (Japan) and Dr. Ian Rae (Australia) as temporary Co-Chairs and is seeking a CEIT or Article 5(1) Co-chair.

The Aerosols TOC was reorganised as the Medical TOC, with Mr. Jose Pons (Venezuela), Dr. Helen Tope (Australia), and Dr. Ashley Woodcock (United Kingdom) continuing as Co-Chairs.

TEAP appointed Dr. Daniel Verdonik (United States) and David Catchpole (United Kingdom) as temporary Co-Chairs of the Halons Technical Options Committee and are seeking a Co-chair from CEIT or Article 5(1) countries.

When Parties did not agree on new TEAP Co-Chairs at the 16th MOP, Dr. Jonathan Banks (Australia) withdrew his resignation and was appointed by TEAP as temporary Co-Chair of the MBTOC. Ms. Michelle Marcotte (Canada) and Dr. Ian Porter (Australia) were appointed as “TOC Convenors,” pending approval of new MBTOC Co-Chairs by Parties. Prof. Nahum Marban-Mendoza continues as an Article 5(1) Co-Chair and TEAP is seeking one or more additional CEIT or Article 5(1) Methyl Bromide TOC Co-chairs to help manage the completion of TOC work.

In 2005, TEAP will continue to recruit experts on the topics of greatest importance to Parties and will continue its reorganisation to focus on sectors where technologies are still rapidly evolving. The Methyl Bromide Technical Options Committee will be strengthened further for consideration of nominations for Critical Use Exemptions and QPS, with particular emphasis on assessing the development, demonstration, registration and deployment of technical options and the economics of implementation. The Foams and Refrigeration/AC Technical Options Committees will be strengthened in preparation for assessing the rapid introduction of alternatives to HCFCs for the Assessment Report in 2006.

As noted by MBTOC in its progress report (see section 7.1.5), the MBTOC was unable to complete the assessment of harmful trade in MB, requested in Decision Ex.I/4(9,a), because its current membership lacks expertise in trade issues, environmental crime, customs codes and procedures, and other technical topics necessary for such evaluation. The MBTOC suggested that TEAP work as a committee or Task Force to comprehensively respond in its 2006 report on this request from Parties. MBTOC suggested that TEAP can involve relevant experts from national and regional governments, UNEP DTIE, international trade and crime organisations, environmental crime NGOs, and agricultural organizations concerned with food quality fairness of trade. Experts involved in issues of harmful or illegal trade in other ODSs could be valuable in transferring lessons and focusing TEAP's work.

TEAP remains hopeful that national governments will continue to commit themselves to sponsor participation and expenses of TEAP members including TOC Co-Chairs. Sponsorship will be vital to completing the assignments given by Parties to be undertaken by TEAP and all its TOCs. Mindful of the large workload and often short deadlines, Parties may also wish to consider special financing to ensure that TEAP and its TOC are able to complete all assignments from Parties on time: such special funding was provided for MBTOC for the year 2005, in recognition of the extraordinary workload of MBTOC associated with the process of evaluating methyl bromide critical use nomination. While the budget for the TEAP and its TOCs under the Montreal Protocol Trust Fund currently covers the travel and other limited expenses of the TEAP/TOC co-chairs and members from Article 5 Parties, the members from non-Article 5 Parties must rely on other sources of funding. In some cases, such funding is becoming more difficult to obtain. TEAP would welcome the opportunity to further elaborate its financial needs and to work with representatives of Parties, as well as the Ozone Secretariat, during the Open-ended Working Group in Montreal on these matters.

## **11 TEAP and TOC Membership Information**

### **11.1 TEAP Member Biographies**

The following contains the background information for all TEAP members as at May 2005.

#### **Dr. Radhey S. Agarwal**

(Refrigeration TOC Co-chair)  
Professor of Mechanical Engineering  
Mechanical Engineering Department  
Indian Institute of Technology Delhi  
India- New Delhi - 110016  
Telephone: 91 11 2659 1120 (O), 2658 2160 (R)  
Fax: 91 11 2652 6645  
E-Mail: rsarwal@mech.iitd.ernet.in

Radhey S. Agarwal, Co-chair of the Refrigeration, Air-conditioning, and Heat Pumps Technical Options Committee, is the Professor of Mechanical Engineering at the Indian Institute of Technology (IIT Delhi), Delhi, India. IIT Delhi makes in-kind contribution for wages. Costs of travel, communication, and other expenses related to participation in the TEAP and its Refrigeration TOC are paid by UNEP's Ozone Secretariat.

#### **Dr. Stephen O. Andersen**

(Panel Co-chair)  
Director of Strategic Climate Projects  
Atmospheric Pollution Prevention Partnerships Division  
United States Environmental Protection Agency  
Ariel Rios Building  
Mail Code 6201J  
1200 Pennsylvania Avenue, NW  
Washington, DC 20460  
U.S.A.  
Telephone: 1 202 343 9069  
Fax: 1 202 343 2379  
E-Mail: andersen.stephen@epa.gov

Stephen O. Andersen, Co-chair of the Technology and Economic Assessment Panel, is Director of Strategic Climate Projects in the Climate Protection Partnerships Division of the U.S. Environmental Protection Agency, Washington, D.C., USA. The U.S. EPA makes in-kind contributions of wages, travel, communication, and other expenses. With approval of its government ethics officer, EPA allows expenses to be paid by other governments and organisations such as the United Nations Environment Programme (UNEP).

**Mr. Paul Ashford**

(Foams TOC Co-chair)

Principal Consultant

Caleb Management Services

The Old Dairy, Woodend Farm Cromhall, Wotton-under-Edge

Gloucestershire, GL12 8AA

United Kingdom

Telephone: 44 1454 269330

Fax: 44 1454 269197

Mobile: 44 7774 110 814

E-Mail: Paul@Calebgroup.net

Paul Ashford, Co-chair of the Rigid and Flexible Foams Technical Options Committee is the principal consultant of Caleb Management Services. He has over 20 years direct experience of foam related technical issues and is active in several studies informing future policy development for the foam sector. Much of his recent work on banks and emissions, performed to inform both IPCC and TEAP processes has been supported by the US EPA. His funding for TEAP activities, which includes professional fees, is provided under contract by the Department of Trade and Industry in the UK. Other related non-TEAP work is covered under separate contracts from relevant commissioning organisations including international agencies (e.g. UNEP DTIE), governments, industry associations and corporate clients. Most work with private clients relates to the lifecycle assessment of products based on ODS alternatives.

**Dr. Jonathan Banks**

(Methyl Bromide TOC Co-chair)

Grainsmith

10 Beltana Rd

Pialligo ACT 2609

Australia

Telephone: 61 2 6248 9228

Fax: 61 2 6248 9228

E-Mail: apples3@bigpond.com

Jonathan Banks, Co-chair of the Methyl Bromide Technical Options Committee, is a private consultant. He serves on some national committees concerned with ODS and their control; he receives contracts from UN and UNEP, other institutions and companies related to methyl bromide alternatives and grain storage technology, including fumigation technology and recapture systems for methyl bromide. In 2005 he received support from UNEP for TEAP and MBTOC activities. Previously funding has been is through grants or contracts from the Department of Environment and Heritage, Australia and from UNEP.

**Mr. David Catchpole**

(Halons TOC Co-chair)

Technical Consultant

Petrotechnical Resources Alaska

Anchorage

Alaska

Telephone: 1 44 907 868 3911

Fax: 1 44 907 868 3911

E-Mail: dcatchpole@gci.net

Mr. Catchpole works part time for Petrotechnical Resources Alaska (PRA), a company that provides consulting services to oil companies in Alaska. Mr. Catchpole advises BP Alaska on fire detection and halon issues as his main activity for PRA. Funding for participation by Mr. Catchpole on the HTOC is provided by the Halon Alternatives Research Corporation (HARC). HARC is a not-for-profit corporation established under the United States Co-operative Research and Development Act. Mr. Catchpole also receives funding support for halon related activities from BP Alaska.

**Dr. Lambert Kuijpers**

(Panel Co-chair, Refrigeration TOC Co-chair, Replenishment Task Force Co-chair)

Technical University Pav A58

P.O. Box 513

NL – 5600 MB Eindhoven

The Netherlands

Telephone: 31 49 247 6371 / 31 40 247 4463

Home: 31 77 354 6742

Fax: 31 40 246 6627

E-Mail: lambermp@wxs.nl, lambermp@planet.nl

Lambert Kuijpers, Co-chair of the Technology and Economic Assessment Panel and Co-chair of the Refrigeration, Air-conditioning and Heat Pumps Technical Options Committee, is based in Eindhoven, The Netherlands. He is supported (through the UNEP Ozone Secretariat) by the European Commission and The Netherlands government for all his activities related to the TEAP and the Refrigeration TOC (including the IPCC/TEAP Special Report and the IPCC AR4). UNEP also funds TEAP administrative costs on an annual budget basis. He works for the Department “Technology for Sustainable Development” at the Technical University Eindhoven and is a consultant to governmental and non-governmental organisations, such as the World Bank, UNEP DTIE. His work is funded by the French Ecoles des Mines, Paris, for activities related to estimating inventories and emissions of ODS and alternatives. Dr. Kuijpers is also an advisor to the Re/genT Company, Netherlands (R&D of components and equipment for refrigeration, air-conditioning and heating).

**Mr. Tamás Lotz**

(Senior Expert Member)

National Directorate of Environment, Nature and Water

Aga utca 4

1113 Budapest

Hungary

Telephone: 36 1 457 3563

Fax: 36 1 201 3056

E-Mail: lotz@mail.kvvm.hu

Tamas Lotz, Senior Expert Member, is a consultant on air pollution control to the Ministry of Environment and Water and to the National Directorate of Environment, Nature and Water in Budapest, Hungary. He was one of the authors of the Hungarian Country Programme for the phase-out of ODSs. Travel, per diem and other costs are covered by the Ministry of Environment and Water of Hungary.

**Ms. Michelle Marcotte**

(Methyl Bromide Convenor)

Marcotte Consulting in Maryland, USA

and Marcotte Consulting in Ontario, Canada

10104 East Franklin Ave

Glenn Dale Maryland USA 20769

Telephone:301-262-9866

FAX: call the above number first

E-Mail: marcotteconsulting@comcast.net

Michelle Marcotte is a consultant to government and agri-food companies in agri-environmental issues, food technology, regulatory affairs, and radiation processing. She is a member of Canadian and Canada –US government-industry methyl bromide working groups. Funding for her work on MBTOC is supplied by Government of Canada and by her own company funds. In 2005, the UNEP Ozone Secretariat has provided some travel funds for meetings.

**Prof. Nahum Marban-Mendoza**  
(Methyl Bromide TOC Co-chair)  
Coordinator, Crop Protection Graduate Programme  
Professor  
Dept de Parasitologia Agricola  
Universidad Autonoma Chapingo  
Chapingo, CP 56230, Edo de Mexico  
Mexico  
Telephone: 52 595 954 1646  
Fax: 52 595 954 1608  
Home: 52 55 56 56 2067  
E-Mail: nahumm@correo.chapingo.mx

Nahum Marban-Mendoza, Co-chair of the Methyl Bromide Technical Options Committee, is a full-time professor of Integrated Pest Management and Plant Nematology at the Universidad Autonoma Chapingo in the graduate programme of crop protection. He has over 25 years experience in the research and development of non-chemical alternatives to control plant parasitic nematodes associated with different crops in Central America and Mexico. Prof. Marban-Mendoza has been funded by both private and government funds; occasionally he receives funds for wages and travel. The communication costs related to MBTOC activities and the costs of travel and other expenses related to participation in TEAP and TOC meetings are paid by the UNEP Ozone Secretariat.

**Mr. E. Thomas Morehouse**  
(Senior Expert Member)  
Institute for Defense Analyses  
4850, Mark Center Drive  
Alexandria, VA 22311  
U.S.A.  
Telephone: 1 703 750 6840  
Fax: 1 703 750 6835  
E-Mail: tom.morehouse@verizon.net

Thomas Morehouse, Senior Expert Member for Military Issues, is a Researcher Adjunct at the Institute for Defense Analysis (IDA), Washington D.C., USA. IDA makes in-kind contributions of communications and miscellaneous expenses. Funding for wages and travel is provided by grants from the Department of Defense and the Environmental Protection Agency. IDA is a not-for-profit corporation that undertakes work exclusively for the US Department of Defense. He also occasionally consults to associations and corporate clients.

**Mr. Jose Pons Pons**

(Panel Co-chair, Medical TOC Co-chair)

Spray Quimica C.A.

Urb.Ind.Soco

Calle Sur #14

La Victoria 2121, Edo Aragua

Venezuela

Telephone: 58 244 3223297 or 3214079 or 3223891

Fax: 58 244 3220192

E-Mail: joseipons@eldish.net

Jose Pons Pons, Panel Co-chair and Co-chair Medical Products Technical Options Committee, is President of Spray Quimica. Spray Quimica is an aerosol filler who produces its own brand products and does contract filling for third parties. Spray Quimica, purchases HFCs for some of its products. Costs of Mr. Pons' travel expenses are paid by the Ozone Secretariat and Spray Quimica makes in-kind contributions of wage, and miscellaneous and communication expenses.

**Dr. Ian J. Porter**

(MBTOC Soils Convenor)

Statewide Leader, Plant Pathology

Primary Industries Research Victoria

Department of Primary Industries

Private Bag 15, Ferntree Gully Delivery Centre 3156,

Victoria, Australia.

Telephone: 61 3 9210 9222

Fax: 61 3 9800 3521

Mobile: 61 (0)417 544 080

Email: ian.j.porter@dpi.vic.gov.au

Ian Porter, Soils Convenor of MBTOC, is the Statewide Leader of Plant Pathology with the Victorian Department of Primary Industries (DPI). He is a member of a number of National Committees regulating ODS, has led the Australian research program on methyl bromide alternatives for soils and has 25 years experience in researching sustainable methods for soil disinfestation of plant pathogens. He has been a member of MBTOC since 1997 and acted as the lead consultant for UNEP in developing programmes to assist China and CEIT countries to replace methyl bromide. The Victorian DPI makes in-kind contributions to attend MBTOC and UNEP meetings. The Department of Environment and Heritage and Australian Federal Government Research Funds have provided funds to support travel and expenses for MBTOC activities.



**Prof. Miguel W. Quintero**

(Foams TOC Co-chair)

Professor of Chemical Engineering

Universidad de Los Andes

Carrera 1a, no 18A-70

Bogota

Colombia

Telephone: 57 1 339 4949, Ext. 3888

Fax: 57 1 332 4334

E-Mail: [miquinte@uniandes.edu.co](mailto:miquinte@uniandes.edu.co)

Prof. Miguel W. Quintero, Co-chair of the Foams Technical Options Committee, is professor at the Chemical Engineering Department at Universidad de los Andes in Bogota, Colombia, in the areas of polymer processing and transport phenomena. Mr. Quintero worked 21 years for Dow Chemical at the R&D and TS&D departments in the area of rigid polyurethane foam. His time in dealing with TEAP and TOC issues is covered by Universidad de los Andes and costs of travel and other expenses related to participation in TEAP and TOC meetings are paid by the Ozone Secretariat.

**Dr. Ian Rae**

(Chemicals TOC Co-Chair)

16 Bates Drive

Williamstown, Vic 3016

AUSTRALIA

Telephone: 61 3 9397 3794

Fax: 61 3 9397 3794

E-mail: [idrae@unimelb.edu.au](mailto:idrae@unimelb.edu.au)

Dr. Rae is Honorary Professorial Fellow at the University of Melbourne, Australia, and a member of advisory bodies for several Australian government agencies. On occasions, he also acts as consultant to government agencies and to universities and companies. The Australian Government Department of the Environment and Heritage finances the cost of travel and accommodation for Dr. Rae's attendance at meetings of CTOC, TEAP, OEWG and MOP.

**Mr. K. Madhava Sarma**

(Senior Expert Member)

AB50, Anna Nagar,

Chennai 600 040

India

Telephone: 91 44 2626 8924

Fax: 91 44 5217 0932

E-mail: sarmam@vsnl.net

K. Madhava Sarma retired in 2000, after nine years as Executive Secretary, Ozone Secretariat, UNEP. Earlier, he was a senior official in the Ministry of Environment and Forests (MOEF), Government of India and held various senior positions in a state government in India. He works occasionally as a consultant to UNEP and is an unpaid member of the Technical and Finance Committee, MOEF, Government of India. The Ozone Secretariat pays the costs in connection with his travels for the TEAP.

**Dr. Helen Tope**

(Medical TOC Co-chair)

Atmosphere and Noise Unit

EPA Victoria

GPO Box 4395QQ

Melbourne, Victoria 3001

Australia

Telephone: 61 3 9695 2637

Fax: 61 3 9695 2578

E-Mail: helen.tope@epa.vic.gov.au

Helen Tope, Co-chair Medical Technical Options Committee, is a senior policy officer, EPA Victoria, Australia. EPA Victoria makes in-kind contributions of wage and miscellaneous expenses. The Ozone Secretariat provides a grant for travel, communication, and other expenses of the Medical Technical Options Committee out of funds granted to the Secretariat unconditionally by the International Pharmaceutical Aerosol Consortium (IPAC). IPAC is a non-profit corporation.

**Dr. Daniel P. Verdonik**

(Halons TOC Co-chair)

Hughes Associates

3610 Commerce Drive, STE 817

Baltimore, MD 21227-1652

U. S. A.

Telephone: 1 443 253 7587

Fax: 1 410 737 8688

E-Mail: danv@haifire.com

Dr. Verdonik is the Director, Environmental Programs, Hughes Associates, Baltimore, MD, USA. He is a consultant in fire protection and environmental management to the US Department of Defense, the US Army, the US EPA and corporate clients. Funding for participation by Dr. Verdonik on the HTOC is provided by the Halon Alternatives Research Corporation (HARC). HARC is a not-for-profit corporation established under the United States Co-operative Research and Development Act.

**Prof. Ashley Woodcock**

(Medical TOC Co-chair)

North West Lung Centre

South Manchester University Hospital Trust

Manchester M23 9LT

United Kingdom

Telephone: 44 161 291 2398

Fax: 44 161 291 5020

E-Mail: Ashley.A.Woodcock@manchester.ac.uk

Ashley Woodcock, Co-chair Medical Technical Options Committee, is a Consultant Respiratory Physician at the NorthWest Lung Centre, Wythenshawe Hospital, Manchester, UK. Prof. Woodcock is a full-time practising physician and Professor of Respiratory Medicine at the University of Manchester. The NorthWest Lung Centre carries out drug trials (including those on CFC-free MDIs and DPIs) for pharmaceutical companies, for some of which Prof. Woodcock is the principal investigator. Prof. Woodcock has received support for his travel to educational meetings and occasionally consults for pharmaceutical companies on the development of study designs to evaluate new drugs. He does not receive any consultancy fees for work associated with the Montreal Protocol and does not own shares in any relevant drug companies. Wythenshawe Hospital makes in-kind contributions of wages and communication. The UK Department of Environment, Food and Rural Affairs sponsors travel expenses in relation to Prof. Woodcock's Montreal Protocol activities.

**Dr. Masaaki Yamabe**

(Senior Expert Member and Chemicals TOC Co-Chair)

National Institute of Advanced Industrial Science and Technology (AIST)

1-1-1 Umezono, Tsukuba

Ibaraki 305-8568

Japan

Telephone: 81 29 862 6032

Fax: 81 29 862 6048

E-Mail: m-yamabe@aist.go.jp

Masaaki Yamabe is research coordinator (Environment and Energy) at the AIST. He was a member of the Solvents TOC during 1990-1996. AIST pays wages, travelling and other expenses.

**Prof. Shiqiu Zhang**

(Senior Expert Member)

Centre for Environmental Sciences

Peking University

Beijing 100871

The People's Republic of China

Telephone: 86 10-627-64974

Fax: 86 10-627-51927

Email: zhangshq@ces.pku.edu.cn

Ms. Shiqiu Zhang, Senior Expert Member for economic issues of the TEAP, is a Professor at the Centre for Environmental Sciences of Peking University. UNEP's Ozone Secretariat pays travel costs and daily subsistence allowances, communication and other expenses.

## 12 TEAP-TOC Membership Lists

### 2005 Technology and Economic Assessment Panel (TEAP)

\* = members of TEAP serving on the IPCC/TEAP Special Report

<b>Co-chairs</b>	<b>Affiliation</b>	<b>Country</b>
Stephen O. Andersen*	Environmental Protection Agency	USA
Lambert Kuijpers*	Technical University Eindhoven	Netherlands
Jose Pons Pons*	Spray Quimica	Venezuela
<b>Senior Expert Members</b>		
Tamás Lotz	Consultant to the Ministry for Environment and Water	Hungary
Thomas Morehouse*	Institute for Defense Analyses	USA
K. Madhava Sarma	Consultant	India
Masaaki Yamabe*	National Institute of Advanced Industrial Science and Technology	Japan
Shiqiu Zhang	Peking University	China
<b>TOC Chairs</b>		
Radhey S. Agarwal*	Indian Institute of Technology Delhi	India
Paul Ashford*	Caleb Management Services	UK
Jonathan Banks	Consultant	Australia
David Catchpole*	Petrotechnical Resources Alaska	UK
Nahum Marban Mendoza	Universidad Autonoma Chapingo	Mexico
Miguel Quintero	Universidad de los Andes	Colombia
Ian Rae	University of Melbourne	Australia
Helen Tope*	EPA, Victoria	Australia
Ashley Woodcock*	Wythenshawe Hospital	UK
Daniel Verdonik*	Hughes Associates	USA
<b>MBTOC Convenors</b>		
Michelle Marcotte	Marcotte Consulting LLC and Marcotte Consulting Inc	Canada
Ian Porter	Institute for Horticultural Development	Australia

### TEAP Chemicals Technical Options Committee (CTOC)

<b>Co-chairs</b>	<b>Affiliation</b>	<b>Country</b>
Ian Rae	University of Melbourne	Australia
Masaaki Yamabe*	National Institute of Advanced Industrial Science and Technology	Japan
<b>Members</b>		
D. D. Arora	Tata Energy Research Institute	India
Steven Bernhardt*	Honeywell	USA
Olga Blinova*	Russian Scientific Center "Applied Chemistry"	Russia
Nick Campbell	Arkema Group	France
Bruno Costes	Airbus	France
Jianxin Hu*	Center of Environmental Sciences, Beijing University	China
A.A. Khan	Indian Institute of Chemical Technology	India
Abid Merchant*	DuPont	US
Koichi Mizuno*	National Institute of Advanced Industrial Science and Technology	Japan
Hans Porre	Teijin Twaron	Netherlands
Patrice Rollet*	Avantec, Dehon Group	France
Shuniti Samejima	Asahi Glass Foundation	Japan
John Stemniski	Consultant	US
Peter Verge	Boeing Manufacturing	US

## TEAP Flexible and Rigid Foams Technical Options Committee (FTOC)

<b>Co-chairs</b>	<b>Affiliation</b>	<b>Country</b>
Paul Ashford*	Caleb Management Services	UK
Miguel Quintero	Universidad de los Andes	Colombia
<b>Members</b>	<b>Affiliation</b>	<b>Country</b>
Volker Brünighaus	Hennecke	Germany
Antonio Cristodero	Consultant	Argentina
Kyoshi Hara	JUFA	Japan
Mike Jeffs*	ISOPA	Belgium
Shigeru Wakana	Dow	Japan
Suzie Kocchi*	Environmental Protection Agency	US
Pranot Kotchabhakdi	Sunprene (Thailand)	Thailand
Candido Lomba	ABRIPUR	Brazil
Yehia Lotfi	Technocom	Egypt
Christoph Meurer	Solvay	Germany
Yoshiyuki Ohnuma	Achilles	Japan
Lorraine Ross	Intech Consulting	US
Robert Russell	Consultant	US
Patrick Rynd	Owens Corning	US
Mudumbai Sarangapani	Polyurethane Council of India	India
Ulrich Schmidt	Haltermann/Dow	Germany
Bert Veenendaal*	RAPPA	US
Mark Weick	Dow	US
Dave Williams	Honeywell	US
Jinghuan Wu*	Arkema Group	US
Lothar Zipfel	Solvay	Germany

## TEAP Halons Technical Options Committee (HTOC)

<b>Co-chairs</b>	<b>Affiliation</b>	<b>Country</b>
David V. Catchpole*	Petrotechnical Resources Alaska	UK
Daniel P. Verdonik*	Hughes Associates	US
<b>Members</b>	<b>Affiliation</b>	<b>Country</b>
Fareed Bushehri	UNEP	Bahrain
Michelle Collins	Consultant	US
Matsuo Ishiyama	Halon Recycling & Support Committee	Japan
H.S. Kaprwan*	Defence Institute of Fire Research	India
Nikolai P. Kopylov	All Russian Research Institute for Fire Protection	Russia
Barbara Kucnerowicz-Polak	State Fire Services Headquarters	Poland
Dirk Legatis	GTZ Proklima	Germany
David Liddy	Dept. Environment, Food and Rural Affairs	UK
Guillermo Lozano	G.L. & Asociados	Venezuela
Bella Maranion	US EPA	US
John O'Sullivan, MBE	British Airways	UK
Erik Pedersen	World Bank	Denmark
Donald Thomson	MOPIA	Canada
Robert Wickham*	Wickham Associates	US
Hailin Zhu	Retired	China
<b>Consulting Experts</b>	<b>Affiliation</b>	<b>Country</b>
Tom Cortina*	HARC	US
Steve McCormick	United States Army	US
Vasily Pivovarov	All Russian Research Institute for Fire Protection	Russia
Joseph Senecal	Kidde-Fenwal	US
Ronald S. Sheinson	Naval Research Laboratory - Department of the Navy	US
Ronald Sibley	Defense Supply Center, Richmond	US
Malcolm Stamp*	Great Lakes Chemicals (Europe) Limited	UK

## TEAP Medical Technical Options Committee (MTOC)

<b>Co-chairs</b>	<b>Affiliation</b>	<b>Country</b>
Jose Pons Pons*	Spray Quimica	Venezuela
Helen Tope*	EPA Victoria	Australia
Ashley Woodcock*	University Hospital of South Manchester	UK
<b>Members</b>	<b>Affiliation</b>	<b>Country</b>
Emmanuel Addo-Yobo	Kwame Nkrumah University of Science and Technology	Ghana
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Vassily Tselikov	ICP "Ozone"	Russia
Paulo Vodianitskaia*	Multibras Electrodomesticos	Brazil



**13 Summary for Policymakers IPCC/TEAP Report**

**IPCC/TEAP SPECIAL REPORT**

**SAFEGUARDING THE OZONE LAYER AND THE  
GLOBAL CLIMATE SYSTEM;**

**Issues Related to Hydrofluorocarbons and Perfluorocarbons**

(This is a copy of the “SUMMARY FOR POLICYMAKERS” as published by the IPCC on the ipcc.ch website; numbers in square brackets refer to the relevant sections in the Technical Summary, not reproduced here;

hard copies of the entire report, including the Summary for Policymakers and the Technical Summary will be available in the second half of 2005)

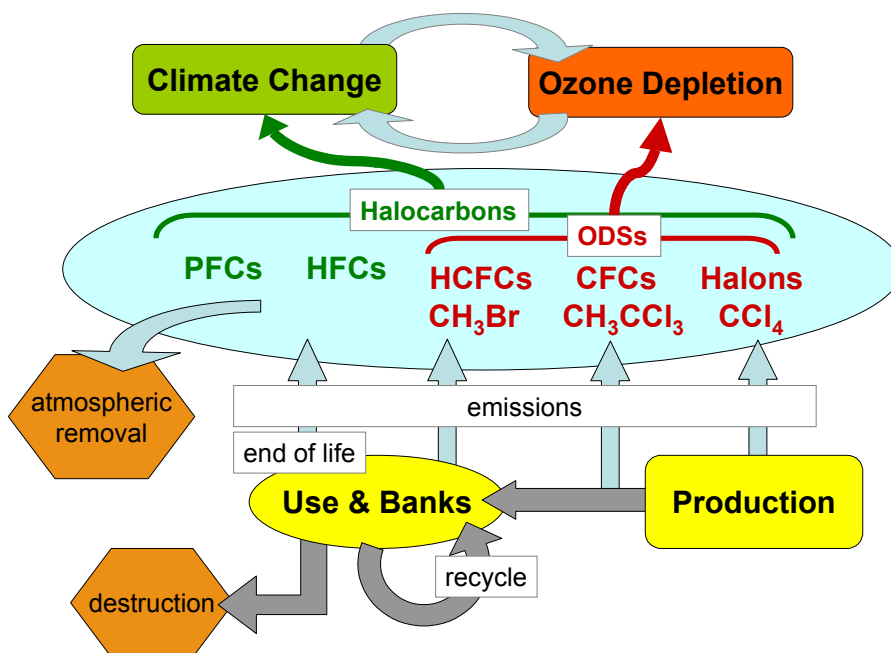
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## 1. Introduction

This IPCC Special Report was developed in response to invitations by the *United Nations Framework Convention on Climate Change (UNFCCC)*<sup>1</sup> and the *Montreal Protocol on Substances that Deplete the Ozone Layer*<sup>2</sup> to prepare a balanced scientific, technical and policy relevant report regarding alternatives to ozone-depleting substances (ODSs) that affect the global climate system. It has been prepared by the IPCC and the Technology and Economic Assessment Panel (TEAP) of the Montreal Protocol.

Because ODSs cause depletion of the stratospheric ozone layer<sup>3</sup>, their production and consumption are controlled under the Montreal Protocol and consequently are being phased out, with efforts made by both developed and developing country parties to the Montreal Protocol. Both the ODSs and a number of their substitutes are greenhouse gases, which contribute to climate change (see Figure SPM-1). Some ODS substitutes, in particular hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), are covered under the UNFCCC and its Kyoto Protocol. Options chosen to protect the ozone layer could influence climate change. Climate change may also indirectly influence the ozone layer.



**Figure SPM-1.** Schematic diagram of major issues addressed by this report. Chlorofluorocarbons (CFCs), halons, and hydrochlorofluorocarbons (HCFCs) contribute to ozone depletion and climate change, while hydrofluorocarbons (HFCs) and perfluorocarbons

<sup>1</sup> Decision 12/CP.8, FCCC/CP/2002/7/Add.1, page 30

<sup>2</sup> Decision XIV/10 UNEP/OzL.Pro.14/9, page 42

<sup>3</sup> Ozone within this report refers to stratospheric ozone unless otherwise noted.

(PFCs) contribute only to climate change and are among possible non-ozone depleting alternatives for ODSs. Red denotes gases included under the Montreal Protocol and its amendments and adjustments<sup>4</sup> while green denotes those included under the UNFCCC and its Kyoto Protocol. Options considered in this report for reducing halocarbon emissions include: improved containment, recovery, recycling, destruction of byproducts and existing banks<sup>5</sup>, and use of alternative processes, or substances with reduced or negligible global warming potentials.

This report considers the effects of total emissions of ODSs and their substitutes on the climate system and the ozone layer. In particular, this provides a context for understanding how replacement options could affect global warming. The report does not attempt to cover comprehensively the effect of replacement options on the ozone layer.

The report considers, by sector, options for reducing halocarbon emissions, options involving alternative substances, and technologies, to address greenhouse gas emissions reduction. It considers HFC and PFC emissions insofar as these relate to replacement of ODSs. HFC and PFC emissions from aluminium or semiconductor production or other sectors are not covered.

The major application sectors using ODSs and their HFC/PFC substitutes include refrigeration, air conditioning, foams, aerosols, fire protection, and solvents. Emissions of these substances originate from manufacture and any unintended by-product releases, intentionally emissive applications, evaporation and leakage from banks contained in equipment and products during use, testing and maintenance, and end of life practices.

With regard to specific emission reduction options, the report generally limits its coverage to the period up to 2015, for which reliable literature is available on replacement options with significant market potential for these rapidly evolving sectors. Technical performance, potential assessment methodologies, and indirect emissions<sup>6</sup> related to energy use are considered, as well as costs, human health and safety, implications for air quality, and future availability issues.

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<sup>4</sup> Hereafter referred to as the Montreal Protocol.

<sup>5</sup> Banks are the total amount of substances contained in existing equipment, chemical stockpiles, foams and other products not yet released to the atmosphere.

<sup>6</sup> It should be noted that the National Inventory Reporting community uses the term “indirect emissions” to refer specifically to those greenhouse gas emissions which arise from the breakdown of another substance in the environment. This is in contrast to the use of the term in this report, which specifically refers to energy-related CO<sub>2</sub> emissions associated with Life Cycle Assessment (LCA) approaches such as Total Equivalent Warming Impact (TEWI) or Life Cycle Climate Performance (LCCP).

## 2. Halocarbons, ozone depletion and climate change

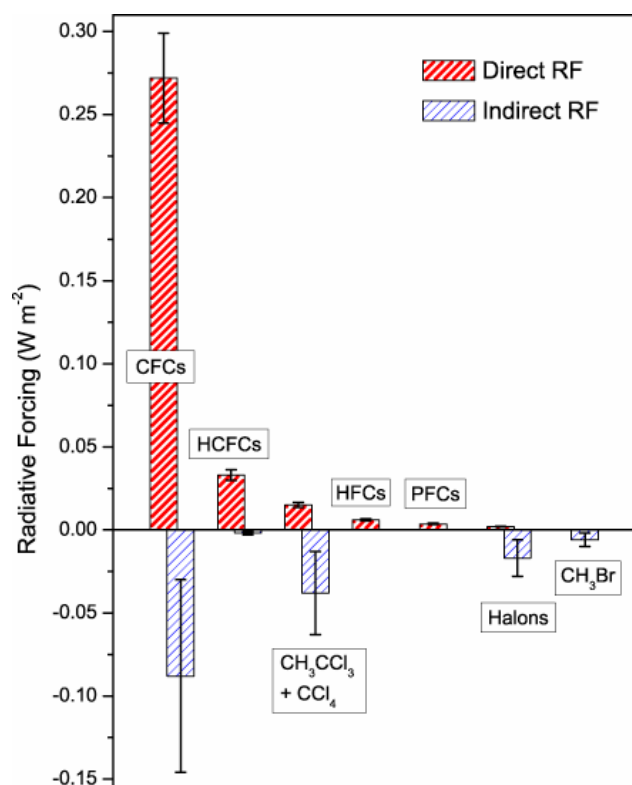
### 2.1 *What are the past and present effects of ODSs and their substitutes on the Earth's climate and the ozone layer?*

**Halocarbons, and in particular ODSs, have contributed to positive direct radiative forcing<sup>7</sup> and associated increases in global average surface temperature (see Figure SPM-2). The total positive direct radiative forcing due to increases in industrially produced ODS and non-ODS halocarbons from 1750 to 2000 is estimated to be  $0.34 \pm 0.03 \text{ W m}^{-2}$ , representing about 14% of the total due to increases in all well-mixed greenhouse gases over that period. Most halocarbon increases have occurred in recent decades. Atmospheric concentrations of CFCs were stable or decreasing in the period 2001–2003 (0 to –3% per year, depending on the specific gas) while the halons and the substitute HCFCs and HFCs increased (+1 to +3% per year, +3 to +7% per year, and +13 to +17% per year, respectively). [1.1, 1.2, 1.5, 2.3]<sup>8</sup>**

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<sup>7</sup> Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system, and is an index of the importance of the factor as a potential climate change mechanism. It is expressed in watts per square meter ( $\text{W m}^{-2}$ ). A greenhouse gas causes direct radiative forcing through absorption and emission of radiation and may cause indirect radiative forcing through chemical interactions that influence other greenhouse gases or particles.

<sup>8</sup> Numbers in square brackets indicate the sections in the main report where the underlying material and references for the paragraph can be found.



**Figure SPM-2.** Direct and indirect radiative forcing (RF) due to changes in halocarbons from 1750 to 2000.<sup>9</sup> Error bars denote  $\pm 2$  standard deviation uncertainties. [Based on Table 1.1]

**Stratospheric ozone depletion observed since 1970 is caused primarily by increases in concentrations of reactive chlorine and bromine compounds that are produced by degradation of anthropogenic ODSs, including halons, CFCs, HCFCs, methyl chloroform ( $CH_3CCl_3$ ), carbon tetrachloride ( $CCl_4$ ), and methyl bromide ( $CH_3Br$ ).** [1.3 and 1.4]

**Ozone depletion produces a negative radiative forcing of climate, which is an indirect cooling effect of the ODSs (see Figure SPM-2).** Changes in ozone are believed to currently contribute a globally averaged radiative forcing of about  $-0.15 \pm 0.10 W m^{-2}$ . The large uncertainty in the indirect radiative forcing of ODSs arises mainly because of uncertainties in the detailed vertical distribution of ozone depletion. This negative radiative forcing is *very likely*<sup>10</sup> to be smaller than the positive direct radiative forcing due to ODSs alone ( $0.33 \pm 0.03 W m^{-2}$ ). [1.1, 1.2, and 1.5]

<sup>9</sup> PFCs used as substitutes for ODSs make only a small contribution to the total PFC radiative forcing.

<sup>10</sup> In this Summary for Policymakers, the following words have been used where appropriate to indicate judgmental estimates of confidence: *very likely* (90–99% chance); *likely* (66–90% chance); *unlikely* (10–33% chance); and *very unlikely* (1–10% chance).



**Warming due to ODSs and cooling associated with ozone depletion are two distinct climate forcing mechanisms that do not simply offset one another.** The spatial and seasonal distributions of the cooling effect of ozone depletion differ from those of the warming effect. A limited number of global climate modelling and statistical studies suggest that ozone depletion is one mechanism that may affect patterns of climate variability which are important for tropospheric circulation and temperatures in both hemispheres. However, observed changes in these patterns of variability cannot be unambiguously attributed to ozone depletion. [1.3, 1.5]

**Each type of gas has had different greenhouse warming and ozone depletion effects (see Figure SPM-2) depending mainly on its historic emissions, effectiveness as a greenhouse gas, lifetime, and the amount of chlorine and/or bromine in each molecule.** Bromine-containing gases currently contribute much more to cooling than to warming, while CFCs and HCFCs contribute more to warming than to cooling. HFCs and PFCs contribute only to warming. [1.5 and 2.5]

**2.2** *How does the phase-out of ozone-depleting substances affect efforts to address climate change and ozone depletion?*

**Actions taken under the Montreal Protocol have led to the replacement of CFCs with HCFCs, HFCs, and other substances and processes. Because replacement species generally have lower Global Warming Potentials<sup>11</sup> (GWPs), and because total halocarbon emissions have decreased, their combined CO<sub>2</sub>-equivalent (direct GWP-weighted) emission has been reduced.** The combined CO<sub>2</sub>-equivalent emissions of CFCs, HCFCs, and HFCs derived from atmospheric observations decreased from about 7.5 ± 0.4 GtCO<sub>2</sub>-eq per year around 1990 to 2.5 ± 0.2 GtCO<sub>2</sub>-eq per year around 2000, equivalent to about 33% and 10%, respectively, of the annual CO<sub>2</sub> emissions due to global fossil fuel burning. Stratospheric chlorine levels have approximately stabilised and may have already started to decline. [1.2, 2.3 and 2.5]

**Ammonia and those hydrocarbons (HCs) used as halocarbon substitutes have atmospheric lifetimes ranging from days to months, and the direct and indirect radiative forcings associated with their use as substitutes are very likely to have a negligible effect on global climate.** Changes in energy-related emissions associated with their use may also need to be considered. (See Section 4 for treatment of comprehensive assessment of ODS replacement options.) [2.5]

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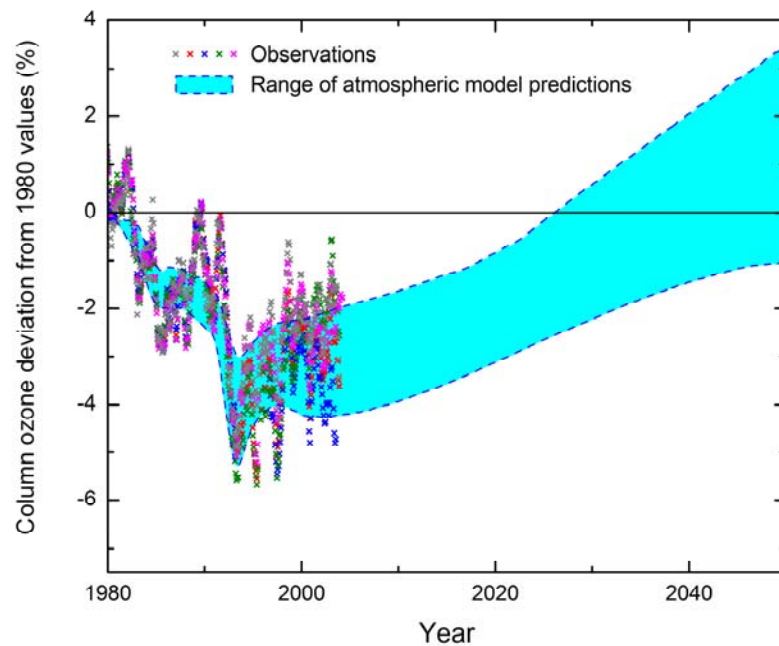
<sup>11</sup> GWPs are indices comparing the climate impact of a pulse emission of a greenhouse gas relative to that of emitting the same amount of CO<sub>2</sub>, integrated over a fixed time horizon.

**Based on the business-as-usual scenario developed in this report, the estimated direct radiative forcing of HFCs in 2015 is about  $0.030 \text{ W m}^{-2}$ ; based on scenarios from the IPCC Special Report on Emission Scenarios (SRES), the radiative forcing of PFCs<sup>9</sup> in 2015 is about  $0.006 \text{ W m}^{-2}$ .**

Those HFC and PFC radiative forcings correspond to about 1.0% and 0.2%, respectively, of the estimated radiative forcing of all well-mixed GHGs in 2015, with the contribution of ODSs being about 10%. While this report particularly focussed on scenarios for the period up to 2015, for the period beyond 2015 the IPCC SRES scenarios were considered but were not re-assessed. These SRES scenarios project significant growth in radiative forcing from HFCs over the following decades, but the estimates are likely to be very uncertain due to growing uncertainties in technological practices and policies. [1.5, 2.5, 11.5]

**Observations and model calculations suggest that the global average amount of ozone depletion has now approximately stabilised (for example, see Figure SPM-3).** While considerable variability in ozone is expected from year to year, including in polar regions where depletion is largest, the ozone layer is expected to begin to recover in coming decades due to declining ODS concentrations, assuming full compliance with the Montreal Protocol. [1.2 and 1.4]

**Over the long term, projected increases in other greenhouse gases could increasingly influence the ozone layer by cooling the stratosphere and changing stratospheric circulation.** As a result of the cooling effect and reducing ODS concentrations, ozone is *likely* to increase over much of the stratosphere, but could decrease in some regions, including the Arctic. However, the effects of changes in atmospheric circulation associated with climate change could be larger than these factors, and the net impact on total ozone due to increases in atmospheric concentrations of GHGs is currently uncertain in both magnitude and sign. Based upon current models an Arctic “ozone hole” similar to that presently observed over the Antarctic is *very unlikely* to occur. [1.4]



**Figure SPM-3.** Observed and modelled low- and mid-latitude (60°S–60°N) column ozone amounts as percent deviations from the 1980 values. [Box 1.7]

**The relative future warming and cooling effects of emissions of CFCs, HCFCs, HFCs, PFCs, and halons vary with gas lifetimes, chemical properties, and time of emission (see Table SPM-1).** The atmospheric lifetimes range from about a year to two decades for most HFCs and HCFCs, decades to centuries for some HFCs and most halons and CFCs, and 1,000 to 50,000 years for PFCs. Direct GWPs for halocarbons range from 5 to over 10,000. ODS indirect cooling is projected to cease upon ozone layer recovery, so that GWPs associated with the indirect cooling effect depend on the year of emission, compliance with the Montreal Protocol, and gas lifetimes. These indirect GWPs are subject to much greater uncertainties than direct GWPs. [1.5, 2.2, and 2.5]

**Table SPM-1.** GWPs of halocarbons commonly reported under the Montreal Protocol and the UNFCCC and its Kyoto Protocol and assessed in this report relative to CO<sub>2</sub>, for a 100-year time horizon, together with their lifetimes and GWPs used for reporting under the UNFCCC. Gases shown in blue (darker shading) are covered under the Montreal Protocol and gases shown in yellow (lighter shading) are covered under the UNFCCC. [Tables 2.6 and 2.7]

Gas	GWP for direct radiative forcing <sup>a</sup>	GWP for indirect radiative forcing (Emission in 2005 <sup>b</sup> )	Lifetime (years)	UNFCCC Reporting GWP <sup>c</sup>
<i>CFCs</i>				
CFC-12	10,720 ± 3750	-1920 ± 1630	100	na <sup>d</sup>
CFC-114	9880 ± 3460	Not available	300	na <sup>d</sup>
CFC-115	7250 ± 2540	Not available	1700	na <sup>d</sup>
CFC-113	6030 ± 2110	-2250 ± 1890	85	na <sup>d</sup>
CFC-11	4680 ± 1640	-3420 ± 2710	45	na <sup>d</sup>
<i>HCFCs</i>				
HCFC-142b	2270 ± 800	-337 ± 237	17.9	na <sup>d</sup>
HCFC-22	1780 ± 620	-269 ± 183	12	na <sup>d</sup>
HCFC-141b	713 ± 250	-631 ± 424	9.3	na <sup>d</sup>
HCFC-124	599 ± 210	-114 ± 76	5.8	na <sup>d</sup>
HCFC-225cb	586 ± 205	-148 ± 98	5.8	na <sup>d</sup>
HCFC-225ca	120 ± 42	-91 ± 60	1.9	na <sup>d</sup>
HCFC-123	76 ± 27	-82 ± 55	1.3	na <sup>d</sup>
<i>HFCs</i>				
HFC-23	14,310 ± 5000	~0	270	11,700
HFC-143a	4400 ± 1540	~0	52	3800
HFC-125	3450 ± 1210	~0	29	2800
HFC-227ea	3140 ± 1100	~0	34.2	2900
HFC-43-10mee	1610 ± 560	~0	15.9	1300
HFC-134a	1410 ± 490	~0	14	1300
HFC-245fa	1020 ± 360	~0	7.6	- <sup>e</sup>
HFC-365mfc	782 ± 270	~0	8.6	- <sup>e</sup>
HFC-32	670 ± 240	~0	4.9	650
HFC-152a	122 ± 43	~0	1.4	140
<i>PFCs</i>				
C <sub>2</sub> F <sub>6</sub>	12,010 ± 4200	~0	10,000	9200
C <sub>6</sub> F <sub>14</sub>	9140 ± 3200	~0	3200	7400
CF <sub>4</sub>	5820 ± 2040	~0	50,000	6500
<i>Halons</i>				
Halon-1301	7030 ± 2460	-32,900 ± 27,100	65	na <sup>d</sup>
Halon-1211	1860 ± 650	-28,200 ± 19,600	16	na <sup>d</sup>
Halon-2402	1620 ± 570	-43,100 ± 30,800	20	na <sup>d</sup>
<i>Other Halocarbons</i>				
Carbon tetrachloride (CCl <sub>4</sub> )	1380 ± 480	-3330 ± 2460	26	na <sup>d</sup>
Methyl chloroform (CH <sub>3</sub> CCl <sub>3</sub> )	144 ± 50	-610 ± 407	5.0	na <sup>d</sup>
Methyl bromide (CH <sub>3</sub> Br)	5 ± 2	-1610 ± 1070	0.7	na <sup>d</sup>

Notes

(a) Uncertainties in GWPs for direct positive radiative forcing are taken to be ±35% (2 standard deviations) (IPCC, 2001).

(b) Uncertainties in GWPs for indirect negative radiative forcing consider estimated uncertainty in the time of recovery of the ozone layer as well as uncertainty in the negative radiative forcing due to ozone depletion.

(c) The UNFCCC reporting guidelines use GWP values from the IPCC Second Assessment Report (see FCCC/SBSTA/2004/8, <http://unfccc.int/resource/docs/2004/sbsta/08.pdf>).

(d) ODSs are not covered under the UNFCCC.

(e) The IPCC Second Assessment Report does not contain GWP values for HFC-245fa or HFC-365mfc. However, the UNFCCC reporting guidelines contain provisions relating to the reporting of emissions from all greenhouse gases for which IPCC-assessed GWP values exist.

**2.3**      *What are the implications of substitution of ODSs for air quality and other environmental issues relating to atmospheric chemistry?*

**Substitution for ODSs in air conditioning, refrigeration, and foam blowing by HFCs, PFCs, and other gases such as hydrocarbons are not expected to have a significant effect on global tropospheric chemistry. Small but not negligible impacts on air quality could occur near localised emission sources and such impacts may be of some concern, for instance in areas that currently fail to meet local standards. [2.4 and 2.6]**

**Persistent degradation products (such as trifluoroacetic acid, TFA) of HFCs and HCFCs are removed from the atmosphere via deposition and washout processes. However, existing environmental risk assessment and monitoring studies indicate that these are not expected to result in environmental concentrations capable of causing significant ecosystem damage. Measurements of TFA in sea-water indicate that the anthropogenic sources of TFA are smaller than natural sources, but the natural sources are not fully identified. [2.4]**

### **3. Production, banks and emissions**

#### **3.1 *How are production, banks, and emissions related in any particular year?***

**Current emissions of ODSs and their substitutes are largely determined by historic use patterns. For CFCs and HCFCs, a significant contribution (now and in coming decades) comes from their respective banks. There are no regulatory obligations to restrict these CFC and HCFC emissions either under the Montreal Protocol or the UNFCCC and its Kyoto Protocol, although some countries have effective national policies for this purpose.**

Banks are the total amount of substances contained in existing equipment, chemical stockpiles, foams and other products not yet released to the atmosphere (see Figure SPM-1). The build-up of banks of (relatively) new applications of HFCs will - in the absence of additional bank management measures - also significantly determine post 2015 emissions.

#### **3.2 *What can observations of atmospheric concentrations tell us about banks and emissions?***

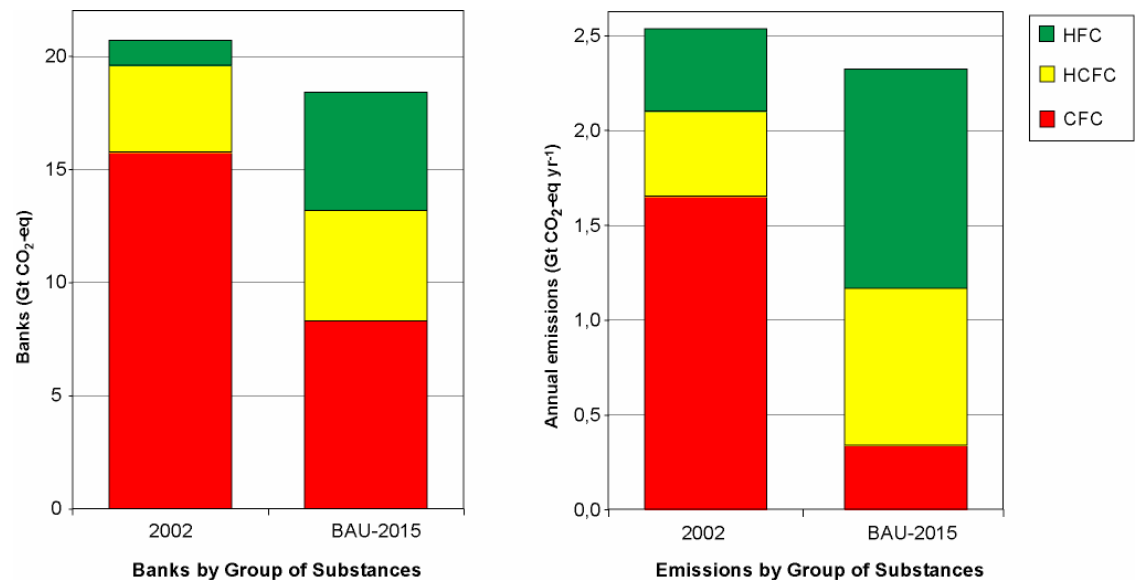
**Observations of atmospheric concentrations, combined with production and use pattern data, can indicate the significance of banks, but not their exact sizes.**

The most accurate estimates of emissions of CFC-11 and CFC-12 are derived from observations of atmospheric concentrations. Those emissions are now larger than estimated releases related to current production, indicating that a substantial fraction of these emissions come from banks built up through past production. Observations of atmospheric concentrations show that global emissions of HFC-134a are presently smaller than reported production, implying that this bank is growing. The total global amount of HFC-134a currently in the atmosphere is believed to be about equal to the amount in banks. [2.5 and 11.3.4]

In the case of CFC-11 and some other gases, the lack of information on use patterns makes it difficult to assess the contribution to observed emissions from current production and use. Further work in this area is required to clarify the sources.

3.3 *How are estimated banks and emissions projected to develop in the period 2002 to 2015?*

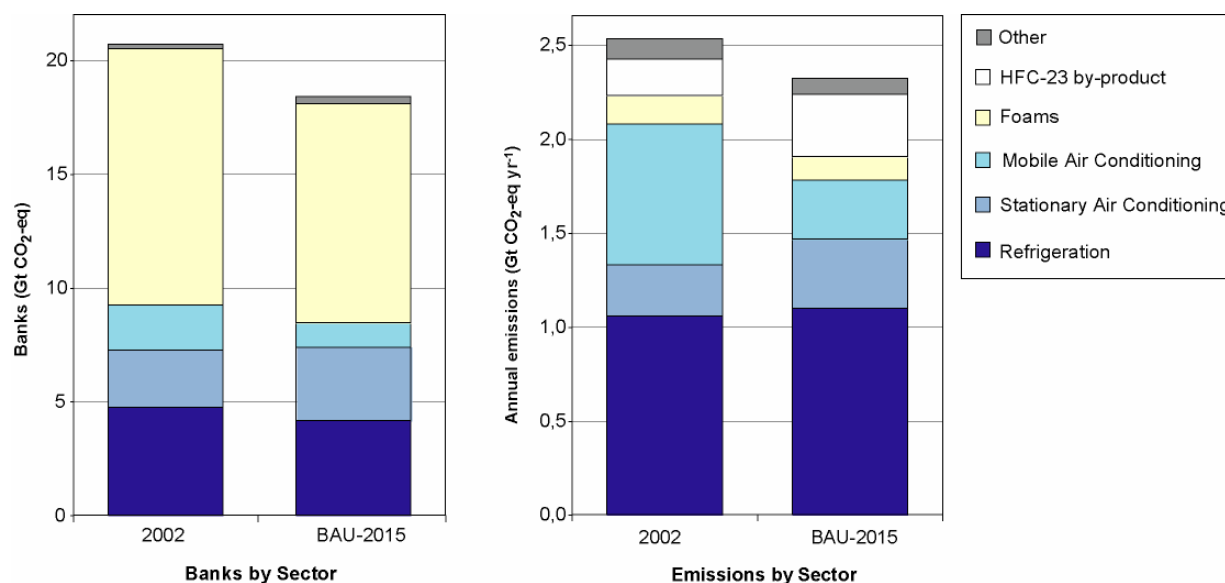
**Banks of CFCs, HCFCs, HFCs, and PFCs were estimated at about 21 GtCO<sub>2</sub>-eq in 2002<sup>12,13</sup>. In a Business-As-Usual (BAU) scenario, banks are projected to decline to about 18 GtCO<sub>2</sub>-eq in 2015<sup>14</sup>. [7, 11.3 and 11.5]**



<sup>12</sup> Greenhouse gas (GHG) emissions and banks expressed in terms of CO<sub>2</sub>-equivalents use GWPs for direct radiative forcing for a 100-year time horizon. Unless stated otherwise, the most recent scientific values for the GWPs are used, as assessed in this report and as presented in Table SPM-1 (Column for ‘GWP for direct radiative forcing’).

<sup>13</sup> Halons cause much larger negative indirect than positive direct radiative forcing and, in the interest of clarity, their effects are not given here.

<sup>14</sup> In the BAU projections, it is assumed that all existing measures continue, including Montreal Protocol (phase-out) and relevant national policies. The current trends in practices, penetration of alternatives, and emission factors are maintained up to 2015. End-of-life recovery efficiency is assumed not to increase.



**Figure SPM-4.** Historic data for 2002 and Business-As-Usual (BAU) projections for 2015 of greenhouse gas CO<sub>2</sub>-equivalent banks (left) and direct annual emissions (right), related to the use of CFCs, HCFCs and HFCs. Breakdown per group of greenhouse gases (top), and per emission sector (bottom). ‘Other’ includes Medical Aerosols, Fire Protection, Non-Medical Aerosols and Solvents. [11.3 and 11.5]

In 2002, CFC, HCFC, and HFC banks were about 16, 4, and 1 GtCO<sub>2</sub>-eq (direct GWP weighted), respectively (see Figure SPM-4). In 2015, the banks are about 8, 5 and 5 GtCO<sub>2</sub>-eq, respectively, in the BAU scenario. Banks of PFCs used as ODS replacements were about 0.005 GtCO<sub>2</sub>-eq in 2002.

CFC banks associated with refrigeration, stationary air conditioning (SAC)<sup>15</sup> and mobile air conditioning (MAC) equipment are projected to decrease from about 6 to 1 GtCO<sub>2</sub>-eq over the period 2002 to 2015, mainly due to release to the atmosphere and partly due to end-of-life recovery and destruction. CFC banks in foams are projected to decrease much more slowly over the same period (from 10 to 7 GtCO<sub>2</sub>-eq), reflecting the much slower release of banked blowing agents from foams when compared with similarly sized banks of refrigerant in the refrigeration and air conditioning sector.

HFC banks have started to build up and are projected to reach about 5 GtCO<sub>2</sub>-eq in 2015. Of these, HFCs banked in foams represent only 0.6 GtCO<sub>2</sub>-eq, but are projected to increase further after 2015.

<sup>15</sup> In this Summary for Policymakers the ‘refrigeration’ sector comprises domestic, commercial, industrial (including food processing and cold storage) and transportation refrigeration. [4] ‘Stationary air-conditioning (SAC)’ comprises residential and commercial air conditioning and heating. [5] ‘Mobile air conditioning (MAC)’ applies to cars, buses and passenger compartments of trucks.



**In the Business-As-Usual scenario, total direct emissions of CFCs, HCFCs, HFCs, and PFCs are projected to represent about 2.3 GtCO<sub>2</sub>-eq yr<sup>-1</sup> by 2015 (as compared to about 2.5 GtCO<sub>2</sub>-eq yr<sup>-1</sup> in 2002). CFC and HCFC emissions are together decreasing from 2.1 (2002) to 1.2 GtCO<sub>2</sub>-eq yr<sup>-1</sup> (2015), and emissions of HFCs are increasing from 0.4 (2002) to 1.2 GtCO<sub>2</sub>-eq yr<sup>-1</sup> (2015)<sup>16</sup>. PFC emissions from ODS substitute use are about 0.001 GtCO<sub>2</sub>-eq yr<sup>-1</sup> (2002) and projected to decrease. [11.3 and 11.5]**

Figure SPM-4 shows the relative contribution of sectors to global direct greenhouse gas (GHG) emissions that are related to the use of ODSs and their substitutes. Refrigeration applications together with SAC and MAC contribute the bulk of global direct GHG emissions in line with the higher emission rates associated with refrigerant banks. The largest part of GHG emissions from foams is expected to occur after 2015 because most releases occur at end-of-life.

With little new production, total CFC banks will decrease due to release to the atmosphere during operation and disposal. In the absence of additional measures a significant part of the CFC banks will have been emitted by 2015. Consequently, annual CFC emissions are projected to decrease from 1.7 (2002) to 0.3 GtCO<sub>2</sub>-eq yr<sup>-1</sup> (2015).

HCFC emissions are projected to increase from 0.4 (2002) to 0.8 GtCO<sub>2</sub>-eq yr<sup>-1</sup> (2015), owing to a steep increase expected for their use in (commercial) refrigeration and SAC applications.

The projected threefold increase in HFC emissions is the result of increased application of HFCs in the refrigeration, SAC, and MAC sectors, and due to by-product emissions of HFC-23 from increased HCFC-22 production (from 195 MtCO<sub>2</sub>-eq yr<sup>-1</sup> in 2002 to 330 MtCO<sub>2</sub>-eq yr<sup>-1</sup> in 2015 BAU).

**Uncertainties in emission estimates are significant.** Comparison of results of atmospheric measurements with inventory calculations shows differences per group of substances in the order of 10 to 25%. For individual gases the differences can be much bigger. This is caused by unidentified emissive applications of some substances, not accounted for in inventory calculations, and uncertainties in the geographically distributed datasets of equipment in use. [11.3.4]

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<sup>16</sup> For these emission values the most recent scientific values for GWPs are used (see Table SPM-1, second column, 'GWP for direct radiative forcing'). If the UNFCCC GWPs would be used (Table SPM-1, last column, 'UNFCCC Reporting GWP'), reported HFC emissions (expressed in tonnes of CO<sub>2</sub>-eq) would be about 15% lower.

**The literature does not allow for an estimate of overall indirect<sup>6</sup> GHG emissions related to energy consumption. For individual applications, the relevance of indirect GHG emissions over a life cycle can range from low to high, and for certain applications may be up to an order of magnitude larger than direct GHG emissions.** This is highly dependent on the specific sector and product/application characteristics, the carbon-intensity of the consumed electricity and fuels during the complete life cycle of the application, containment during the use-phase, and the end-of-life treatment of the banked substances. [3.2, 4 and 5]

## 4. Options for ODS phase-out and reducing greenhouse gas emissions

### 4.1 *What major opportunities have been identified for reductions of greenhouse gas emissions and how can they be assessed*

**Reductions in direct GHG emissions are available for all sectors discussed in this report and can be achieved through:**

- **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 reduced or negligible global warming potential; and**
- **not-in-kind technologies<sup>17</sup>.**

**A comprehensive assessment would cover both direct emissions and indirect energy-related emissions, full life cycle aspects, as well as health, safety and environmental considerations. However, due to limited availability of published data and comparative analyses, such comprehensive assessments are currently almost absent.**

Methods for determining which technology option has the highest GHG emission reduction potential address both direct emissions of halocarbons or substitutes and indirect energy-related emissions over the full life cycle. In addition, comprehensive methods<sup>18</sup> assess a wide range of environmental impacts. Other, simplified methods<sup>19</sup> exist to assess lifecycle impacts and commonly provide useful indicators for lifecycle greenhouse gas emissions of an application. Relatively few transparent comparisons applying these methods have been published. The conclusions from these comparisons are sensitive to assumptions about application-specific, and often region- and time-specific, parameters (e.g. site-specific situation, prevailing climate, energy system characteristics). [3.5]

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<sup>17</sup> Not-in-kind technologies achieve the same product objective without the use of halocarbons, typically with an alternative approach or unconventional technique. Examples include the use of stick or spray pump deodorants to replace CFC-12 aerosol deodorants; the use of mineral wool to replace CFC, HFC or HCFC insulating foam; and the use of dry powder inhalers (DPIs) to replace CFC or HFC metered dose inhalers (MDIs).

<sup>18</sup> Comprehensive methods, e.g. Life Cycle Assessment, (LCA) covers all phases of the life cycle for a number of environmental impact categories. The respective methodologies are detailed in international ISO standards ISO 14040:1997, ISO 14041:1998, ISO 14042:2000, and ISO 14043: 2000.

<sup>19</sup> Typical simplified methods include Total Equivalent Warming Impact (TEWI), which assesses direct and indirect greenhouse emissions connected only with the use-phase and disposal; and Life Cycle Climate Performance (LCCP), which also includes direct and indirect greenhouse emissions from the manufacture of the active substances.

Comparative economic analyses are important to identify cost-effective reduction options. However, they require a common set of methods and assumptions (e.g. costing methodology, time-frame, discount rate, future economic conditions, system boundaries). The development of simplified standardised methodologies would enable better comparisons in the future. [3.3]

The risks of health and safety impacts can be assessed in most cases using standardised methods. [3.4 and 3.5]

**GHG emissions related to energy consumption can be significant over the lifetime of appliances considered in this report. Energy efficiency improvements can thus lead to reductions in indirect emissions from these appliances, depending on the particular energy source used and other circumstances and produce net cost reductions, particularly where the use-phase of the application is long (e.g. in refrigeration and SAC).** The assessed literature did not allow for a global estimate of this reduction potential, although several case studies at technology and country level illustrate this point.

**Through application of current best practices<sup>20</sup> and recovery methods, there is potential to halve (1.2 GtCO<sub>2</sub>-eq yr<sup>-1</sup> reduction) the BAU direct emissions from ODSs and their GHG substitutes by 2015<sup>21</sup>. About 60% of this potential concerns HFC emissions, 30% HCFCs and 10% CFCs.** The estimates are based on a Mitigation Scenario<sup>22</sup> which makes regionally differentiated assumptions on best practices in production, use, substitution, recovery, and destruction of these substances. Sectoral contributions are shown in Figure SPM-5. [11.5]

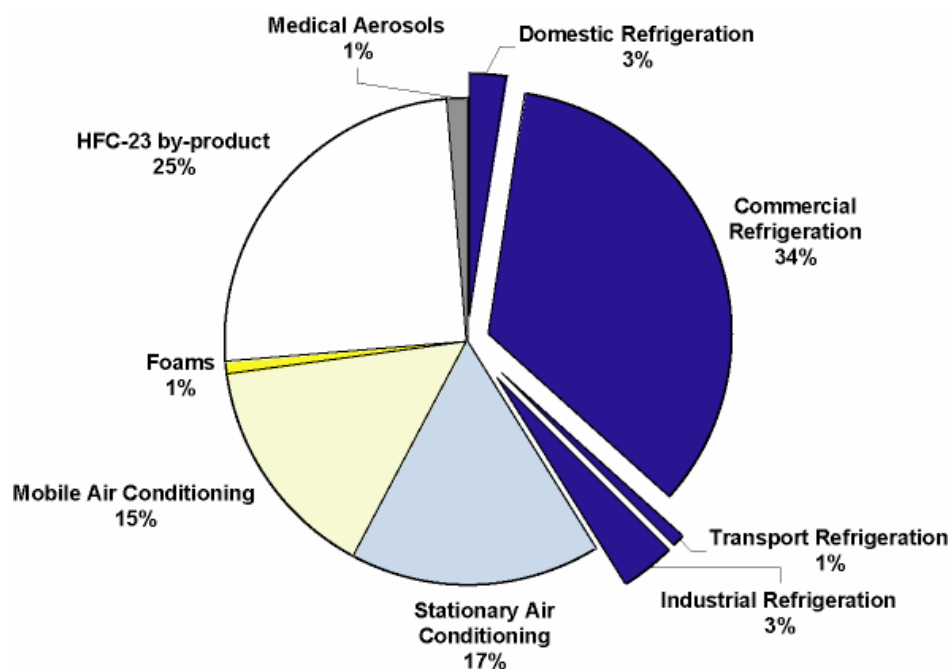
Of the bank-related emissions that can be prevented in the period until 2015, the bulk are in refrigerant-based applications where business-as-usual emission rates are considerably more significant than they are for foams during the period in question. With earlier action, such as recovery/destruction and improved containment, more of the emissions from CFC banks can be captured.

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<sup>20</sup> For this Report, best practice is considered the lowest achievable value of halocarbon emission at a given date, using commercially proven technologies in the production, use, substitution, recovery and destruction of halocarbon or halocarbon-based products (for specific numbers, see Table TS-6).

<sup>21</sup> For comparison, CO<sub>2</sub> emissions related to fossil fuel combustion and cement production were about 24 GtCO<sub>2</sub> yr<sup>-1</sup> in 2000.

<sup>22</sup> The Mitigation Scenario used in this Report, projects the future up to 2015 for the reduction of halocarbon emissions, based on regionally differentiated assumptions of best practices.



### Sectoral Emission Reduction Potentials 2015

**Figure SPM-5.** Sectoral reduction potentials for direct emissions of CFCs, HCFCs, and HFCs in 2015 as compared to the BAU projections. The overall reduction potential is about half (1.2 GtCO<sub>2</sub>-eq yr<sup>-1</sup>) of the BAU direct GHG emissions.

#### 4.2 *What are the sectoral emission reduction potentials in 2015 and what are associated costs?*

**In refrigeration applications direct GHG emissions can be reduced by 10% to 30%. For the refrigeration sector as a whole, the Mitigation Scenario shows an overall direct emission reduction of about 490 MtCO<sub>2</sub>-eq yr<sup>-1</sup> by 2015, with about 400 MtCO<sub>2</sub>-eq yr<sup>-1</sup> predicted for commercial refrigeration. Specific costs are in the range of 10 to 300 US\$/tCO<sub>2</sub>-eq<sup>23</sup>. Improved system energy efficiencies can also significantly reduce indirect GHG emissions.**

In full supermarket systems, up to 60% lower LCCP<sup>19</sup> values can be obtained by using alternative refrigerants, improved containment, distributed systems, indirect systems or cascade systems. Refrigerant specific emission abatement costs range for the commercial refrigeration sector from 20 to 280 US\$/tCO<sub>2</sub>-eq.

<sup>23</sup> The presented cost data concern direct emission reductions only. Taking into account energy efficiency improvements may result in even net negative specific costs (savings).

In food processing, cold storage and industrial refrigeration, ammonia is forecast for increased use in the future, with HFCs replacing HCFC-22 and CFCs. Industrial refrigeration refrigerant specific emissions abatement costs were determined to be in the range from 27 to 37 US\$/tCO<sub>2</sub>-eq. In transport refrigeration, lower GWP alternatives, such as ammonia, hydrocarbons, and ammonia/carbon dioxide have been commercialised.

The emission reduction potential in domestic refrigeration is relatively small, with specific costs in the range of 0 to 130 US\$/tCO<sub>2</sub>-eq. Indirect emissions of systems using either HFC-134a or HC-600a (isobutane) dominate total emissions, for different carbon intensities of electric power generation. The difference between the LCCP<sup>19</sup> of HFC-134a and isobutane systems is small and end-of-life recovery, at a certain cost increase, can further reduce the magnitude of the difference. [4]

**Direct GHG emissions of residential and commercial air conditioning and heating equipment (SAC) can be reduced by about 200 MtCO<sub>2</sub>-eq yr<sup>-1</sup> by 2015 relative to the BAU scenario. Specific costs range from -3 to 170 US\$/tCO<sub>2</sub>-eq<sup>23</sup>. When combined with improvements in system energy efficiencies, which reduce indirect GHG emissions, in many cases net financial benefits accrue.** Opportunities to reduce direct GHG (i.e. refrigerant) emissions can be found in (i) more efficient recovery of refrigerant at end-of-life (in the Mitigation Scenario assumed to be 50% and 80% for developing and developed countries, respectively); (ii) refrigerant charge reduction (up to 20%); (iii) better containment and (iv) the use of refrigerants with reduced or negligible GWPs in suitable applications.

Improving the integrity of the building envelope (reduced heat gain or loss) can have a significant impact on indirect emissions.

HFC mixtures and HCs (for small systems) are used as alternatives for HCFC-22 in developed countries. For those applications where HCs can be safely applied, the energy efficiency is comparable to fluorocarbon refrigerants. Future technical developments could reduce refrigerant charge, expanding the applicability of HCs. [5]

**In mobile air conditioning, a reduction potential of 180 MtCO<sub>2</sub>-eq yr<sup>-1</sup> by 2015 could be achieved at a cost of 20 to 250 US\$/tCO<sub>2</sub>-eq<sup>23</sup>. Specific costs differ per region and per solution.**

Improved containment, and end-of-life recovery (both of CFC-12 and HFC-134a) and recycling (of HFC-134a) could reduce direct GHG emissions by up to 50%, and total (direct and indirect) GHG emissions of the MAC unit by 30 to 40% at a financial benefit to vehicle owners. New systems with either CO<sub>2</sub> or HFC-152a, with equivalent LCCP, are likely to enter the market, leading to total GHG system emission reductions estimated at 50 to 70% in 2015 at an estimated added specific cost of 50 to 180 US\$ per vehicle.

Hydrocarbons and hydrocarbon blends, which have been used to a limited extent, present suitable thermodynamic properties and permit high energy efficiency. However, the safety and liability concerns identified by vehicle manufacturers and suppliers limit the possible use of hydrocarbons in new vehicles. [6.4.4]

**Due to the long life-span of most foam applications, by 2015 a limited emission reduction of 15 to 20 MtCO<sub>2</sub>-eq yr<sup>-1</sup> is projected at specific costs ranging from 10 to 100 US\$/tCO<sub>2</sub>-eq<sup>23</sup>. The potential for emission reduction increases in following decades.**

Several short-term emission reduction steps, such as the planned elimination of HFC use in emissive one-component foams in Europe, are already in progress and are considered as part of the BAU. Two further key areas of potential emission reduction exist in the foams sector. The first is a potential reduction in halocarbon use in newly manufactured foams. However, the enhanced use of blends and the further phase-out of fluorocarbon use both depend on further technology development and market acceptance. Actions to reduce HFC use by 50% between 2010 and 2015, would result in emission reduction of about 10 MtCO<sub>2</sub>-eq yr<sup>-1</sup>, at a specific cost of 15 to 100 US\$/tCO<sub>2</sub>-eq, with further reductions thereafter<sup>23</sup>.

The second opportunity for emission reduction can be found in the world-wide banks of halocarbons contained in insulating foams in existing buildings and appliances (about 9 and 1 GtCO<sub>2</sub>-eq for CFC and HCFC, respectively in 2002). Although recovery effectiveness is yet to be proven, and there is little experience to date, particularly in the buildings sector, commercial operations are already recovering halocarbons from appliances at 10 to 50 US\$/tCO<sub>2</sub>-eq<sup>23</sup>. Emission reductions may be about 7 MtCO<sub>2</sub>-eq yr<sup>-1</sup> in 2015. However, this potential could increase significantly in the period between 2030 and 2050, when large quantities of building insulation foams will be decommissioned. [7]

**The reduction potential for medical aerosols is limited due to medical constraints, the relatively low emission level and the higher costs of alternatives.** The major contribution (14 MtCO<sub>2</sub>-eq yr<sup>-1</sup> by 2015 compared to a BAU emission of 40 MtCO<sub>2</sub>-eq yr<sup>-1</sup>) to a reduction of GHG emissions for metered dose inhalers (MDIs) would be the completion of the transition from CFC to HFC MDIs beyond what was already assumed as BAU. The health and safety of the patient is considered to be of paramount importance in treatment decisions, and there are significant medical constraints to limit the use of HFC MDIs. If salbutamol MDIs (approximately 50% of total MDIs) would be replaced by dry powder inhalers (which is not assumed in the Mitigation Scenario) this would result in an annual emission reduction of about 10 MtCO<sub>2</sub>-eq yr<sup>-1</sup> by 2015 at projected costs in the range of 150 to 300 US\$/tCO<sub>2</sub>-eq. [8]

**In fire protection, the reduction potential by 2015 is small due to the relatively low emission level, the significant shifts to not-in-kind alternatives in the past and the lengthy procedures for introducing new equipment.** Direct GHG emissions for the sector are estimated at about 5 MtCO<sub>2</sub>-eq yr<sup>-1</sup> in 2015 (BAU). Seventy five percent of original halon use has been shifted to agents with no climate impact. Four percent of the original halon applications continue to employ halons. The remaining 21% has been shifted to HFCs with a small number of applications shifted to HCFCs and to PFCs. PFCs are no longer needed for new fixed systems and are limited to use as a propellant in one manufacturer's portable extinguisher agent blend. Due to the lengthy process of testing, approval and market acceptance of new fire protection equipment types and agents, no additional options will likely have appreciable impact by 2015. With the introduction of a fluoroketone (FK) in 2002, additional reductions at an increased cost are possible in this sector through 2015. Currently those reductions are estimated to be small compared to other sectors. [9]

**For non-medical aerosols and solvents there are several reduction opportunities, but the reduction potentials are likely to be rather small because most remaining uses are critical to performance or safety.** The projected BAU emissions by 2015 for solvents and aerosols are about 14 and 23 MtCO<sub>2</sub>-eq yr<sup>-1</sup>, respectively. Substitution of HFC-134a by HFC-152a in technical aerosol dusters is a leading option for reducing GHG emissions. For contact cleaners and plastic casting mould release agents, the substitution of HCFCs by hydrofluoroethers (HFEs) and HFCs with lower GWPs offers an opportunity. Some countries have banned HFC use in cosmetic, convenience and novelty aerosol products, although HFC-134a continues to be used in many countries for safety reasons.

A variety of organic solvents can replace HFCs, PFCs and ODSs in many applications. These alternative fluids include lower GWP compounds such as traditional chlorinated solvents, HFEs, HCs and oxygenated solvents. Many not-in-kind technologies, including no-clean and aqueous cleaning processes, are also viable alternatives. [10]

**Destruction of by-product emissions of HFC-23 from HCFC-22 production has a reduction potential of up to 300 MtCO<sub>2</sub>-eq yr<sup>-1</sup> by 2015 and specific costs below 0.2 US\$/tCO<sub>2</sub>-eq according to two European studies in 2000<sup>24</sup>.**

Reduction of HCFC-22 production due to market forces or national policies, or improvements in facility design and construction also could reduce HFC-23 emissions. [10.4]

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<sup>24</sup> Costs in this report are given in 2002 US dollars unless otherwise stated.



#### 4.3 *What are the current policies, measures, and instruments?*

**A variety of policies, measures and instruments have been implemented in reducing the use or emissions of ODSs and their substitutes, such as HFCs and PFCs. These include regulations, economic instruments, voluntary agreements and international co-operation. Furthermore, general energy or climate policies affect the indirect GHG emissions of applications with ODSs, their substitutes, or not-in-kind alternatives.**

This report contains information on policies and approaches in place in some countries (mainly developed) for reducing the use or emissions of ODSs and their substitutes. Those relevant policies and approaches include:

- Regulations (e.g., performance standards, certification, restrictions, end-of-life management)
- Economic instruments (e.g., taxation, emissions trading, financial incentives, and deposit refunds)
- Voluntary agreements (e.g., voluntary reductions in use and emissions, industry partnerships, and implementation of good practice guidelines)
- International co-operation (e.g., Clean Development Mechanism)

It should be noted that policy considerations are dependent on specific applications, national circumstances, and other factors.

#### 4.4 *What can be said about availability of HFCs/PFCs in the future for use in developing countries?*

**No published data are available to project future production capacity. However, as there are no technical or legal limits to HFC and PFC production, it can be assumed that the global production capacity will generally continue to satisfy or exceed demand. Future production is therefore estimated in this report by aggregating sectoral demand.**

In the BAU scenario, global production capacity is expected to expand with additions taking place mainly in developing countries and through joint ventures. Global production capacity of HFCs and PFCs most often exceeds current demand. There are a number of HFC-134a plants in developed countries and one plant in a developing country with others planned; the few plants for other HFCs are almost exclusively in developed countries. The proposed European Community phase-out of HFC-134a in mobile air conditioners in new cars and the industry voluntary programme to reduce their HFC-134a emissions by 50% will affect demand and production capacity and output. Rapidly expanding markets in developing countries, in particular for replacements for CFCs, is resulting in new capacity for fluorinated gases which is at present being satisfied through the expansion of HCFC-22 and 141b capacity. [11]

## **Annex I: Glossary of Terms**

The definitions in this glossary refer to the use of the terms in the context of the Summary for Policymakers of the Special Report on Ozone and Climate.

**Aerosol**

A suspension of very fine solid or liquid particles in a gas. Aerosol is also used as a common name for a spray (or “aerosol”) can, in which a container is filled with a product and a propellant and is pressurised so as to release the product in a fine spray.

**Banks**

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

**Best practice**

For this Report, best practice is considered the lowest achievable value of halocarbon emission at a given date, using commercially proven technologies in the production, use, substitution, recovery and destruction of halocarbon or halocarbon-based products.

**Blends/Mixtures (Refrigeration)**

A mixture of two or more pure fluids. Blends are used to achieve properties that fit many refrigeration purposes. For example, a mixture of flammable and non-flammable components can result in a non-flammable blend. Blends can be divided into three categories: azeotropic, non-azeotropic and near-azeotropic blends.

**Blowing Agent (Foams)**

A gas, volatile liquid, or chemical that generates gas during the foaming process. The gas creates bubbles or cells in the plastic structure of a foam.

**Business as Usual (BAU) Scenario (2015, this report)**

A baseline scenario for the use of halocarbons and their alternatives, which assumes that all existing regulation and phase-out measures, including the Montreal Protocol and relevant national regulations, continue to 2015. The usual practices (including end-of-life recovery) and emission rates are kept unchanged up to 2015.

**Carbon Dioxide (CO<sub>2</sub>)**

A naturally occurring gas which occurs as a by-product of burning fossil fuels and biomass, as well as other industrial processes and land-use changes. It is the principal anthropogenic greenhouse gas that affects the Earth’s radiative balance and is the reference gas against which other greenhouse gases are generally measured.

**Chlorofluorocarbons (CFCs)**

Halocarbons containing only chlorine, fluorine, and carbon atoms. CFCs are both ozone-depleting substances (ODSs) and greenhouse gases.

**Climate Change**

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Note that Article 1 of the Framework Convention on Climate Change (UNFCCC) defines “climate change” as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability, observed over comparable time periods”. The UNFCCC thus makes a distinction between “climate change” attributable to human activities altering the atmospheric composition, and “climate variability” attributable to natural causes.

**Climate Variability**

Variations in the mean state and other statistics (such as the standard deviation and the occurrence of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events.

Climate variability may be caused by natural internal processes within the climate system (internal variability), or by variations in natural or anthropogenic external forcings (external variability). See also: Climate change.

#### **CO<sub>2</sub>-Equivalent**

The amount of carbon dioxide (CO<sub>2</sub>) that would cause the same amount of radiative forcing as a given amount of another greenhouse gas. When used with concentrations this refers to the instantaneous radiative forcing caused by the greenhouse gas or the equivalent amount of CO<sub>2</sub>. When used with emissions this refers to the time integrated radiative forcing over a specified time horizon caused by the change in concentration produced by the emissions. See Global Warming Potential.

#### **Column Ozone**

The total amount of ozone in a vertical column above the Earth's surface. Column ozone is measured in Dobson Units (DU).

#### **Containment (Refrigeration)**

The application of service techniques or special equipment designed to preclude or reduce loss of refrigerant from equipment during installation, operation, service, or disposal of refrigeration and air-conditioning equipment.

#### **Destruction**

Destruction of ozone-depleting substances (ODSs) by approved destruction plants, in order to avoid their emissions.

#### **Dry Powder Inhaler (DPI) (Medical Aerosols)**

An alternate technology to metered dose inhalers (MDIs) that can be used if the medication being dispensed can be satisfactorily formulated as microfine powder, thus eliminating the use of a chemical propellant.

#### **Fluorocarbons**

Halocarbons containing fluorine atoms, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

#### **Fluoroketones (FKs)**

Organic compounds in which two fully fluorinated alkyl groups are attached to a carbonyl group (C=O).

#### **Global Warming Potential (GWP)**

An index, comparing the climate impact of an emission of a greenhouse gas relative to that of emitting the same amount of carbon dioxide. GWPs are determined as the ratio of the time-integrated radiative forcing arising from a pulse emission of 1 kg of a substance relative to that of 1 kg of carbon dioxide, over a fixed time horizon. See also: Radiative forcing.

#### **Greenhouse Gases (GHGs)**

The gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation within the spectrum of the thermal infrared radiation that is emitted by the Earth's surface, by the atmosphere, and by clouds. This property causes the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapour (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>), and ozone (O<sub>3</sub>). Moreover, there are a number of entirely anthropogenic greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances that are covered by the Montreal Protocol. Some other trace gases such as sulphur hexafluoride (SF<sub>6</sub>), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) are also greenhouse gases.

#### **Halocarbons**

Chemical compounds containing carbon atoms, and one or more atoms of the halogens chlorine (Cl), fluorine (F), bromine (Br), or iodine (I). *Fully*

*halogenated halocarbons* contain only carbon and halogen atoms, whereas *partially halogenated halocarbons* also contain hydrogen (H) atoms. Halocarbons that release chlorine, bromine, or iodine into the stratosphere cause ozone depletion. Halocarbons are also greenhouse gases. Halocarbons include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and halons.

#### **Halons**

Fully halogenated halocarbons that contain, bromine, and fluorine atoms.

#### **Hydrocarbons (HCs)**

Chemical compounds consisting of one or more carbon atoms surrounded only by hydrogen atoms.

#### **Hydrochlorofluorocarbons (HCFCs)**

Halocarbons containing only hydrogen, chlorine, fluorine and carbon atoms. Because HCFCs contain chlorine, they contribute to ozone depletion. They are also greenhouse gases.

#### **Hydrofluorocarbons (HFCs)**

Halocarbons containing only carbon, hydrogen and fluorine atoms. Because HFCs contain no chlorine, bromine, or iodine, they do not deplete the ozone layer. Like other halocarbons, they are potent greenhouse gases.

#### **Hydrofluoroethers (HFEs)**

Chemicals composed of hydrogen, fluorine and ether, which has similar performance characteristics to certain ozone-depleting substances (ODSs) that are used as solvents.

#### **Life Cycle Assessment (LCA)**

An assessment of the overall environmental impact of a product over its entire life cycle (manufacture, use, and recycling or disposal).

#### **Life Cycle Climate Performance (LCCP)**

A measure of the overall global-warming impact of equipment based on the total related emissions of greenhouse gases over its entire life cycle. LCCP is an extension of the total equivalent warming impact (TEWI). LCCP also takes into account the direct fugitive emissions arising during manufacture, and the greenhouse gas emissions associated with their embodied energy.

#### **Metered Dose Inhalers (MDIs) (Medical Aerosols)**

A method of dispensing inhaled pulmonary drugs.

#### **Miscible**

The ability of two liquids or gases to uniformly dissolve into each other. Immiscible liquids will separate into two distinguishable layers.

#### **Not-in-kind technologies (NIK)**

Not-in-kind technologies achieve the same product objective without the use of halocarbons, typically with an alternative approach or unconventional technique. Examples include the use of stick or spray pump deodorants to replace CFC-12 aerosol deodorants; the use of mineral wool to replace CFC, HFC or HCFC insulating foam; and the use of dry powder inhalers (DPIs) to replace CFC or HFC metered dose inhalers (MDIs).

#### **One-component foam (OCF)**

A foam in which the blowing agent acts both as a frothing agent and as a propellant. These foams are primarily used for gap filling (to prevent air infiltration) rather than for thermal insulation per se. As such the use of blowing agent is fully emissive.

#### **Ozone**

The triatomic form of oxygen (O<sub>3</sub>), which is a gaseous atmospheric constituent. In the troposphere it is created by photochemical reactions involving gases occurring naturally

and resulting from anthropogenic activities (“smog”). Tropospheric ozone acts as a greenhouse gas. In the stratosphere ozone is created by the interaction between solar ultraviolet radiation and molecular oxygen (O<sub>2</sub>). Stratospheric ozone plays a major role in the stratospheric radiative balance. Its concentration is highest in the ozone layer.

#### **Ozone-Depleting Substances (ODSs)**

Substances known to deplete the stratospheric ozone layer. The ODSs controlled under the Montreal Protocol and its amendments are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl bromide (CH<sub>3</sub>Br), carbon tetrachloride (CCl<sub>4</sub>), methyl chloroform (CH<sub>3</sub>CCl<sub>3</sub>), hydrobromofluorocarbons (HBFCs), and bromochloromethane.

#### **Ozone Depletion**

Accelerated chemical destruction of the stratospheric ozone layer by the presence of substances produced by human activities.

#### **Perfluorocarbons (PFCs)**

Synthetically produced halocarbons containing only carbon and fluorine atoms. They are characterised by extreme stability, non-flammability, low toxicity, zero ozone depleting potential, and high global warming potential.

#### **Radiative Forcing**

Radiative forcing is the change in the net irradiance (expressed in Watts per square meter: W m<sup>-2</sup>) at the tropopause due to an internal change or a change in the external forcing of the climate system, such as a change in the concentration of carbon dioxide (CO<sub>2</sub>) in the atmosphere or in the output of the Sun. Usually radiative forcing is computed after allowing for stratospheric temperatures to readjust to radiative equilibrium, but with all tropospheric properties held fixed at their unperturbed values. Radiative forcing is called *instantaneous* if no

change in stratospheric temperature is accounted for. See also: Global warming potential.

#### **Recovery**

The collection and storage of controlled substances from machinery, equipment, containment vessels, etc., during servicing or prior to disposal without necessarily testing or processing it in any way.

#### **Recycling**

Reuse of a recovered controlled substance following a basic cleaning process such as filtering and drying. For refrigerants, recycling normally involves recharge back into equipment and it often occurs “on-site”.

#### **Refrigerant (Refrigeration)**

A heat transfer agent, usually a liquid, used in equipment such as refrigerators, freezers and air conditioners.

#### **Solvent**

Any product (aqueous or organic) designed to clean a component or assembly by dissolving the contaminants present on its surface.

#### **Specific costs (of abatement options)**

The difference in costs of an abatement option as compared to a reference case, expressed in relevant specific units. In this Report the specific costs of greenhouse gas emission reduction options are generally expressed in US\$ per tonne of avoided CO<sub>2</sub>-equivalents (US\$/tCO<sub>2</sub>-eq).

#### **SRES Scenarios**

Emission scenarios developed by the IPCC Special Report on Emission Scenarios (2000).

#### **Stratosphere**

The highly stratified region of the atmosphere above the troposphere. It extends from an altitude of about 8 km in high latitudes and 16 km in the tropics to an altitude of about 50 km.

This region is characterised by increasing temperature with altitude.

**Total Equivalent Warming Impact (TEWI)**

A measure of the overall global-warming impact of equipment based on the total related emissions of greenhouse gases during the operation of the equipment and the disposal of the operating fluids at the end of life. TEWI takes into account both direct fugitive emissions, and indirect emissions produced through the energy consumed in operating the equipment. TEWI is measured in units of mass of CO<sub>2</sub> equivalent. See also: Life cycle climate performance (LCCP).

**Troposphere**

The lowest part of the atmosphere above the Earth's surface, where clouds and "weather" phenomena occur. The thickness of the troposphere is on average 9 km in high latitudes, 10 km in mid-latitudes, and 16 km in the tropics. Temperatures in the troposphere generally decrease with height.

## Annex II: Major Chemical Formulae and Nomenclature

This annex presents the formulae and nomenclature for several halogen-containing and other species that are referred to in the Summary for Policymakers.

The *Montreal Protocol on Substances that Deplete the Ozone Layer* controls the production and consumption of the following halocarbons: chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, hydrobromofluorocarbons (HBFCs), carbon tetrachloride (CCl<sub>4</sub>), methyl chloroform (CH<sub>3</sub>CCl<sub>3</sub>), methyl bromide (CH<sub>3</sub>Br) and bromochloromethane (CH<sub>2</sub>BrCl).

The *United Nations Framework Convention on Climate Change (UNFCCC)* covers anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol. The *Kyoto Protocol* of the UNFCCC covers the basket of greenhouse gases carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>).

### Halocarbons

For each halocarbon the following information is given in columns:

Chemical compound [Number of isomers if more than one] (or common name)

Chemical formula

Chemical name (or alternative name)

<b>Chlorofluorocarbons (CFCs)</b> [Production and consumption are controlled by the Montreal Protocol]		
CFC-11	CCl <sub>3</sub> F	Trichlorofluoromethane
CFC-12	CCl <sub>2</sub> F <sub>2</sub>	Dichlorodifluoromethane
CFC-13	CClF <sub>3</sub>	Chlorotrifluoromethane
CFC-113	[2] C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>	Trichlorotrifluoroethane
	CFC-113 CCl <sub>2</sub> FCClF <sub>2</sub>	1,1,2-Trichloro-1,2,2-trifluoroethane
	CFC-113a CCl <sub>3</sub> CF <sub>3</sub>	1,1,1-Trichloro-2,2,2-trifluoroethane
CFC-114	[2] C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>	Dichlorotetrafluoroethane
	CFC-114 CCIF <sub>2</sub> CCIF <sub>2</sub>	1,2-Dichloro-1,1,2,2-tetrafluoroethane
	CFC-114a CCl <sub>2</sub> FCF <sub>3</sub>	1,1-Dichloro-1,2,2,2-tetrafluoroethane
CFC-115	CClF <sub>2</sub> CF <sub>3</sub>	Chloropentafluoroethane

<sup>1</sup> Note that the substances presented here are a selection of the substances that are controlled by the Montreal Protocol.



<b>Hydrochlorofluorocarbons (HCFCs)</b>		<b>[Production and consumption are controlled by the Montreal Protocol]<sup>1</sup></b>
HCFC-21	CHCl <sub>2</sub> F	Dichlorofluoromethane
HCFC-22	CHClF <sub>2</sub>	Chlorodifluoromethane
HCFC-123 [3]	C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>	Dichlorotrifluoroethane
HCFC-123	CHCl <sub>2</sub> CF <sub>3</sub>	2,2-Dichloro-1,1,1-trifluoroethane
HCFC-123a	C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>	1,2-Dichloro-1,1,2-trifluoroethane
HCFC-123b	C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>	1,1-Dichloro-1,2,2-trifluoroethane
HCFC-124 [2]		Chlorotetrafluoroethane
HCFC-124	CHClFCF <sub>3</sub>	2-Chloro-1,1,1,2-tetrafluoroethane
HCFC-124a	C <sub>2</sub> HClF <sub>4</sub>	1-Chloro-1,1,2,2-tetrafluoroethane
HCFC-141b	CH <sub>2</sub> CCl <sub>2</sub> F	1,1-Dichloro-1-fluoroethane
HCFC-142b	CH <sub>3</sub> CClF <sub>2</sub>	1-Chloro-1,1-difluoroethane
HCFC-225ca	CHCl <sub>2</sub> CF <sub>2</sub> CF <sub>3</sub>	3,3-Dichloro-1,1,1,2,2-pentafluoropropane
HCFC-225cb	CHClFCF <sub>2</sub> CClF <sub>2</sub>	1,3-Dichloro-1,1,2,2,3-pentafluoropropane

<b>Halons [Production and consumption are controlled by the Montreal Protocol]<sup>1</sup></b>		
Halon-1202	CBr <sub>2</sub> F <sub>2</sub>	Dibromodifluoromethane
Halon-1211	CBrClF <sub>2</sub>	Bromochlorodifluoromethane (Chlorodifluorobromomethane), R-12B1
Halon-1301	CBrF <sub>3</sub>	Bromotrifluoromethane, R-13B1
Halon-2402	CBrF <sub>2</sub> CBrF <sub>2</sub>	1,2-Dibromotetrafluoroethane (1,1,2,2-Tetrafluoro-1,2-dibromoethane, 1,2-Dibromo-1,1,2,2-tetrafluoroethane)

<b>Other Halocarbons [Production and consumption are controlled by the Montreal Protocol]<sup>1</sup></b>		
Carbon tetrachloride	CCl <sub>4</sub>	Halon 104, R-10
Methyl chloroform	CH <sub>3</sub> CCl <sub>3</sub>	1,1,1-Trichloroethane
Methyl bromide	CH <sub>3</sub> Br	Halon-1001, Bromomethane
Bromochloromethane	CH <sub>2</sub> BrCl	Halon-1011

## ***Hydrofluorocarbons (HFCs)***

HFC-23	$\text{CHF}_3$	Trifluoromethane
HFC-32	$\text{CH}_2\text{F}_2$	Difluoromethane (Methylene fluoride)
HFC-41	$\text{CH}_3\text{F}$	Fluoromethane (Methyl fluoride)
HFC-125	$\text{CHF}_2\text{CF}_3$	Pentafluoroethane
HFC-134	[2] $\text{C}_2\text{H}_2\text{F}_4$	Tetrafluoroethane
	HFC-134 $\text{CHF}_2\text{CHF}_2$	1,1,2,2-Tetrafluoroethane
	HFC-134a $\text{CH}_2\text{FCF}_3$	1,1,1,2-Tetrafluoroethane
HFC-143	[2] $\text{C}_2\text{H}_3\text{F}_3$	Trifluoroethane
	HFC-143 $\text{CH}_2\text{CHF}_2$	1,1,2-Trifluoroethane
	HFC-143a $\text{CH}_3\text{CF}_3$	1,1,1-Trifluoroethane
HFC-152	[2] $\text{C}_2\text{H}_4\text{F}_2$	Difluoroethane
	HFC-152 $\text{CH}_2\text{FCH}_2\text{F}$	1,2-Difluoroethane
	HFC-152a $\text{CHF}_2\text{CH}_3$	1,1-Difluoroethane
HFC-161	$\text{CH}_3\text{CH}_2\text{F}$	Monofluoroethane (Ethyl fluoride)
HFC-227	[2] $\text{C}_3\text{HF}_7$	Heptafluoropropane
	HFC-227ca $\text{CF}_3\text{CF}_2\text{CHF}_2$	1,1,1,2,2,3,3-Heptafluoropropane
	HFC-227ea $\text{CF}_3\text{CHFCF}_3$	1,1,1,2,3,3,3-Heptafluoropropane
HFC-236	[4] $\text{C}_3\text{H}_2\text{F}_6$	Hexafluoropropane
	HFC-236ca $\text{CHF}_2\text{CF}_2\text{CHF}_2$	1,1,2,2,3,3-Hexafluoropropane
	HFC-236cb $\text{CH}_2\text{FCF}_2\text{CF}_3$	1,1,1,2,2,3-Hexafluoropropane
	HFC-236ea $\text{CHF}_2\text{CHFCF}_3$	1,1,1,2,3,3-Hexafluoropropane
	HFC-236fa $\text{CF}_3\text{CH}_2\text{CF}_3$	1,1,1,3,3,3-Hexafluoropropane
HFC-245	[5] $\text{C}_3\text{H}_3\text{F}_5$	Pentafluoropropane
e.g.	HFC-245ca $\text{CH}_2\text{FCF}_2\text{CHF}_2$	1,1,2,2,3-Pentafluoropropane
	HFC-245fa $\text{CHF}_2\text{CH}_2\text{CF}_3$	1,1,1,3,3-Pentafluoropropane
HFC-365mfc	$\text{CH}_3\text{CF}_2\text{CH}_2\text{CF}_3$	1,1,1,3,3-Pentafluorobutane
HFC-43-10mee	$\text{CF}_3\text{CHFCHFCF}_2\text{CF}_3$	1,1,1,2,2,3,4,5,5,5-Decafluoropentane (2H,3H-Perfluoropentane)
HFC-c-447ef	$\text{c-C}_5\text{H}_3\text{F}_7$	Heptafluorocyclopentane

### ***Perfluorocarbons (PFCs)***

PFC-14	CF <sub>4</sub>	Tetrafluoromethane (Carbon tetrafluoride)
PFC-116	C <sub>2</sub> F <sub>6</sub> (CF <sub>3</sub> CF <sub>3</sub> )	Perfluoroethane (Hexafluoroethane)
PFC-218	C <sub>3</sub> F <sub>8</sub> (CF <sub>3</sub> CF <sub>2</sub> CF <sub>3</sub> )	Perfluoropropane (Octafluoropropane)
PFC-318 or PFC-c318	c-C <sub>4</sub> F <sub>8</sub> (-(CF <sub>2</sub> ) <sub>4</sub> -)	Perfluorocyclobutane (Octafluorocyclobutane)
PFC-3-1-10	C <sub>4</sub> F <sub>10</sub>	Perfluorobutane
PFC-5-1-14	C <sub>6</sub> F <sub>14</sub>	Perfluorohexane
PFC-6-1-16	C <sub>7</sub> F <sub>16</sub>	Perfluoroheptane
PFC-7-1-18	C <sub>8</sub> F <sub>18</sub>	Perfluorooctane

### ***Fluorinated Ethers***

HFE-449s1	C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O CF <sub>3</sub> (CF <sub>2</sub> ) <sub>3</sub> OCH <sub>3</sub> (CF <sub>3</sub> ) <sub>2</sub> CF <sub>2</sub> OCF <sub>2</sub> CH <sub>3</sub>	Methyl nonafluorobutyl ether Perfluoroisobutyl methyl ether
HFE-569sf2	C <sub>6</sub> H <sub>3</sub> F <sub>9</sub> O CF <sub>3</sub> (CF <sub>2</sub> ) <sub>3</sub> OCF <sub>2</sub> CF <sub>3</sub> (CF <sub>3</sub> ) <sub>2</sub> CF <sub>2</sub> OCF <sub>2</sub> CF <sub>3</sub>	Ethyl perfluorobutyl ether Ethyl perfluoroisobutyl ether
HFE-347pcf2	C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O (CF <sub>3</sub> CH <sub>2</sub> OCF <sub>2</sub> CHF <sub>2</sub> )	1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl ether

### ***Other Halocarbons***

Trifluoroacetic acid (TFA)	C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub> (CF <sub>3</sub> COOH)	Perfluoric acid
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### **Non-Halogenated Hydrocarbons**

Methane	CH <sub>4</sub>	R-50
Ethane	C <sub>2</sub> H <sub>6</sub> (CH <sub>3</sub> CH <sub>3</sub> )	R-170
Propane	C <sub>3</sub> H <sub>8</sub> (CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub> )	R-290
Butane	C <sub>4</sub> H <sub>10</sub> (CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub> )	R-600, n-Butane
Isobutane	C <sub>4</sub> H <sub>10</sub> ((CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>3</sub> )	R-600a, i-Butane, 2-Methylpropane
Pentane	C <sub>5</sub> H <sub>12</sub> (CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub> )	R-601, n-Pentane
Isopentane	C <sub>5</sub> H <sub>12</sub> ((CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> CH <sub>3</sub> )	R-601a, i-Pentane, 2-Methylbutane