

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



UNEP

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

MAY 2008

VOLUME 1

PROGRESS REPORT

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UNEP Technology and Economic Assessment Panel

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

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Foreword

The May 2008 TEAP Report

The May 2008 TEAP Report consists of three volumes:

Volume 1: May 2008 TEAP Progress Report

Volume 2: May 2008 TEAP Replenishment Task Force Report

Volume 3: May 2008 TEAP CTC Emissions Report

Volume 1

Volume 1 contains the essential use report, progress reports, halon evaluations, the HCFC alternatives for high ambient temperature preliminary report, the MB CUN report, a consideration on the climate issue related to Decision XIX/6, TEAP organisation issues and TEAP member biographies (this report).

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 2009-2011, in response to Decision XIX/10.

Volume 3

Volume 3 is the CTC Emissions Report by the TEAP CTC Task Force.

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1 Essential Uses

1.1 Executive Summary Essential Use Nominations for Metered Dose Inhalers

The following Table summarises the recommendations of the Technology and Economic Assessment Panel (TEAP) and its Medical Technical Options Committee (MTOC) on nominations for essential use production exemptions for chlorofluorocarbons (CFCs) for metered dose inhalers (MDIs).

Table ES-1 Recommendations for essential use nominations

	European Community	Russian Federation	United States
2009	Unable to recommend exemption for CFCs for MDIs for 38 tonnes.	Recommend exemption for CFCs for MDIs for 248 tonnes (for single-moiety salbutamol to be sold within the Russian Federation).	
2010			Unable to recommend exemption for CFCs for MDIs for 182 tonnes.

European Community: MTOC does not consider that 65 per cent (about 25 tonnes) of the nominated quantities, designated for export to Article 5 Parties, meet the requirements of Decision IV/25(b)(ii) (regarding the availability of sufficient quantity of controlled substances from existing stocks) since MTOC believes that these nominated quantities could be supplied from the existing CFC stockpiles in the European Community (about 340 tonnes). If the European Community is unable to supply the amounts for CFC MDI manufacture for export to Article 5 Parties from existing stockpiles to meet manufacturing requirements for uses, which are demonstrated to be essential, in 2009 it could make a request to the Secretariat to authorise an emergency essential use in accordance with Decision VIII/9(10), which can provide up to 20 tonnes of ODS. The remaining 35 per cent (about 13 tonnes) requested is for combination MDI products to be used within the European Community. As previously stated, MTOC does not consider these combination CFC MDI products to be an essential use under Decision IV/25(a) when the individual components, or equivalents, are available as CFC-free alternatives.

Russian Federation: The Russian Federation states that 2009 will be the last year for which it will make an essential use nomination for CFCs for MDIs. Companies in the Russian Federation are in the process of developing new HFC MDIs containing salbutamol. However, the Russian Federation states that lack of financial resources and regulatory delays are impeding the large-scale conversion of their production facilities, which it anticipates should be completed in 2010. The Russian Federation also states “any financial assistance for MDI producers or technology transfer may provide some time-saving”. Therefore it is unclear whether the Russian Federation will require CFCs for MDI manufacture in 2010. MTOC recognises the immediate need of the nomination for 2009, and the quantity of CFC is justified based on consumption trends. Further clarification is needed on the final phase-out strategy for the Russian Federation, including stockpile management.

United States: MTOC does not consider that the United States’ nomination meets the requirements of Decision IV/25(b)(ii), regarding the availability of sufficient quantity of controlled substances from existing stocks. MTOC considers that the anticipated United States’ stockpile in 2010, estimated to be about 1,000 tonnes, should be adequate to supply CFC requirements, especially with the flexibility

afforded by the additional exempted quantity for 2009. MTOC does not consider that CFC MDIs for the drug moieties subject to the nomination are an essential use under Decision IV/25(a). According to the nomination, for the bronchodilators (pirbuterol and epinephrine CFC MDIs), there are four salbutamol HFC alternatives (MTOC considers salbutamol to be a suitable alternative bronchodilator in relation to this nomination). For the inhaled steroid triamcinolone CFC MDI, there are four suitable alternative moieties in a range of formulations (HFC MDIs and DPIs).

General Comments: MTOC notes that the timelines for drug development and approval in non-Article 5 Parties mean that any formulation that is going to be available by 2010 will already have to be a final commercial formulation, which has completed clinical studies and commenced regulatory assessment in 2008 (assuming regulatory approval takes a minimum of 12 months). Parties may wish to consider not allocating CFCs to companies without a final CFC-free formulation in regulatory assessment by the end of 2008.

For combination products for which the separate moieties are available as CFC-free alternatives, MTOC believes that these combination products continue to be used for patient convenience and commercial considerations. Patients will not come to any harm by using the drugs in separate CFC-free inhalers. The combination inhalers cannot therefore be considered to be essential under Decision IV/25. Parties may wish to consider a decision not to allocate CFCs for these combination products.

Parties have a range of suitable CFC-free alternatives for domestic use. For those Parties that continue to export CFC MDIs to Article 5 Parties, one option would be for Parties to consider regulations to restrict CFC MDI export and import (and encourage a transition to export/import of HFC MDIs or DPIs) to countries where these products are no longer needed. Parties may also wish to consider establishing a date by which exports and imports of all CFC MDIs cease.

MTOC believes that with the essential use exemption process for non-Article 5 Parties in its final phase and complete global transition a few years away, accurate and complete accounting frameworks of all CFC stockpiles, including pre-1996 stocks, should be provided by all Parties who hold them. Parties may wish to consider the advantages of requiring that plans for use or disposal of stockpiles be required with future accounting frameworks. Parties that have acquired CFCs under essential use exemptions are also reminded that accounting frameworks should continue to be submitted annually to account for destruction and depletion of stocks, including through transfers or use, even after nominations are no longer made and until no further stocks remain.

1.2 Essential Use Nominations for Metered Dose Inhalers

1.2.1 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, XVI/12, and XVIII/16 have set the criteria and the process for the assessment of essential use nominations for MDIs for Parties not operating under paragraph 1 of Article 5 of the Protocol. Other essential use decisions relevant to these Parties are Decisions XIX/13, XVIII/7, and XVII/5.

1.2.2 Review of Nominations

The review of essential use nominations by the MTOC was conducted as follows.

Three members of the MTOC independently reviewed each nomination, each preparing an assessment. The exception was for the assessment of the nomination from the Russian Federation this year, which was

reviewed by the entire committee. Further information was requested where necessary. The MTOC considered the assessments, made recommendation decisions and prepared a consensus report at its meeting in Tokushima, Japan, 1-4 April 2008. Where appropriate, members declared a potential conflict of interest ahead of the discussion.

Nominations were assessed according to the guidelines for essential use contained within the *Handbook on Essential Use Nominations* (TEAP, 2005) 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 and its TOCs can consult with other individuals or organisations to assist in the review and to prepare TEAP recommendations for the Parties.

1.2.3 Summary of Parties' Essential Use Nominations and Quantities for 2009 and 2010 (in tonnes)

	European Community	Russian Federation	United States
2009	38	248	-
2010	-	-	182

1.2.4 Observations

Three essential use nominations were received for consideration by the MTOC in 2008: the European Community for 2009, the Russian Federation for 2009, and the United States for 2010. The nomination from the Russian Federation was received on 27th March 2008, after the deadline of 31st January established by Parties. Supporting documentation, including the accounting framework, for the nomination from the United States was received on 2nd April 2008, after the deadline of 31st January established by Parties.

Decision VIII/10 (1) states “*That Parties not operating under Article 5 will request companies applying for MDI essential-use exemptions to demonstrate ongoing research and development of alternatives to CFC MDIs with all due diligence and/or collaborate with other companies in such efforts and, with each future request, to report in confidence to the nominating Party whether and to what extent resources are deployed to this end and progress is being made on such research and development, and what licence applications if any have been submitted to health authorities for non-CFC alternatives*”. The nominations for the European Community and the United States state that they have requested information on on-going research and development from individual companies, which remains confidential and is not provided for review by MTOC. While MTOC is confident that nominating Parties received information regarding research and development activity towards reformulation, MTOC is unsure that some companies can complete research and development before 2010.

MTOC notes that the timelines for drug development and approval in non-Article 5 Parties mean that any formulation that is going to be available by 2010 will already have to be a final commercial formulation, which has completed clinical studies and commenced regulatory assessment in 2008 (assuming regulatory approval takes a minimum of 12 months). This means that several of the drugs, which are included in CFC volumes requested in the current nominations, will not be commercially available in a CFC-free version within this timeline. Parties may wish to consider not allocating CFCs to companies without a final CFC-free formulation in regulatory assessment by the end of 2008.

Last year, the EC stated “Companies targeting the export of generic type of CFC MDI to developing countries tend not to pursue very active R&D activities to develop alternative products. This is a remaining issue to be dealt with consistently with the phase-out of CFC MDI in Article 5 Parties.” Parties have a range of suitable CFC-free alternatives for domestic use. For those Parties that continue to export CFC MDIs to Article 5 Parties, one option would be for Parties to consider regulations to restrict CFC MDI export and import (and encourage a transition to export/import of HFC MDIs or DPIs) to countries where these products are no longer needed. Parties may also wish to consider establishing a date by which exports and imports of all CFC MDIs cease.

In addition, in its 2008 submission to MTOC, the International Pharmaceutical Aerosol Consortium (IPAC)¹ member companies have committed to “not seek new production of essential use CFCs after 2008 for use in MDIs intended for either Article 5 or non-Article 5 Parties, absent compelling evidence that existing stockpiles are unavailable – an exceptional and unlikely circumstance”. IPAC companies have also committed not to market CFC MDIs in markets in Article 5 Parties after 2009, except in very narrow circumstances. It is anticipated that CFCs for these MDIs would be sourced from existing stockpiles, rather than from new production. Rationalising small quantities of already-produced CFCs to meet patient needs in Article 5 (as well as non-Article 5) Parties, rather than simply destroying all remaining stockpiles, is a pragmatic approach.

For combination products for which the separate moieties are available as CFC-free alternatives, MTOC believes that these combination products continue to be used for patient convenience and commercial considerations. Patients will not come to any harm by using the drugs in separate CFC-free inhalers. The combination inhalers cannot therefore be considered to be essential under Decision IV/25. Parties may wish to consider a decision not to allocate CFCs for these combination products.

MTOC notes that both the European Community and the United States again report significant pre-1996 stockpiles. There are a number of issues related to the management of existing stockpiles (e.g. environmental, commercial, regulatory etc.) that are critical for Parties to resolve. MTOC believes that failure to address these issues could adversely affect final phase-out. MTOC emphasises that pre-1996 stocks should be used first; the management of stockpiles at this final stage of the phase-out will be extremely important to avoid unnecessary production of CFCs and the need for excessive destruction. Parties may wish to remind CFC MDI manufacturers that any CFCs approved under essential use exemptions must be used for this essential use (including through a transfer), transferred to an Article 5 Party for basic domestic needs, or destroyed. For essential use applications in 2010 and beyond, use of surplus CFCs for basic domestic needs is not allowable under the Protocol. Parties may also wish to review domestic laws to facilitate transfers of stockpiles between companies and/or countries.

MTOC believes that with the essential use exemption process for non-Article 5 Parties in its final phase and complete global transition a few years away, accurate and complete accounting frameworks of all CFC stockpiles, including pre-1996 stocks, should be provided by all Parties who hold them. Parties may wish to consider the advantages of requiring that plans for use or disposal of stockpiles be required with future accounting frameworks. Parties that have acquired CFCs under essential use exemptions are also reminded that accounting frameworks should continue to be submitted annually to account for destruction

¹ The International Pharmaceutical Aerosol Consortium is a group of companies (Abbott, Astrazeneca, Boehringer Ingelheim, Chiesi Farmaceutici, Glaxosmithkline, Inyx, Inc. and Sepracor, Inc.) that manufacture medicines for the treatment of respiratory illnesses, such as asthma and COPD.

and depletion of stocks, including through transfers or use, even after nominations are no longer made and until no further stocks remain.

1.2.5 Committee Evaluation and Recommendations

Quantities are expressed in metric tonnes.

European Community

Year	Quantity nominated
2009	38 tonnes

Specific Use: MDIs for asthma and COPD

Active ingredients and intended markets for which the European Community nomination applies:

Active Ingredients	Intended market
Salbutamol	Chile
Beclomethasone	Colombia, Venezuela, Pakistan, Argentina, Mexico, Chile
Budesonide	Colombia, Venezuela, Chile
Cromoglicic acid	European Community, Venezuela
Salbutamol+Ipratropium bromide (combination)	European Community
Salbutamol+Flunisolide (combination)	European Community
Salbutamol+Beclomethasone dipropionate (combination)	European Community, Chile
Isoproterenol HCl+Fenilefrina HCl (combination)	European Community

Recommendation: Unable to recommend.

Comments

MTOC notes that the transition within the European Community has continued to proceed well, with a significant reduction in the amount of CFCs nominated for 2009. MTOC also commends the European Community for making a commitment that there will be no nominations for 2010 and beyond.

However MTOC does not consider that 65 percent (about 25 tonnes) of the nominated quantities, designated for export to Article 5 Parties, meet the requirements of Decision IV/25(b)(ii) (regarding the availability of sufficient quantity of controlled substances from existing stocks) since MTOC believes that these nominated quantities could be supplied from the existing CFC stockpiles in the European Community (about 340 tonnes).

The remaining 35 percent (about 13 tonnes) requested is for combination MDI products to be used within the European Community. As previously stated, MTOC does not consider these combination CFC MDI products essential under Decision IV/25(a) when the individual components, or equivalents, are available as CFC-free alternatives.

MTOC notes with concern that the European Community continues to supply CFC-containing MDIs to some Article 5 Parties despite the availability of technically feasible alternatives in those countries. While supply to Article 5 Parties may be driven partly by economic, commercial and regulatory reasons, continuing supply may impede the speed of transition to CFC-free alternatives in Article 5 Parties. The European Community has not adequately demonstrated that continued supply of CFC MDIs to these export markets is essential.

The European Community also reported a total stockpile of about 340 tonnes (including pre-1996 stocks) at the end of 2007. This amount is higher than the total stockpile at the end of 2006 (333 tonnes, including pre-1996 stocks), contrary to expectations that Parties should be reducing their stockpiles as the final phase of the transition is entered. It appears likely that surplus CFCs will exist at the end of 2009. The European Community states that it is not known at this point to what extent the pre-1996 material (213 tonnes) will be destroyed or transferred. It also states that the assumption that the entire amount will be transferred would not be valid, as the stock of pre-1996 material contains CFC-11, -12, and -114 in quantities that may not meet the potential demand.

The European Community also states that some companies have indicated that they intend to destroy their stocks, while other companies may either transfer the rights to companies still holding a licensed quota or produce CFC MDIs for export to Article 5 Parties where the relevant CFCs “are deemed essential”. MTOC believes that best efforts should be made to facilitate the use of the stockpile for essential uses, and to avoid the production of new pharmaceutical-grade CFCs for the European Community and the need for destruction of usable CFCs.

Given the reasons outlined above, the MTOC is unable to recommend the quantity requested for CFC MDI manufacture for export to Article 5 Parties and is unable to recommend combination CFC MDIs as an essential use. However, if the European Community is unable to supply the amounts for CFC MDI manufacture for export to Article 5 Parties from existing stockpiles to meet manufacturing requirements for uses which are demonstrated to be essential, in 2009 it could make a request to the Secretariat to authorise an emergency essential use in accordance with Decision VIII/9(10), which can provide up to 20 tonnes of ODS.

Russian Federation

Year	Quantity nominated
2009	248 tonnes

Specific Usage: MDIs for asthma and COPD, for active ingredient salbutamol for use solely within the Russian Federation.

Recommendation: Exemption for CFCs for MDIs – 248 tonnes (for single-moiety salbutamol to be sold within the Russian Federation).

Comments

The MTOC reviewed a nomination for essential uses received from the Russian Federation on 27th March (after the 31st January deadline) for the production of CFCs for MDIs in the Russian Federation. The nomination is for 248 tonnes of CFCs to be used exclusively for the manufacture of salbutamol CFC MDIs for domestic use, by two local companies in 2009 (MTOC has been unable to confirm information from other sources suggesting that there could be some limited export to countries such as Mongolia).

The majority of salbutamol CFC MDIs used in the Russian Federation is locally made and substantially cheaper than imported MDIs (~ US\$2 vs US\$7). The remaining MDIs, which do not contain salbutamol, are largely imported.

In its nomination for 2008, the Russian Federation stated that it would not submit any further essential use nominations, and expected to have completed its CFC MDI transition by the end of 2008. However, it now states that 2009 will be the last year for which it will make an application for an essential use exemption for CFCs for MDIs. Companies in the Russian Federation are in the process of developing new HFC MDIs containing salbutamol. However, the Russian Federation states that lack of financial resources and regulatory delays are impeding the large-scale conversion of their production facilities, which it anticipates should be completed in 2010. The Russian Federation also states “any financial assistance for MDI producers or technology transfer may provide some time-saving”. Therefore it is unclear whether the Russian Federation will require CFCs for MDI manufacture in 2010.

MTOC recognises the immediate need of the nomination for 2009, and the quantity of CFC is justified based on consumption trends. Further clarification is needed on the final phase-out strategy for the Russian Federation, including stockpile management. MTOC notes that there were discrepancies in the stockpile accounting in the framework when compared with last year.

United States

Year	Quantity nominated
2010	182 tonnes

Specific Use: MDIs for asthma and COPD, for the following active ingredients for use solely within the United States: epinephrine, pirbuterol, triamcinolone.

Recommendation: Unable to recommend.

Comments

The nomination from the United States is for 182 tonnes CFCs for use in 2010, for the manufacture of epinephrine, pirbuterol, and triamcinolone CFC MDIs for domestic use only. This is a reduction of 35 percent on the exemption for 2009 (282 tonnes). Parts of the nomination were received on time, but the accounting framework and other supporting documentation were received during the MTOC meeting on 2nd April, after the 31st January deadline established by Parties.

MTOC does not consider that the nomination meets the requirements of Decision IV/25(b)(ii), regarding the availability of sufficient quantity of controlled substances from existing stocks. At the end of 2007, the United States' stockpile was 1,489 tonnes of CFCs (including pre- and post-1996 stocks). In addition, the United States has an essential use exemption for 2009 of 282 tonnes. The Parties consider it reasonable to maintain a stock of one year's operational supply (including Decisions XVI/12 and XVII/5). Taking these matters into account, MTOC considers that the anticipated United States' stockpile in 2010 should be adequate to supply CFC requirements, especially with the flexibility afforded by the additional exempted quantity for 2009.

MTOC does not consider that CFC MDIs for these drug moieties are an essential use under Decision IV/25(a). According to the nomination, for the bronchodilators (pirbuterol and epinephrine CFC MDIs), there are four salbutamol HFC alternatives (MTOC considers salbutamol to be a suitable alternative bronchodilator in relation to this nomination). For the inhaled steroid triamcinolone, there are four suitable alternative moieties in a range of formulations (HFC MDIs and DPIs).

The US FDA is undertaking a further series of rule-making processes. Under these, the essential use designation under US law for salbutamol will be removed after 31st December 2008. Under two proposed rules to amend regulations, the essential use designation under US law of pirbuterol and triamcinolone CFC MDIs would be removed (and no longer for sale) after 31st December 2009, and epinephrine CFC MDI after 31st December 2010. The final rules are expected during 2008.

Salbutamol HFC MDI sales have increased steeply and by April 2008 it is estimated that they constitute 70 percent of total salbutamol inhaler sales. Consequently MTOC calculates that CFCs required for salbutamol MDI manufacture in 2008 could be reduced to about 150 tonnes in the United States. MTOC estimates that total CFC use for MDIs could be less than 500 tonnes in 2008, and less than 300 tonnes in 2009. With this declining consumption combined with a domestic allocation of 27 tonnes in 2008 (proposed by the United States) and an exemption of 282 tonnes in 2009, the stockpile may be about 1,000 tonnes in 2010.

One company (Armstrong) manufactures salbutamol CFC MDIs, and is also the only manufacturer of epinephrine CFC MDIs. Armstrong has indicated that a replacement epinephrine HFC MDI will not be available until 2011, raising the question of future essential use applications. MTOC believes that the company could instead consider using its existing CFC stock (originally designated for salbutamol) to produce epinephrine CFC MDIs in 2010.

2 Updated Response to Decision XVIII/16: Difficulties faced by some Article 5 Parties manufacturing metered-dose inhalers which use chlorofluorocarbons

2.1 Executive Summary

Progress has been made towards transition in the use of CFC metered dose inhalers (MDIs) in Article 5 Parties for certain key moieties, with a range of technically feasible alternatives available. However, for many Article 5 Parties, the conversion of locally owned CFC MDI manufacturing is only just commencing.

The mandated phase-out date under the Montreal Protocol for the global production of CFCs is only a little more than one year away. The Montreal Protocol's Decision IV/25 allows for the production of CFCs for essential uses, if approved by Parties, after the mandated phase-out date. The pace of implementation of projects to convert CFC MDI manufacturing in Article 5 Parties will largely determine the quantities of CFCs that will be required for CFC MDI manufacturing after 2009. However, the economics of CFC production will make impractical the continued production of small amounts of pharmaceutical-grade CFCs after 2009.

Given the uncertainties and risks associated with the long-term supply after 2009 of suitable quality CFCs, the Medical Technical Options Committee (MTOC) emphasises that the highest priority for continued supply of inhalers is to complete transition as quickly as possible and ensure the expeditious introduction of CFC-free alternatives.

As an update to its response to Decision XVIII/16 in the April 2007 *Progress Report of the Technology and Economic Assessment Panel*, the MTOC considered a number of options for the production of pharmaceutical-grade CFCs after 2009 and recommends a preferred option that can best facilitate the final phase-out of CFCs MDIs in countries that are still manufacturing CFC MDIs.

Open-ended annual CFC production after 2009 (under annual essential use exemptions) is not recommended. It does not provide a clear target or timetable for ending CFC production, predictability for CFC producers, or incentive for those companies currently manufacturing CFC MDIs to switch to CFC-free alternatives. At a certain point, the economics of CFC production would not be favourable, and would make impractical and too uncertain the continued production of relatively small amounts of pharmaceutical-grade CFCs. At this point, continuity of affordable healthcare would be jeopardised. Overall destruction costs for out-of-specification CFCs would be relatively high with this option.

In its 2007 report, MTOC proposed a final campaign in 2009, which is no longer recommended for 2009 for two reasons. In 2007 Parties did not adopt a decision on a final campaign, deferring consideration until a later date. To manage a final campaign in 2009, it will be necessary to make several decisions, for which lead times are needed. Also, the large-scale conversion of local CFC MDI manufacturing in Article 5 Parties is slower than anticipated, and so the quantity for a final campaign in 2009 is now larger, estimated to be about 5,000 tonnes. The logistics of organising such a large production campaign no later than 2009, the short timeframe for the associated essential use nomination and approval process, and the large costs of inventory and storage make this option impractical.

MTOC believes that with appropriate planning and co-ordination a final campaign production of pharmaceutical-grade CFCs could be feasible in 2011, providing for CFC MDI manufacturing countries that do not have domestic CFC production. This option assumes that project implementation is not delayed further, and presumes that China maintains domestic production of pharmaceutical-grade CFCs and continues annual CFC production, if approved by Parties under the essential use process, until it completes its national CFC MDI phase-out. Anticipating a final campaign production at an agreed date provides a clear target for ending CFC production, predictability for CFC producers, and incentive for those companies currently manufacturing CFC MDIs to switch to CFC-free alternatives.

It will be necessary to wait at least another year to assess the progress of phase-out projects and their impact on future requirements of CFCs before confirming the date of a final campaign production. Based on estimated CFC requirements, the economics of CFC production should be favourable, firstly in 2010 to allow annual production (of between 1,200-1,700 tonnes) in that year under an essential use, and then in 2011 for a final campaign production for multiple years. The quantity of the final campaign production, for all countries excluding China, would be between 1,000-2,000 tonnes (depending on whether India ceases CFC production and import for MDI production at the end of 2009 or not). Costs would be relatively lower than for open-ended annual CFC production (for destruction of out-of-specification CFCs) and the costs and logistics of organising a more modest campaign make a final campaign in 2011 more practical than in 2009 or 2010.

Article 5 Parties' essential use nominations will need to be submitted by 31st January 2009 for Parties to consider essential use exemptions for CFC production in 2010. In order to anticipate a final campaign production, accurate forward projections will be needed of annual quantities of each CFC required for MDI manufacture for 2010 and for each year thereafter until each Party's agreed phase-out date. These projections should accompany and justify each year's nomination for 2010 and onwards, starting with the nominations submitted in 2009. This would allow an accurate global picture to be developed from 2009, and a recommendation by TEAP on the preferred date for a final campaign to be made. It is anticipated that in 2009, Parties would consider Decisions to approve the CFC volumes intended for manufacture in 2010 only. In the next year (2010), the remaining volumes to complete phase-out in each Party would be considered and, if appropriate, approved to allow a final campaign production to occur in 2011.

A final campaign production risks exaggerated and non-essential use of CFCs produced for multiple years. Therefore a multi-year essential use production exemption to allow a final campaign production will need to work in parallel with an annual exemption process to approve annual quantities to be *used* from the stockpile produced under a final campaign, and to signal the need for destruction of any surplus CFCs.

MTOC believes that a co-ordinated approach to the final phase of the CFC MDI transition is needed to overcome some of the technical challenges. The current pace of CFC MDI manufacturing phase-out in Article 5 Parties is slow because access to suitable CFC-free technology is difficult. The implementing agencies are being asked to undertake very challenging projects with very short timelines, and delays will inevitably occur – this is the nature of “new product development”.

A co-ordinated approach could:

- Maximise the chances of successful product development;
- Allow equipment manufacturers transparent understanding of the timing of future equipment needs for HFC MDI production lines; and
- Better estimate the need for final campaign production of pharmaceutical-grade CFCs, and facilitate stockpile storage and destruction.

Parties may wish to consider the appointment of a single entity to co-ordinate these urgent and complex issues and activities, while also recognising the need to continue to address country specific requirements and country/company-specific project implementation.

Pharmaceutical-grade CFCs to supply CFC requirements for MDI production after 2009 could also be sourced from remaining surplus CFC stockpiles in non-Article 5 Parties. Sourcing CFCs from existing stockpile of pharmaceutical-grade CFCs in preference to new CFC production is a requirement of Decision IV/25(1)(b). A co-ordinated approach to identifying, locating and transferring surplus stockpiles would be an advantage for Article 5 Parties, and would avoid destruction of CFCs that could otherwise be diverted to an essential use. Parties may also wish to review domestic laws to facilitate transfers of stockpiles between companies and/or countries.

MTOC has reviewed the Protocol's current essential use decisions and supporting guidance in the *Handbook on Essential Use Nominations* (TEAP, 2005), to conclude whether the essential use process can accommodate the situation of Article 5 Parties, the last stages of global transition and final campaign production. As a result, MTOC has suggested options to refine and modify the essential use framework. Parties may wish to consider these options in making a set of new Decisions that build on the previous essential use Decisions and associated guidance on information requirements in the Handbook. Parties may wish to consider a suite of new Decisions because some of the existing Decisions are currently not applicable to Article 5 Parties but their intended effects are still relevant; other Decisions may need strengthening; and new Decisions may be needed to take account of issues not currently included.

2.2 Background

At their 17th Meeting, the Parties to the Montreal Protocol discussed the difficulties faced by some Article 5 Parties with respect to the phase-out of chlorofluorocarbons (CFCs) used in the manufacture of MDIs. In Decision XVII/14 the Parties expressed their concern that Article 5 Parties that manufacture CFC MDIs might find it difficult to phase out these substances without incurring economic losses to their countries. There was the further risk that, for some Article 5 Parties, consumption levels in 2007 of CFCs for MDIs might exceed the amounts allowed for all CFC uses under the Protocol.

The Parties considered the issue again at their 18th Meeting and took Decision XVIII/16. Paragraph 12 of this Decision requested:

“TEAP to assess and report on progress at the 27OEWG and to report to the MOP19 on the need for, feasibility of, optimal timing of, and recommended quantities for a limited campaign production of chlorofluorocarbons exclusively for metered-dose inhalers in both Parties operating under paragraph 1 of Article 5 and Parties not operating under paragraph 1 of Article 5.”

The TEAP and its MTOC included its response to Decision XVIII/16 in the April 2007 *Progress Report of the Technology and Economic Assessment Panel* to the 27th Open-ended Working Group Meeting. The Open-ended Working Group discussed the possibility of maintaining the current system of “just-in-time production”. However, the Working Group did not achieve consensus, and accordingly agreed that interested Parties would consult informally on the text of a draft decision on the matter for consideration by the 19th Meeting of the Parties. In the ensuing discussion, one representative stated that her Government was currently engaged in consultations with pharmaceutical companies that manufactured CFCs for metered-dose inhalers and was not yet in a position to make a decision on the item. The Meeting of the Parties agreed to defer further consideration of the matter until a later meeting.

In this updated response to Decision XVIII/16, MTOC has reviewed new information available from the Multilateral Fund Secretariat, implementing agencies, countries, and industry sources. This report considers not only those Parties manufacturing CFC MDIs but also issues surrounding CFC MDI transition in importing Article 5 Parties.

MTOC also drew on the resources, information, and outcomes of the recent South Asia and Southeast Asia & Pacific Regional Thematic Workshop on Phasing-out CFC Metered Dose Inhaler (MDI) in Langkawi, Malaysia, during 13-15 March 2008, which was attended by 23 countries and 6 industries in the region producing MDIs, and also a number of MTOC members. Some of the key outcomes were the Langkawi Declaration on Public-Private Partnership on Phasing Out CFC Metered Dose Inhalers and the conclusions and recommendations, which are referred to further in this report. The UNEP DTIE OzoneAction Programme wrote to TEAP on 27th March 2008 conveying some of the important findings of the workshop and requesting TEAP to consider some aspects in its report, including:

1. *“Options for storage and handling of stockpile pharmaceutical-grade CFCs and their surrounding issues;*
2. *Logistics and transfer to destruction facilities of “Out of Specification” CFCs;*
3. *Safe specifications for pharmaceutical-grade CFCs and appropriate testing method to ensure that specifications are met;*
4. *Procedures for a Multi-year Essential Use Nomination.”*

These and other issues are addressed below.

2.3 Progress and challenges in CFC MDI manufacturing transition in Article 5 Parties

Most Article 5 Parties have their inhalers provided by importation. As elaborated in section 2.3, progress has been made towards transition in the use of CFC MDIs in Article 5 Parties for certain key moieties, with a range of technically feasible alternatives available. However, for many Article 5 Parties the conversion of locally owned CFC MDI manufacturing is only just commencing.

MDIs may be manufactured in at least 20 Article 5 Parties (Algeria, Argentina, Bangladesh, Brazil, China, Colombia, Croatia, Cuba, Egypt, India, Indonesia, Iran, Jordan, Mexico, Pakistan, South Africa, Syria, Tunisia, Uruguay, Venezuela), with an estimated consumption of about 2,100 tonnes in 2007. Many have locally owned MDI manufacturing companies that are not affiliated with multi-national pharmaceutical companies.

Some countries (e.g. Croatia and Tunisia) have successfully completed their manufacturing transition to CFC-free inhalers. A number of countries (e.g. Cuba, Uruguay, Egypt, and Iran) have requested financial assistance in recent years from the Multilateral Fund (MLF) to achieve the conversion of their industry to produce CFC-free alternatives, and a number are in the process of seeking assistance from the MLF (e.g. China and India). A number of countries (e.g. Algeria, Brazil, Jordan, Syria) are not eligible for funding by the MLF under the decisions of the Executive Committee. At its 54th Meeting, the Executive Committee of the MLF decided (Decision 54/35) that all requests for MDI investment projects be submitted for Executive Committee consideration no later than the 56th Meeting at the end of 2008, and that requests would not be considered eligible for funding after that meeting.

Table 2-1 summarises MTOC's current understanding of transition status for most Article 5 Parties with CFC MDI manufacturing. Detailed country information is also available from Executive Committee documents, such as ExCom/51/39¹.

The implementing agencies of the MLF (UNDP and UNIDO) are responsible for implementing MLF-funded MDI investment projects and work with the companies and the respective governments to achieve the agreed timelines. This has proven to be a challenging task, and it appears likely that production of CFCs will be needed to supply MDI manufacture after 31 December 2009 in a number of countries where manufacturing conversion will not have been completed.

¹ UNEP/OzL.Pro/ExCom/51/39, <http://www.multilateralfund.org/files/51/5139.pdf>

Table 2-1 Status of transition in Article 5 Parties with CFC MDI manufacturing

Status of transition in Article 5 Parties with CFC MDI manufacturing	Algeria	Argentina	Bangladesh	Brazil	China	Colombia	Cuba	Egypt	India	Indonesia	Iran	Jordan	Mexico	Pakistan	South Africa	Syria	Uruguay	Venezuela
Approved investment projects with MLF funding			✓ ¹				✓ ²	✓ ³			✓ ⁴		✓ ⁵				✓ ⁶	
Requesting MLF funding for MDI investment project or for project preparation of an MDI investment project		✓ ⁷			✓ ⁸	✓ ⁹			✓ ¹⁰	✓ ¹¹				✓ ¹²				✓ ¹³

¹ MDI investment project approved (ExCom decision 52/32). Expected completion date 48 months after commencement (UNEP/OzL.Pro/ExCom 52/26).

² MDI investment project approved. Expected completion date was March 2008 (UNEP/OzL.Pro/ExCom/51/39), but is now October 2008.

³ MDI investment project approved. Expected completion date December 2009 (UNEP/OzL.Pro/ExCom/51/39), but is now about 2010.

⁴ MDI investment project approved. Expected completion date is 28 to 30 months after the national transition strategy and the MDI phase-out investment project have been approved by ExCom (UNEP/OzL.Pro/ExCom 52/36), which is now about 2010-2011.

⁵ MDI investment project approved (ExCom/53/67). Expected completion date February 2011 (UNEP/OzL.Pro/ExCom/53/44).

⁶ MDI investment project approved. Expected completion date was July 2007 (ExCom/51/39), but is now at least the 2nd quarter of 2008.

⁷ Project preparation proposal approved. Project proposal expected to be submitted for ExCom consideration during 2008.

⁸ Project proposal expected to be submitted for ExCom consideration during 2008.

⁹ Project preparation proposal submitted for ExCom consideration in 2007, and again in 2008 (UNEP/OzL.Pro/ExCom/54/Inf.5). Project preparation proposal approved at 54th Meeting of ExCom.

¹⁰ Project preparation proposal approved under ExCom decision 52/25. MDI investment project proposal expected to be submitted for ExCom consideration at its 55th Meeting in July 2008.

¹¹ MTOC understands that there may be CFC consumption for medical aerosols in Indonesia, but not for MDIs.

¹² Project preparation proposal expected to be submitted by UNDP for ExCom consideration during its 55th Meeting (UNEP/OzL.Pro/ExCom/54/19).

¹³ Not eligible for funding under ExCom decision 35/57. Project proposal expected to be submitted for ExCom consideration at its 56th Meeting, November 2008.

Table 2-1: Status of transition in Article 5 Parties with CFC MDI manufacturing (cont.)

Status of transition in Article 5 Parties with CFC MDI manufacturing	Algeria	Argentina	Bangladesh	Brazil	China	Colombia	Cuba	Egypt	India	Indonesia	Iran	Jordan	Mexico	Pakistan	South Africa	Syria	Uruguay	Venezuela
Not eligible for funding by the MLF	✓ ¹⁴			✓ ¹⁵								✓ ¹⁶			✓ ¹⁷	✓ ¹⁸		

¹⁴ Not eligible for funding (ExCom decision 35/57). Project proposal expected to be submitted for ExCom consideration at its 56th Meeting, November 2008.

¹⁵ Not eligible for funding by the MLF. There are two producers in Brazil for which shareholder composition is fully from non-Article 5 Parties, and which are working without assistance from the Multilateral Fund on the conversion of their CFC MDIs to alternatives.

¹⁶ Not eligible for funding (ExCom decision 35/57). Project proposal expected to be submitted for ExCom consideration at its 56th Meeting, November 2008. MTOC understands that there may be CFC consumption for medical aerosols in Jordan, but not for MDIs.

¹⁷ Not eligible for funding by the MLF. CFC consumption for MDIs is estimated to be about 71 tonnes, and there are 18 locally owned MDI manufacturers.

¹⁸ Not eligible for funding (ExCom decision 35/57). Project proposal expected to be submitted for ExCom consideration at its 56th Meeting, November 2008.

2.4 Elements needed for successful transition in Article 5 Parties

Elements needed for successful transition in Article 5 Parties include:

- National CFC MDI transition strategies: to facilitate the transition through national networks working towards shared goals, with a focus on patient health;
- Global partnerships and co-operation: to share information, facilitate decision-making and global consistency, and respond quickly to resolve any potential barriers; and
- Adequate funding, capacity building and support through the institutions of the Montreal Protocol: to facilitate timely CFC MDI manufacturing transition, and to ensure a framework suited to the circumstances of Article 5 Parties and the final stages of phase-out.

Some of these elements are elaborated below.

2.4.1 *National CFC MDI transition strategies*

National transition strategies to non-CFC-MDI alternatives need to be developed on a country-by-country basis with the participation of major stakeholders, such as the relevant environment, health and trade authorities, physician and patient groups, pharmaceutical companies, and CFC/HFC importers (where there is local MDI manufacture). All stakeholders must be involved, and the formation of private/public partnerships is essential. Transition strategies must have a clear, final date by which time the country expects no longer to need CFC MDIs. The details of a strategy vary according to the circumstances of the country, its health system and whether it imports or locally manufactures CFC MDIs. Transition strategies need to ensure adequate supplies of inhaled therapy throughout the transition period. Protection of patient health should be the key guiding principle in transition strategies.

In preparing their national transition strategies, Parties may wish to consider successful strategies adopted by Article 5 and non-Article 5 Parties. Several Article 5 Parties, including Fiji, Malaysia, Thailand and the Philippines, have already successfully implemented their national transition strategies, and are on track to complete transition by 2010. The regional workshops currently being conducted (such as the Langkawi workshop for the South Asia and South East Asia Pacific region) will greatly assist Parties in the development and implementation of national strategies.

The slow progress of some countries to develop national transition strategies is of concern. It is important that Article 5 Parties develop their own national transition strategy and provide them to the Secretariat, to be posted on its website, and then to report each year on progress in transition, both in accordance with Decision XII/2. Parties may also wish to consider making a national transition strategy a requirement for Article 5 Parties nominating for an essential use exemption to produce CFCs for MDIs, as has been the case for Parties not operating under Article 5.

Issues and actions to be addressed in national transition strategies are:

- Determination of a final phase-out date for CFC MDIs, setting a target and timetable;
- Availability and affordability of CFC-free alternatives, through an investigation of CFC and CFC-free alternatives on the national market;

- Fast-track approval for CFC-free alternatives, and assuring seamless availability of inhaled therapy;
- Serious consideration by relevant authorities of pricing policies favourable to CFC-free alternatives and removal of any associated tariffs and import taxes;
- Timely withdrawal of CFC MDIs following a reasonable post-marketing period for CFC-free inhalers (absent compelling circumstances, MTOC recommends 12 months), and consideration of establishment of policies and regulations to ban parallel marketing and imports of CFC MDIs after a certain date;
- Educational activities for patients, doctors and other healthcare providers on the reasons for phase-out, supported by pharmaceutical companies and health authorities;
- CFC-free MDIs to be clearly labelled as such on the packaging, with consideration given to the development and promotion of an agreed CFC-free logo to be displayed on CFC-free MDIs; and
- The anticipated timelines of any MDI investment projects funded by the MLF to assist technology transfer.

Some Parties may also wish to consider application to the Asthma Drug Facility (ADF) of the International Union Against Tuberculosis and Lung Disease for the supply of low cost CFC-free MDIs (www.GlobalADF.org). The ADF provides access to affordable good quality essential asthma drugs, promotes the use of CFC-free inhalers and the monitoring of asthma management for quality care. Some countries have indicated that the necessary commitment to data collection could be challenging for them. The conclusions of the Langkawi Workshop suggested that Sri Lanka applies to the ADF as a pilot program.

2.4.2 Global partnerships

Partnerships between government, industry, and non-government organisations can facilitate successful transition in Article 5 Parties.

Regional alliances of Article 5 Parties may facilitate transition through common strategies. The Langkawi MDI Workshop for the Asia-Pacific region held in March 2008, as well as other workshops scheduled later in the year for other regions, is a prime example of how such collaborative efforts can be of value in advancing common goals in this regard. Future MLF-funded regional meetings that are planned for other regions, include Africa, Eastern Europe and Central Asia, and Latin America.

The Langkawi Workshop developed a Langkawi declaration as a public-private partnership between government and industry. This partnership model could be propagated to resolve common challenges facing Article 5 Parties that require a concerted effort by governments and industry.

Some of the factors that may impact CFC phase-out in the Article 5 Parties that could be addressed through a partnership approach, include:

- Timely withdrawal of CFC MDIs as alternatives become available. This can be addressed through co-operation between government and industry (and included in a national transition strategy), including through import bans;

- Prompt government regulatory actions to approve CFC-free alternatives, through a commitment by governments to industry to facilitate regulatory approvals;
- Pricing policies favourable to CFC-free alternatives, through a commitment by governments to review and remove tariffs and import taxes.

2.4.3 Adequate funding and capacity building

Capacity building through transfer of technology or expertise in accordance with Article 10A (of the Protocol) is necessary to help countries in which companies are still trying to develop CFC-free MDI formulations.

Timely and effective management of projects by the implementing agencies (UNIDO and UNDP) will be critical to successful transition. At the present time there is no successfully completed project, and most approved projects are behind schedule. Projects need to be initiated and completed within realistic timelines that take account of the experience gained so far.

Current approved projects are often for new product development by locally owned companies in Article 5 Parties. Projects may take in excess of five years to complete due to the requirement for new manufacturing processes, clinical testing, regulatory approval and commercialisation. Delay in project implementation will further prolong CFC MDI phase-out. In-licensing of established products may be faster than new product development, and should be considered as an option.

Dry powder inhalers (DPI) are less commonly used in Article 5 Parties, because the more recently introduced DPI devices are technically sophisticated and more expensive than MDIs. However, single dose DPIs using simple devices (eg. *Rotahaler*®) are widely used in India and elsewhere. The technology required to manufacture such devices and units may be easier to transfer and the cost of setting up a manufacturing facility should also be less.

The principal supplier of manufacturing lines for HFC MDIs (Pamasol Willi Mäder AG, Switzerland) currently has a lead-time of 6-12 months to supply new plant. This means that planned scheduling of orders for new lines is essential, and needs a co-ordinated approach by the implementing agencies to minimise delays.

MTOC believes that a co-ordinated approach to the final phase of the CFC MDI transition is needed to overcome some of the technical challenges. Regional level workshop(s) facilitated by the implementing agencies can assist transition efforts and this process is now underway. However, the current pace of CFC MDI manufacturing phase-out in Article 5 Parties is slow because access to suitable CFC-free technology is difficult. The implementing agencies are being asked to undertake very challenging projects with very short timelines, and delays will inevitably occur – this is the nature of “new product development”.

A co-ordinated approach could:

- Maximise the chances of successful product development;
- Allow equipment manufacturers transparent understanding of the timing of future equipment needs for HFC MDI production lines; and
- Better estimate the need for final campaign production of pharmaceutical-grade CFCs, and facilitate their storage and destruction.

Parties may wish to consider the appointment of a single entity to co-ordinate these urgent and complex issues and activities, while also recognising the need to continue to address country specific requirements and country/company-specific project implementation.

2.5 Estimated CFC requirements to supply MDIs in 2010 and beyond

Table 2-2 summarises MTOC's analysis of CFC consumption for MDI manufacture in those Article 5 Parties with local production of CFC MDIs. This analysis estimates future requirements of CFCs up to the year 2013 and updates the data presented in the April 2007 *Progress Report of the Technology and Economic Assessment Panel*.

MTOC's updated analysis includes data provided by industry and government representatives at the Langkawi South Asia and SEAP Regional Workshop on Phasing-out CFC based Metered Dose Inhalers. New information regarding the situation of approved CFC MDI phase-out projects was available from a range of sources including the MLFS, the implementing agencies and MTOC members. Information available from the April 2008 54th Executive Committee Meeting was also taken into account. In particular, Decision 54/35 establishes a CFC production phase-out agreement for India by 1 August 2008, including limits on CFC production and consumption for MDIs for 2008 and 2009, and with no allowance for CFC imports after 2009. However, it is not clear whether this agreement will mean that India does not seek essential use consumption (production and import) of CFCs for MDIs after 2009. Table 3-2 includes previously unreported production in Venezuela. No data were available for Algeria, Jordan, or South Africa, where CFC MDI manufacture may also be occurring.

The main constraint in the implementation of MDI investment projects has been access to suitable CFC-free inhaler technology. The implementing agencies are facing major challenges in securing technical assistance for what have become individual "new product development" projects for CFC-free alternatives. It now appears that the time required for new product development and the time to have a formulation available on the market were underestimated at the time of project preparation. In a few cases the projects have faced delays in the delivery of the MDI manufacturing equipment. The equipment for the manufacture of HFC MDIs is highly specialised and the principal supplier has a significant backlog of orders.

Given the delays in the preparation, approval and implementation of projects, MTOC has made assumptions about the annual consumption data for a number of countries, combined with information provided by technical experts and from the Langkawi meeting. The table shows consumption up to and including 2013, although it is too early to know whether this would actually be the final year of CFC MDI production need or not. A few countries (including China and India) in Langkawi indicated that they might continue production of CFC MDIs up to 2014-2015.

The assumption that some Parties would still need CFCs in 2013 was used to estimate a global requirement for future production of CFC MDIs in Article 5 Parties. These estimates were then used to evaluate preferred strategic options for the final phase-out of CFC MDI production. Any CFC consumption after 2013 is difficult to estimate; if any, it is likely to be relatively small and unlikely to be a significant proportion of the overall projected quantity, but that would still need to be phased out.

Table 2-2 Estimated CFC demand for Article 5 Parties with local production of CFC MDIs*

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013
Countries with an approved project for the complete phase-out of CFCs for MDIs									
Bangladesh	61.8	76.0	60.0	66.0	72.6	120.0	105.0	15.0	45.0
Cuba	109.0	114.5	120.2	126.2	35.0				
Egypt	159.5	163.0	176.0	190.1	205.3	221.0	200.0		
Iran	68.2	96.4	102.0	112.2	123.4	100.0	70.0	50.0	40.0
Mexico	47.5	52.3	57.5	63.2	69.5	76.5	50.0		
Uruguay	10.0	10.5	11.0	11.6	12.2	12.8	5.0		
Subtotal	456.0	512.6	526.7	569.3	518.1	530.3	430.0	65.0	85.0
Countries without an approved project for the complete phase-out of CFCs for MDIs as of March 2008									
Argentina	187.7	180.0	180.0	200.0	220.0	150.0	165.0	80.0	
Brazil	156.9	134.5	148.0	162.7	179.0				
China	243.7	280.9	309.0	339.9	373.9	400.0	440.0	484.0	550.0
Colombia	2.1	2.3	10.0	11.0	12.1	3.4	3.0		
India	748.3	773.7	780.0	412.5	412.5	400.0	350.0	265.0	345.0
Indonesia	30.1	33.1	36.4	40.1	44.1	48.5	40.0		
Pakistan	85.8	80.0	80.0	80.0	80.0	36.0	36.0	20.0	
Syria	20.0	22.0	38.0	41.8	46.0	50.6	33.0	33.0	
Venezuela			22.9	29.6	32.5	20.0			
Subtotal	1,474.6	1,506.6	1,604.2	1,317.6	1,400.1	1,108.4	1,067.0	882.0	895.0
Total	1,930.6	2,019.2	2,130.9	1,886.9	1,918.1	1,638.7	1,497.0	947.0	980.0

*Data was not available for Algeria, or South Africa (estimated consumption in 2007 was 71 tonnes p.a.). Data was not available for Jordan, although MTOC understands CFC consumption is for medical aerosols, not MDIs. Data was included for Indonesia, although CFC consumption may be for medical aerosols, not MDIs. Multinational companies operating in Article 5 Parties are assumed to complete CFC MDI production in 2009.

CFCs are still used by multinational pharmaceutical companies operating in Article 5 Parties like Argentina, China, India and Pakistan. It is assumed that this use will decrease to zero in 2009.

In Table 2-2 it can be observed that the projected annual total for all Article 5 Parties that manufacture CFC MDIs is between 1,200-2,000 tonnes per annum for the period 2008-2010.

The two largest consumers of pharmaceutical-grade CFCs are China (up to 1,900 tonnes projected for the years 2010-2013) and India (up to 1,400 tonnes projected for the years 2010-2013, according to data presented in Langkawi, or 0 tonnes, if Executive Committee Decision 54/35 applies to the cessation of import after 2009 of any kind of CFCs, including essential use CFCs). The total requirements for the remaining Article 5 Parties between 2010 and 2013, excluding China and India, amount to less than 2,000 tonnes. It is not clear at this stage whether pharmaceutical-grade CFC production in non-Article 5 Parties, such as the Russian Federation, will be required during this period, but consumption, if any, is likely to be relatively small, and is not considered further here.

2.6 Pharmaceutical-grade CFC supply during transition

Pharmaceutical-grade CFCs for MDIs are manufactured in a few locations globally: USA (Honeywell); Spain (Arkema); India (Navine and possibly others); and China (Juzhou). The plants in India and China are currently scheduled to cease production in August 2008 and in 2009, respectively, based on agreements with the Multilateral Fund.

China stopped production of CFCs in 2007 with the exception of one plant with capacity to produce 550 tonnes of CFCs to cover its pharmaceutical-grade CFC requirements. The phase-out project for CFC MDIs in China has been under discussion during the last year and will be resubmitted at the 55th Executive Committee meeting. This project will cover a number of MDI products including those that deliver traditional Chinese medicine. It is unlikely that reductions

in CFC consumption for MDIs due to the implementation of this project would be noticeable before 2013. China has the production capacity to supply its own pharmaceutical-grade CFC requirements.

India has local production of pharmaceutical-grade CFCs for the manufacture of MDIs, and also currently imports some of its CFC requirements. Under Decision 54/35 of the 54th Executive Committee, India has agreed to cease CFC production in August 2008, and is allowed to sell up to 825 tonnes (690 tonnes to be produced before August 2008, and 135 tonnes from existing stockpile) of pharmaceutical-grade CFCs into MDI production in 2008 and 2009. The agreement also states, "*India will not import any more CFCs of any kind*". However, it is not clear whether this agreement will mean that India does not seek essential use consumption (production and import) of CFCs for MDIs after 2009.

There are several MDI producers in India, including at least one multinational, that intend to close CFC MDI production in 2009. Several of the local producers have also already developed alternative HFC-based products and DPIs. Despite this, it is not yet clear whether MDI manufacturers will seek essential use exemptions for 2010 onwards to import pharmaceutical-grade CFCs. MTOC has assumed consumption of CFCs for MDIs according to the data received from Indian representatives of government and industry during the Langkawi workshop. However, it should also be noted that, in the case of India, there are widespread alternatives to CFC MDIs already available.

All other Article 5 Parties with CFC MDI manufacture rely on imported CFCs for MDI production.

2.6.1 Final campaign production considerations

Some Article 5 Parties have approved projects for the phase-out of their CFC MDI manufacturing, some of which may not be completed by the end of 2009. Under Decision 54/35, the Executive Committee agreed that Parties with requests for funding investment projects for CFC MDI manufacture must come forward for consideration by the Executive Committee by the 56th Meeting, November 2008 "*to provide ample time for project initiation before the 2010 phase-out and to avoid, to the extent possible, the need for essential-use exemption requests*". After 2009, Article 5 Parties may be in potential non-compliance unless CFC production for MDIs is under an essential use exemption.

There is no co-ordinated manufacture of pharmaceutical-grade CFCs and competition/anti-trust legislation would forbid such an arrangement. There are no dedicated pharmaceutical-grade CFC plants left, except for one in China, and there are only a few multi-product plants that can make pharmaceutical-grade CFCs.

Depending upon operational parameters, a bulk CFC production facility will produce a certain percentage of CFCs that do not meet the pharmaceutical-grade specifications required by MDI manufacturers. Although the expectations for purity may vary between Article 5 Parties, the percentage of production not fit for pharmaceutical use is projected to be no lower than 25 per cent and may be as high as 50 per cent of CFC production. Currently, CFCs that do not meet pharmaceutical specifications can be used for basic domestic consumption. This will not be possible after 2009 when these non-pharmaceutical-grade CFCs would need to be destroyed.

Further, the larger the quantity of a single campaign production of CFCs, the lower the proportion of low quality, out-of-specification, CFCs will be produced. Conversely, the smaller the quantity

is, the higher the proportion of low quality CFCs produced. For a single plant, a quantity of about 200 tonnes may be the limit below which CFC production becomes impractical, both for the efficiency and cost of CFC production.

These factors mean that the economics of CFC production will make impractical the continued production of small amounts of pharmaceutical-grade CFCs after 2009. These are important factors that need to be kept in mind when considering options for CFC production after 2009 and for final campaign production needs and timing.

Given the uncertainties and risks associated with the long-term supply of suitable quality CFCs after 2009, MTOC emphasises that the best option for continued supply of inhalers is to complete transition as quickly as possible and ensure the expeditious introduction of CFC-free alternatives. This can be achieved in many countries by establishing a clear end date for ceasing the manufacture and/or import of CFC MDIs and planning phase-out activities with this deadline in mind. Parties are encouraged to consider policies and regulations that establish phase-out dates for the manufacture and/or import of CFC MDIs. For countries that manufacture CFC MDIs, much is dependent on the successful, timely completion of conversion projects.

The MTOC considered three options for the production of CFCs to supply requirements for MDI manufacture after 2009. MTOC considered issues such as security of CFC supply, predicted volume requirements, relative costs for production, storage and destruction, and recommends a preferred option that can best facilitate the final phase-out of CFCs MDIs in countries that still currently manufacture CFC MDIs. These options are outlined below.

1. Open-ended annual CFC production after 2009

Open-ended annual CFC production after 2009 (under annual essential use exemptions) does not provide a clear target or timetable for ending CFC production, predictability for CFC producers, or incentive for those companies currently manufacturing CFC MDIs to switch to CFC-free alternatives. At a certain point, the economics of CFC production will not be favourable, and will make impractical and too uncertain the continued production of relatively small amounts of pharmaceutical-grade CFCs. At this point, continuity of affordable healthcare would be jeopardised. Overall destruction costs for out-of-specification CFCs will be relatively high with this option. This option is not recommended.

2. An Extensive Final Campaign Production in late 2009

Although this option looks attractive from an environmental perspective and is consistent with the Protocol phase-out date, the logistics of organising such a large production campaign no later than 2009, in terms of the total multi-year quantity (estimated to be up to about 5,000 tonnes) and the associated essential use nomination and approval process, make this option impractical.

The costs of inventory and storage would also be large. Historically in the earlier years of the essential use process, non-Article 5 Parties made over-projections of CFC requirements because of uncertainty in the 'ground-up' development of alternatives at that time. For this option, a premature final campaign would almost certainly again lead to over-production. This would result in costly destruction of surplus CFC volumes or unnecessarily prolonged CFC MDI production.

In its 2007 report, MTOC proposed a final campaign in 2009. This option is no longer recommended for 2009. There are two reasons that now make it necessary to postpone the date for a final campaign.

- Procedural: In 2007 Parties did not adopt a decision on this subject, deferring consideration until a later date. To manage a final campaign and to produce CFCs after 2009 it will be necessary to make several decisions, for which lead times are needed. Parties may wish to consider the proposals made in section 3.8 concerning adjustments to the essential use process that takes into account the special circumstances of Article 5 Parties and final transition.
- Technical: The large-scale conversion of local CFC MDI manufacturing in Article 5 Parties is slower than anticipated. It will be necessary to wait at least another year to assess the progress of phase-out projects and their impact on future requirements of CFCs.

3. Final Campaign Production in 2011

MTOC believes that with appropriate planning and co-ordination a final campaign production of pharmaceutical-grade CFCs, for CFC MDI manufacturing countries that do not have domestic CFC production, could be feasible in 2011. This option assumes that project implementation is not delayed further.

This option also presumes that China maintains domestic production of CFCs and continues annual CFC production, if approved by Parties under the essential use process, until it completes its national CFC MDI phase-out. China has consumption and CFC production capacity at a scale that enables self-sufficiency.

Anticipating a final campaign production at an agreed date provides a clear target for ending CFC production, predictability for CFC producers, and incentive for those companies currently manufacturing CFC MDIs to switch to CFC-free alternatives.

Based on estimated CFC requirements, the economics of CFC production should still be favourable, firstly in 2010 to allow annual production (of less than 1,700 tonnes) in that year under an essential use, and then in 2011 for a final campaign production. The quantity of the final campaign production, for all countries excluding China, depends on whether India ceases CFC MDI production at the end of 2009 (as implied by Executive Committee Decision 54/35) or not. If India continues CFC MDI production after 2009, then the quantity of a final campaign would be about 2,000 tonnes, for all countries excluding China. If India ceases CFC MDI manufacture at the end of 2009, then the quantity of a final campaign would be about 1,000 tonnes, for all countries excluding China. With either of these outcomes with this option, overall destruction costs for out-of-specification CFCs would be relatively lower than for open-ended annual CFC production.

The logistics of organising a more modest final production campaign in 2011 (in terms of a total multi-year quantity of about 1,000-2,000 tonnes and the associated timelines for essential use nomination and approval no later than 2010) make a final campaign in 2011 more practical than in 2009. The costs of inventory and storage would also be relatively lower than for a final campaign in 2009 or 2010.

Suggested adjustments to the essential use process to accommodate this option are outlined in section 2.8.

2.6.2 Production and stockpiling considerations for final campaign production

Production of pharmaceutical-grade CFCs beyond 2009 will require firm contractual commitments (quantity, cost, timing) from MDI manufacturers to CFC manufacturers for producing, storing and distributing pharmaceutical-grade CFCs. Contractual arrangements

should aim to avoid opportunistic pricing that takes advantage of the limited supply situation. CFC producers require that payment for any CFC production will be made upfront, with sufficient notice to run plants for pharmaceutical CFC production. Such payment will include costs for the destruction of off-specification material. Without the certainty of guaranteed orders, production plants may either take the commercial decision to shut down or dedicate production to other fluorocarbons. The liability for destruction of unused surplus CFCs will reside with the owner of the material.

Pharmaceutical-grade CFCs to supply CFC requirements for MDI production after 2009 could also be sourced from remaining surplus CFC stockpiles in non-Article 5 Parties. Sourcing CFCs from existing stockpile of pharmaceutical-grade CFCs in preference to new CFC production is a requirement of Decision IV/25(1)(b). A co-ordinated approach to identifying, locating and transferring surplus stockpiles would be an advantage for Article 5 Parties, and would avoid destruction of CFCs that could otherwise be diverted to an essential use.

Stockpiling of pharmaceutical-grade CFCs will be an important element of the efficient management of the pharmaceutical-grade CFC supply as part of a final campaign production. The critical steps to manage stockpiles include the following:

1. Agree on the quantity and quality of pharmaceutical-grade CFCs to be stored;
2. Identify and source ISO tanks/cylinders/drums for storage and distribution;
3. Identify general storage location;
4. Agree all key quality protocols (specifications, testing, traceability);
5. Resolve any repacking issues (CFC-11);
6. Identify an entity to manage stockpile procurement, dispatch, maintenance, and destruction of final surplus.

Storage and handling of stockpiled pharmaceutical-grade CFCs is considered further in section 2.7.

MDI manufacturing companies in CFC MDI producing countries must begin to engage in discussions with pharmaceutical CFC producers to ensure the appropriate cost, appropriate quantity and quality issues are agreed upon prior to any final production being commenced.

2.6.3 Volume justification and timing

For 2010 onwards, production of CFCs can only occur under an essential use exemption for Parties including Article 5 Parties. As concluded earlier, final campaign production is less advisable for 2010 but an essential use exemption will still be needed for that year for CFC production for MDIs. Article 5 Parties' essential use nominations will need to be submitted by 31st January 2009 for Parties to consider essential use exemptions for CFC production in 2010.

In order to anticipate a final campaign production, accurate forward projections will be needed of annual quantities of each CFC required for MDI manufacture for 2010 and for each year thereafter until each Party's agreed phase-out date. These projections should accompany and justify each year's nomination for 2010 and onwards, starting with the nominations submitted in 2009. This would allow an accurate global picture to be developed from 2009, and a recommendation by TEAP on the preferred date for a final campaign to be made.

A final campaign production risks exaggerated and non-essential use of CFCs produced for multiple years. Therefore a multi-year essential use production exemption to cover a final campaign production will need to work in parallel with an annual exemption process to approve annual quantities to be used from the stockpile, and to signal the need for destruction of any surplus CFCs.

National transition strategies will also be needed to justify the volume and timing of a final campaign production, along with a complete justification (for both domestic and export use) to demonstrate the use to be essential.

Article 5 Parties will need to work closely with implementing agencies, industry, and other stakeholders to prepare essential use nominations for 2010, with all necessary multi-year data, by 31st January 2009.

It is anticipated that in 2009, Parties would consider Decisions to approve the CFC volumes intended for manufacture in 2010 only. In the next year (2010), the remaining volumes to complete phase-out in each Party would be considered and, if appropriate, approved to allow a final campaign production to occur in 2011.

2.6.4 CFC Specification

Specifications are agreed on a "case-by-case" basis between CFC suppliers and MDI manufacturers as part of the normal commercial negotiations. One important element of a final campaign would be an agreement on a suitable specification against which the CFC manufacturer would supply pharmaceutical-grade material. Parties may wish to highlight the need for national health authorities to work with CFC suppliers and MDI manufacturers to ensure that acceptable specifications are in place. Independent actions could lead to a multiplicity of different specifications, which would complicate a final campaign, however, given the few CFC production facilities remaining, this situation is unlikely.

Of the existing specifications, the British Pharmacopoeia (1988) has already been withdrawn and there is a possibility that the USP (1998) specification may follow.

2.7 Storage and handling of stockpiled pharmaceutical-grade CFCs

2.7.1 Physical-chemical properties and storage

Three different CFCs are used in the manufacture of MDIs and their storage requirements change according to their pressures. CFC-12 accounts for roughly 60 per cent of total consumption for MDIs and at room temperature is a gas with a pressure of several atmospheres, which requires the use of expensive storage tanks. The value of a 30 tonne CFC 12 pressure tank is in the order of US\$100,000. CFC-11 accounts for approximately 30 per cent of total consumption for MDIs and can be stored as a bulk liquid or in disposable drums. In the latter case the storage temperature should not raise above 30°C. CFC-114 is not used in all CFC MDIs and accounts roughly for the remaining 10 per cent of global consumption for MDIs; it has a much lower pressure than CFC-12, but still needs to be stored in a pressurised tank.

When an MDI manufacturer used a fixed ratio of different CFCs in its products, it was common practice that the CFC supplier shipped the pre-mixed blend to the MDI producer. If the CFCs were stockpiled as a pre-mixed blend, their use by another MDI manufacturer would require

some adjustment of the composition unless both used the same CFC ratio in their formulations. However, it is not believed that the use of mixtures is common practice at present because CFC-11 is generally used as solvent for suspending the active ingredient.

CFC-12 and CFC-114 are very stable compounds that will not undergo chemical transformations, therefore they can be stored safely provided contamination is prevented and they are stored under proper conditions. However, CFC-11 can decompose in the presence of water, and it is therefore important that drums are stored in a warehouse that prevents their exposure to rain. Large temperature fluctuations should also be avoided as the drums are not designed to withstand the resultant pressure changes, and will deform and may eventually leak.

2.7.2 *Size of Storage*

Bulk pressurised tanks usually have a capacity of 20-100 tonnes; those in the upper size range are usually used at the CFC manufacturer site, while a 20 tonne tank will hold sufficient CFC to produce approximately 1,000,000 MDIs.

ISO tanks are another bulk storage option that are built to fit a 20' shipping container and can be easily transported. CFC manufacturers usually use ISO tanks to export CFCs, but because their availability is limited CFC manufacturers normally expect that their contents will be emptied at the MDI facility and the ISO tank returned promptly. ISO tanks can also be rented, but this is expensive at around US\$40 per day¹. If several ISO tanks were used to store CFCs, a suitable area for proper storage would be needed.

Small MDI manufacturers usually purchase their CFCs in one-tonne cylinders. These will provide sufficient CFC-12 propellant to produce close to 50,000 MDIs. Usually the smaller the container used to store the CFC, the larger the losses proportionately. Handling of these cylinders is costly and time-consuming; CFC manufacturers or suppliers usually demand that they are returned empty after a reasonable amount of time.

Apart from large storage facilities at CFC manufacturing plants, there are some storage complexes that have been used by pharmaceutical companies in the European Community and the United States to hold their stocks during the phase-out of CFC MDIs. It is unlikely that similar storage complexes exist in Article 5 Parties. Use of this type of facilities will be needed when a campaign for the final production of CFCs is defined.

2.7.3 *Quality control and risks associated with storage*

Pharmaceutical regulations demand that stockpiled material is re-circulated and tested periodically. Usually sampling is conducted every six months. Discharging of material stored in a large vessel into a smaller container requires specialised equipment and personnel. Assurance that containers are clean and free of contaminants is crucial, particularly to avoid contamination of the material stored in the larger vessel.

¹ Taken from a presentation given by Dr Tim Noakes at the South Asia and Southeast Asia and Pacific Regional Thematic Workshop on Phasing-out CFC Metered Dose Inhaler (MDI) in Langkawi, Malaysia, during 13-15 March 2008.

The risks of catastrophic failure and venting also have to be considered. Tanks must be located in a secure area where only authorised personnel can enter. Tanks must also be in a site where there are no risks of fires that could cause undesired high temperatures and eventual rupture of a safety valve.

2.7.4 Transfer of existing stockpiles of pharmaceutical-grade CFCs

Transfer of existing stockpiles would be logistically possible through the use of dedicated ISO tanks, provided adequate planning could be established. Timing and costs would be dependent upon the distance of the transfer as well as testing requirements. Costs would also be determined by the need for storage of the "transferred" product. Should it be necessary to keep the product on-site in ISO tanks then, as described earlier, extra charges would apply. Quality would need to be ensured through testing procedures.

Sourcing CFCs from existing stockpile of pharmaceutical-grade CFCs in preference to new CFC production is a requirement of Decision IV/25(1)(b), but not one that has been strictly adhered to by non-Article 5 Parties. In the final stages of transition, Parties should be encouraged to facilitate the identification and transfer of suitable stocks. Parties should be encouraged to facilitate intra-company, international CFC transfers. Nominating Parties must confirm that nominated quantities cannot be sourced from existing global stockpile to meet the requirements of Decision IV/25(1)(b). Decisions VII/28(2)(c), IX/20 and XII/2(8) address the means and conditions for the transfer of essential use exemptions and authorisations by Parties. Parties may wish to clarify that with these Decisions, Parties can transfer CFCs already produced under an essential use exemption and ensure that the Decisions provide the flexibility and accountability needed to allow the transfer of stockpile. In addition, it is not clear whether a stockpile produced before the phase-out date (that is, not produced under an essential use exemption) can be transferred. Parties may wish to consider authorising through a Decision the transfer of any stockpile under the conditions of IX/20.

The import/export of CFCs is subject to strict licensing requirements between Parties. These would have to be dealt with on a "case-by-case" basis with the assistance of national authorities. Parties may also wish to review domestic laws to facilitate transfers of stockpiles between companies and/or countries.

2.7.5 Logistics

The costs associated with stockpiling are substantial. The cost of the stock itself is of the order of \$7/kg or \$14,000,000 for a 2,000 tonne stockpile. Apart from the financial cost of carrying the inventory, storage costs per year could be in the order of \$100/tonne². CFC producers and the operator of the storage facility will probably prefer to deal with a single entity that would assume ownership or stewardship of the stock and its costs.

Parties may wish to consider establishing a single entity, such as an implementing agency, to be responsible for the stockpile and its costs.

² Taken from a presentation given by Dr Tim Noakes at the South Asia and Southeast Asia and Pacific Regional Thematic Workshop on Phasing-out CFC Metered Dose Inhaler (MDI) in Langkawi, Malaysia, during 13-15 March 2008.

2.7.6 Destruction of surplus or out-of-specification CFCs

Destruction of out-of-specification CFCs can take place at any CFC manufacturing facility with destruction technology approved by Parties (Decision XV/9), such as high-temperature incineration, and with the ability to handle fluorinated chemicals. Virtually all CFC production facilities have such incinerators or access to them, and there are many more commercial operators.

Parties are reminded that surplus CFCs, acquired under an essential use exemption, have to be used in another essential use or destroyed according to means approved by the Montreal Protocol (Decision XV/9). Destruction technologies for ozone-depleting substances have been discussed previously in the 2002 Report of the TEAP Task Force on Destruction Technologies.

Destruction of surplus CFCs will require consideration of the logistics of collection, handling, and transport to a facility with approved destruction technology. It will be important to use tracking and reporting systems, such as through the accounting frameworks for essential uses, to avoid unauthorised venting. The requirements of the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal* will also need to be considered. Liaison with government officers responsible for Basel Convention requirements for a Party will need to be consulted.

The costs of destruction are extremely difficult to estimate accurately since they are regionally driven and dependent on the distance and means for transporting waste CFCs to destruction facilities, and the destruction facility used. Nonetheless, TEAP has reported previously in its 2005 Supplement to the IPCC/TEAP Report Special Report "*Safeguarding the Ozone Layer and the Global Climate System; Issues related to Hydrofluorocarbons and Perfluorocarbons*" that average destruction costs (destruction only, excluding collection and transport) are US\$2,500-4,500 per tonne (up to US\$5/kg in 2005). Consolidation of national stocks for destruction, and a co-ordinated collection and transport system, could reduce the total costs of destruction through economies of scale. Liability for destruction, including associated costs, would reside with the MDI manufacturer that had been allocated the CFCs under an essential use exemption.

2.8 Recommended modifications to the essential use process to accommodate Article 5 Parties and final campaign production

MTOC has reviewed the Protocol's current essential use decisions and supporting guidance in the *Handbook on Essential Use Nominations* (TEAP, 2005), to conclude whether the essential use process can accommodate the situation of Article 5 Parties, the last stages of global transition and final campaign production.

While Decision IV/25 and subsequent related essential use decisions provide a good starting point for an essential use process for 2010 and beyond, much has changed since 1992 when the framework was established. The final stages of global transition after 2009 will be characterised by circumstances that make desirable refinement of and modifications to the essential use framework and guidance on information requirements in the Handbook.

Parties may wish to consider the following suggested options in making a set of new Decisions that build on the previous essential use Decisions and associated guidance on information requirements in the Handbook. Parties may wish to consider a suite of new Decisions because:

some of the existing Decisions are currently not applicable to Article 5 Parties but their intended effects are still relevant; other Decisions may need strengthening; and new decisions may be needed to take account of issues not currently included.

These circumstances and suggested options include the following.

- While Decision IV/25 is applicable to Article 5 Parties after the 2009 phase-out, many of the subsequent Decisions related to essential use nomination requirements and procedures have language that make them specifically applicable only to Parties not operating under Article 5. All of the Decisions on MDIs and essential uses have been reviewed with a view to suggesting options for consideration by Parties on a new set of Decisions that provide for an essential use process after 2009 that includes Article 5 Parties.
- Under Decision IX/19(5) and other Decisions (including Decision XII/2), Parties not operating under Article 5 have been required to develop and implement national transition strategies and report on progress each year, and included as a requirement in making essential use nominations. To date, Article 5 Parties have been encouraged but not required to develop national transition strategies (under Decision XII/2(6)). Parties may wish to consider making a national transition strategy a requirement for Article 5 Parties nominating for an essential use exemption to produce CFCs for MDIs, as has been the case for Parties not operating under Article 5. Prompt financing for development of these national transition strategies, as encouraged in Decision 54/35 of the Executive Committee, will assist these efforts.
- Global manufacturing transition is well progressed except in some Article 5 Parties manufacturing CFC MDIs. There are many technically feasible alternatives to CFC MDIs for a range of active ingredients available in Article 5 Party markets. However price may be one issue affecting the uptake of alternatives in some countries (where government or commercial pricing policies do not favour the alternatives), and the rate of regulatory approval may be another issue. These factors make technical feasibility of the alternatives no longer as relevant as economic feasibility when considering the essential nature of CFC MDIs, and more information is needed about the circumstances in consuming countries, including the availability and affordability of CFC-free alternatives in the intended markets. Adjustments to the Handbook can provide additional guidance to nominating Parties. Parties may also wish to consider strengthening Decision VIII/11 to include Article 5 Parties and to request, rather than encourage, the promotion of co-ordination between government authorities to facilitate the transition and the expeditious review of regulatory approvals and launch of CFC-free alternatives.
- The cost to manufacture CFC and HFC MDIs is now generally comparable, and arguments to justify essentiality will be difficult to sustain where intentional or inadvertent pricing policies are unfavourable to CFC-free alternatives. Parties may wish to consider strengthening Decision VIII/11 to include Article 5 Parties, and to request, rather than encourage, Parties to set pricing policies that do not discriminate against CFC-free alternatives.
- With the implementation of projects in Article 5 Parties it should be possible for manufacturing countries to establish phase-out policies and deadlines for stopping the manufacture of CFC MDIs. Essential use nominations will need to justify the volume and timing of a final campaign production in accordance with national transition strategies, project timelines, the status of CFC free alternative development and approval,

and the anticipated timing of introductions. Article 5 Parties will need to work closely with implementing agencies, industry, and other stakeholders to prepare essential use nominations. The Executive Committee of the MLF may wish to consider the advantages of assisting the Article 5 Parties with MDI manufacturing to establish phase-out policies and deadlines under regulations in this regard.

- Reformulation/development and registration of inhalers is a complex undertaking. Criteria will need to be considered to properly elaborate the status of research and development by companies in Parties nominating essential uses, as well as limits on a reasonable period for the reformulation/development and registration of products where there is limited opportunity of alternatives becoming available. Parties may wish to consider strengthening and expanding the existing Decisions around research and development (Decisions XIX/13(3), XVIII/7(3), and VIII/10(1)) to include Article 5 Parties and also to establish clear criteria for reasonable levels of active research and development (removing ambiguity around what constitutes 'active'), and an end-point or trigger point for the conclusion of reformulation/development efforts that may ultimately prove unsuccessful.
- Despite the fact that the date of CFC production phase-out for Article 5 Parties has been known for many years, some MDI manufacturers in Article 5 Parties are even recently registering and marketing new CFC MDIs in markets in Article 5 Parties. Parties may wish to consider that a CFC MDI approved in an Article 5 Party after 31st December 2007 should not be considered an essential use, similar to the requirement for non-Article 5 Parties under Decision XII/2(2). Parties may also wish to require nominating Parties to specify the date that CFC MDI production commenced for each active ingredient subject to a nomination.
- Some MDI manufacturing companies are practising dual marketing of CFC MDIs and their CFC-free alternatives for the same active ingredient. After an adequate post-marketing period for the CFC-free alternative of not more than 12 months, absent compelling circumstances, the company's corresponding CFC MDI product cannot be considered essential. Parties may wish to consider clarifying this in a Decision, that is, absent compelling circumstances, CFCs should not be requested in an essential use nomination or allocated to a company for a product where the company has launched the corresponding CFC-free alternative, after an adequate parallel marketing period of not more than 12 months. The Governments of such Parties may wish to consider the advantages of establishing policies and regulations to ban such dual marketing.
- Parties may wish to consider the advantages of encouraging Parties not manufacturing CFC MDIs to establish bans on the import of CFC MDIs at a certain date, when adequate alternatives to CFC MDIs will be available. MTOC will consider information in essential use nominations next year, and can suggest options for a possible date to ban the import of CFC MDIs in Article 5 Parties.
- Due to the uncertainty surrounding the security of future supply of pharmaceutical-grade CFCs, there will be a point in the next few years when annual just-in-time CFC production will no longer be economically feasible and a final campaign production will be needed. From 2010 onwards, production of CFCs can only occur under an essential use exemption. As concluded earlier, final campaign production is less advisable for 2010 but an essential use exemption will still be needed for that year for CFC production for MDIs. In order to anticipate a final campaign production, accurate forward

projections will be needed of annual quantities of CFCs required for MDI manufacture for 2010 and for each year thereafter until each Party's agreed phase-out date in national transition strategies. This should accompany and justify each year's nomination for 2010 and onwards, starting with the nominations submitted in 2009. This would allow an accurate global picture to be developed from 2009, and a recommendation by TEAP on the necessary date for a final campaign to be made. Parties may wish to consider a Decision to clarify information for a final production campaign in each year's essential use nomination. Information needs for a final campaign are elaborated below.

- Final campaign production for CFC MDI manufacturing countries that do not have domestic CFC production could be feasible in 2011. This assumes that project implementation is not delayed any further, and that China maintains domestic production of CFCs beyond 2011 to complete its national phase-out. Lead times need to be considered for a Decision on the quantity for a final campaign production, to ensure nominations for multiple years are made in time to allow a decision in the year prior to the production campaign. For example, multi-year essential use nominations for a final campaign in 2011 would be required by 31st January 2010 at the latest.
- A final campaign production risks exaggerated, non-essential use of CFCs produced for multiple years. Therefore a multi-year essential use exemption to allow a final campaign production will need to work in parallel with an exemption process to approve annual quantities to be used from the stockpile produced under a final campaign, and to signal the need for destruction of any surplus CFCs. Decision IV/25 and subsequent Decisions imply review provisions for previously qualified essential uses, but do not clearly articulate yearly processes such as might be needed. Parties may wish to consider a Decision to clarify an essential use nomination process that would allow approval by Parties of future annual use of the stockpile produced in a final campaign previously approved by Parties.
- Exporting countries nominating for essential uses need to demonstrate that importing countries deem the nominated products to be essential. Decision XII/2(3) requests Parties, including Article 5 Parties, to notify the Ozone Secretariat of any MDI products determined to be non-essential, which is then posted on the website of the Ozone Secretariat, and for Parties to take this information into consideration when nominating for essential uses. However only one Party's information is listed on the Ozone Secretariat's website. Given the complexity and fluidity of export markets, Parties may wish to consider strengthening this decision, with a request for all Parties, including those operating under Article 5, to make annual declarations of any MDI products determined to be non-essential within their own country, and that these declarations accompany essential use nominations from Parties manufacturing and exporting CFC MDIs to these countries, in order to justify an essential use under Decision IV/25. Decision XIV/5 also requests each Party to supply annual data on CFC MDIs and their CFC-free alternatives to the Ozone Secretariat. Twenty-two Article 5 Parties have submitted data pursuant to Decision XIV/5 since its inception, but in many cases the data have not been updated annually. Parties may wish to consider a decision emphasising the importance of providing such data as part of the final stages of transition.
- One-year operational supply has been an important mechanism to control over-production and hoarding of CFCs produced annually for essential uses. However in the final stages of transition and after a final campaign production, a one-year operational supply may not be as desirable as part of an essential use process. Prior to a final

campaign, flexibility in stockpiling may be desirable for Article 5 Parties wishing to build a stockpile prior to a final campaign, and thereby reduce the final campaign production quantity. After a final campaign production, one-year operational supply is not relevant to a multi-year stockpile. Decisions XIX/13(2), XVIII/7(2), XVII/5(2), regarding one-year's operational supply, do not include Article 5 Parties. Decision XVI/12(3) asks Parties, in general, nominating for essential uses to give due consideration to existing stocks with the objective of maintaining no more than one year's operational supply. Parties may wish to consider more flexibility in stockpiling for the final stages of transition than is available through the current Decisions.

- Sourcing CFCs from existing stockpiles of pharmaceutical-grade CFCs in preference to new CFC production is a requirement of Decision IV/25(1)(b), but not one that has been strictly adhered to by non-Article 5 Parties. In the final stages of transition, Parties should be encouraged to facilitate the identification and transfer of suitable stocks. Parties should be encouraged to facilitate intra-company, international CFC transfers. Nominating Parties must confirm that nominated quantities cannot be sourced from existing global stockpile to meet the requirements of Decision IV/25(1)(b). Decisions VII/28(2)(c), IX/20 and XII/2(8) address the means and conditions for the transfer of essential use exemptions and authorisations by Parties, although in the case of Decision VII/28(2)(c) for non-Article 5 Parties only. Parties may wish to clarify that with these Decisions, Parties can transfer CFCs already produced under an essential use exemption and ensure that the Decisions provide the flexibility and accountability needed to allow the transfer of stockpile. Parties may also wish to review domestic laws to facilitate transfers of stockpiles between companies and/or countries. In addition, it is not clear whether a stockpile produced before the phase-out date (that is, not produced under an essential use exemption) can be transferred. Parties may wish to consider authorising through a Decision the transfer of any stockpile under the conditions of IX/20. Parties may wish to strengthen Decision VII/28(2)(c) to include Article 5 Parties. Parties may also wish to consider minor modifications to the accounting framework under Decision VIII/9 to allow reporting of stockpile transfers.
- Well-monitored and accounted stockpile management and destruction of out-of-specification or surplus CFCs becomes even more critical after 2009. Any out-of-specification CFCs produced after 2009 and any pharmaceutical-grade CFC remaining at the conclusion of MDI transition must be destroyed by approved technologies. Parties may wish to strengthen Decision VII/28(2) to include Article 5 Parties regarding the requirement to destroy any surplus essential use CFCs. In relation to a nomination for a final campaign production, Parties may wish to consider requiring nominating Parties to describe storage capacity, facilities and maintenance arrangements, access to approved destruction technologies and contingency plans for destruction of surplus stocks, including consideration of Basel Convention requirements. Parties may also wish to consider strengthening the accounting framework under Decision VIII/9 to require Parties to report the destruction via approved technologies of out-of-specification CFCs or surplus essential use pharmaceutical-grade CFCs.

MTOC lists below the Decisions that might be considered relevant in making modifications to the essential use process to provide coverage for Article 5 Parties and final campaign production: Decision IV/25; Decision V/18 par. 5; VI/9 par. 4; VII/34 par. 5(b); VII/28 par. 2; VIII/9 pars. 8, 9 and 10; VIII/10; VIII/11; VIII/12 par. 3; IX/19 par. 5; IX/20; X/6 par. 5; XII/2 pars. 2, 3, 4, 5, 6 and 8; XIV/5; XV/5; XVI/12 pars. 2 and 3; XVII/5 par. 2; XVIII/7 pars. 2 and 3; XVIII/16 pars. 7 and 8; and XIX/13 pars. 2 and 3.

This list may not be complete but represents the most relevant Decisions, in MTOC's view, that might need modification and incorporation into a new set of Decisions.

TEAP and its MTOC remain ready to assist Parties in these refinements and modifications (and with subsequent accompanying changes to the Handbook) for which Decisions by Parties will be needed this year (to allow essential use nominations to be considered in 2009 for any CFC production in 2010).

2.8.1 Information needed to define quantities for a final campaign production of pharmaceutical-grade CFCs

In 2007 MTOC reported information needs for a final campaign. These information requirements have been updated since last year and are elaborated below. All of the information requirements can be accommodated under the existing Decisions and with the suggested modifications to the essential use Decisions and associated changes to the Handbook recommended in this report.

In order to calculate the quantities to be produced in a final campaign, the following information will be needed on a country-by-country basis:

- Country transition strategy for CFC MDIs, including a phase-out date for CFC MDI production;
- Quantity required for each year (2010 and beyond), and historical three-year consumption data;
- Within the Party, a summary of conversion projects for CFC MDI manufacturing plants, including: timelines; availability of manufacturing equipment, delivery and commissioning dates;
- Availability of CFC-free alternatives from local manufacture and from import, status of CFC-free alternative development and approval, anticipated timing of introduction, relative pricing of imports compared with locally manufactured products and whether this presents a barrier to transition;
- The destination, quantity and essentiality of CFC MDIs intended for export;
- Information on storage capacity, facilities and maintenance arrangements, access to approved destruction technologies and contingency plans for destruction of surplus stocks, including consideration of Basel Convention requirements;
- The date CFC MDI production commenced; and
- Existing stockpile size, CFC type, availability and quality, and demonstrated efforts to acquire CFCs through the transfer of stockpile from within and outside of the Party.

The annual accounting process will need to continue to track the quantities of CFCs: produced for MDI manufacture; transferred for MDI manufacture; used in MDI manufacture; within exported finished product and to what destinations; stockpiled; and destroyed.

2.8.2 *Suggested changes to Section 2.5 of the Handbook on information requirements*

MTOC has some initial suggestions for changes to Section 2.5 of the Handbook, relating to information requirements for essential use nominations. These suggestions are based on the current Section 2.5, taking into account the recommendations above for changes to the essential use process and the Handbook, and are presented for the purposes of illustration. A final set of changes to the Handbook can be recommended following Decisions by Parties about the form of any new essential use process to include Article 5 Parties and final campaign production.

Due to the timelines for adoption of any Decisions by Parties at the 20th MOP and subsequent related changes to and publication of an updated Handbook, Parties may wish to consider provisional approval of the suggested changes below to Section 2.5 of the Handbook to assist Parties planning to submit essential use nominations in early 2009.

The following information is requested for each essential use nomination.

1. Provide a detailed description of the use that is the subject of the nomination. (*Decision IV/25, pars. 2 and 3*)
2. Provide details of the type, quantity and quality of the controlled substances that is requested to satisfy the use. Specify whether the quantity is requested for production or for use from existing stockpile. (*Decision IV/25, pars. 2 and 3*).
3. Indicate the period of time and the annual quantities of the controlled substances that are requested. For CFC MDIs, indicate the expected annual future requirements until CFC MDI transition is completed and historic 3-year consumption data to satisfy the use. (*Decision IV/25, pars. 2 and 3*) [*This Decision is flexible and allows for multi-year essential use nominations, as would be required for a final campaign production, and also allows for Parties to provide data for all future years until anticipated phase-out*].
5. For CFC MDIs, specify the intended market(s) for sale or distribution for the use, the active ingredient(s) for the use in each market and the quantity of CFCs required for each active ingredient in each market. If necessary, provide the best estimate for quantities for intended markets, using available data from requesting companies. When more specific data are not available, data aggregated by region and product group may be submitted for CFC MDIs intended for sale in export markets. (*Currently covered by Decisions XV/5, par. 2 and XVI/12, par. 2*). Specify the date that CFC MDI production commenced for each active ingredient subject to the nomination.
6. For CFC MDIs, state whether each intended market for sale or distribution is subject to a transition strategy adopted and submitted to the Secretariat and posted by the Secretariat on its website (*pursuant to current Decision XII/2 or Decision IX/19*). (*Currently covered by Decision XV/5, par. 3*) Summarise the nominating Parties national transition strategy, including national phase-out dates and CFC MDI manufacturing plant conversion timelines (including new manufacturing equipment delivery and commissioning dates).
7. For CFC MDIs, briefly describe progress made on the transition to CFC-free alternatives under a national or regional MDI transition strategy. (*Currently covered by Decision IX/19, par. 5 and Decision XII/2, par. 5(c) for non-Article 5 Parties only. Decision XII/2(6) encourages, rather than requires, Article 5 Parties to develop strategies and annually report on progress, and there is no equivalent requirement for Article 5 Parties submitting essential use nominations to present national transition strategies as for non-Article 5 Parties in Decision IX/19, par.5*).

8. Explain why the nominated volumes and the intended use of these quantities are necessary for health and/or safety, or why it is critical for the functioning of society. (*Decision IV/25, pars. 1(a)(i), 2 and 3*).
9. For CFC MDIs, confirm that the Secretariat's list of CFC MDI active ingredients and/or category of products determined to be non essential by a Party has been consulted and that none of the volumes requested shall be used for items posted on that list. (*Decision XII/2, par. 3*). Attach annual declarations by Parties, for each of the intended markets subject to the nomination, of active ingredients and/or CFC MDI products determined to be non-essential by the Party.
10. Explain what other alternatives and substitutes have been employed to reduce the dependency on the controlled substance for this application in the intended markets subject to the nomination. (*Decision IV/25, pars. 1(a)(ii), 1(b)(i), 2 and 3(d)*).
11. Explain what alternatives were investigated or are available in the intended markets and why they were not considered adequate. Describe information on the availability and affordability of alternatives in the intended markets subject to the nomination. Explain whether any barriers, such as the pace of regulatory approvals or unfavourable pricing policies, are slowing the uptake of alternatives. (*Decision IV/25, pars. 1(a)(ii), 1(b)(i), 2 and 3(d)*). For CFC MDIs, confirm that the global database of CFC MDIs and their alternatives has been consulted and taken into account in the nomination (*Decision XIV/5*). For the intended markets for sale or distribution, confirm that each company, requesting essential use allocations, does not have a CFC-free alternative marketed for more than 12 months for each active ingredient for which a CFC MDI is also being marketed that is subject to the nomination. Confirm that CFCs are not requested for and will not be allocated to a company, absent compelling circumstances, for a product where the company has launched the corresponding CFC-free alternative (for any of the intended markets for sale or distribution), after an adequate parallel marketing period of not more than 12 months.
12. For CFC MDIs, confirm that each company requesting essential use allocations has demonstrated ongoing active research and development of alternatives to CFC MDIs with all due diligence and/or collaborate with other companies in such efforts. (*Currently covered by Decision VIII/10, par. 1 for non-Article 5 Parties only*) Describe the status of the development of alternatives to CFC MDIs, plans for their approval and expected launch dates.
13. Explain what efforts are being undertaken to employ other measures for this application in the future, including, in the case of MDIs, efforts to foster approval of alternatives in the domestic and export markets. (*Decision IV/25, pars. 1(a)(ii), 3(d) and 4; Decision XII/2, par. 4; and current Decisions VIII/10, par. 1 and VIII/11 for non-Article 5 Parties only*).
14. If the use is for a CFC MDI product approved after 31 December 2000 for non-Article 5 Parties (*currently covered by Decision XII/2, par. 2 for non-Article 5 Parties only*) or after 31 December 2007 for Article 5 Parties for the treatment of asthma and/or chronic obstructive pulmonary disease, provide documentation to demonstrate that this product is necessary for health or safety and that there are no technically and economically feasible alternatives available.
15. Describe the measures that are proposed to eliminate all unnecessary emissions. At a minimum, this explanation should include design considerations and maintenance procedures. (*Decision IV/25, pars. 1(b)(i), 2 and 3(b); Decision VI/9, par. 4; and current Decision VIII/10, pars. 6 and 7 for non-Article 5 Parties only*)

16. Explain whether the nomination is being made because national or international regulations require use of the controlled substance to achieve compliance. Provide full documentation including the name, address, phone and fax number of the regulatory authority requiring use of the controlled substance and provide a full copy or summary of the regulation. Explain what efforts are being made to change such regulations or to achieve acceptance on the basis of alternative measures that would satisfy the intent of the requirement. [*MTOC queries the need for this requirement for MDIs.*]
17. For CFC MDIs, describe progress made towards determining and submitting a specific date by which time the Party, for those not operating under paragraph 1 of Article 5, will cease making nominations for essential use exemptions for CFCs for metered-dose inhalers where the active ingredient(s) is not solely salbutamol and the metered-dose inhalers are expected to be sold or distributed on the market of any Party not operating under paragraph 1 of Article 5. (*Decision XV/5, par. 6*) [*MTOC queries whether this is relevant to Article 5 Parties where salbutamol will likely be reformulated in parallel with other active ingredients.*]
18. Describe the efforts that have been made to acquire stockpiled or recycled controlled substance for this application both domestically and internationally. Explain what efforts have been made to establish banks for the controlled substance. (*Decision IV/25, par. 1(b)(ii)*). For CFC MDIs, in relation to a nomination for a final campaign production or for the use of a final campaign stockpile, describe storage capacity, facilities and maintenance arrangements, access to approved destruction technologies and contingency plans for destruction of surplus stocks, including consideration of Basel Convention requirements.
19. For CFC MDIs, indicate the existing stock of pharmaceutical-grade CFCs (pre- and post-1996 for non-Article 5 Parties, and pre- and post-2010 for Article 5 Parties) held by the Party requesting an essential use exemption, describing the quantity (metric tonnes), the quality and the availability for the year prior to the nomination. Confirm that existing stockpiles have been taken into account in making essential use requests. Describe how this stockpile will be utilised in coming years. (*Decision IV/25, par. 1(b)(ii), current Decision XVI/12, par. 3, and current Decisions XVII/5 par. 2 and XIX/13 par. 2 for non-Article 5 Parties only*)
20. Briefly state any other barriers encountered in attempts to eliminate the use of the controlled substance for this application.

3 Medical Technical Options Committee Progress Report

3.1 Executive Summary

The Medical Technical Options Committee (MTOC) thanks Otsuka Pharmaceutical Company, and MTOC member Mr Hideo Mori, for hosting the MTOC meeting in Tokushima, Japan, 1-4 April 2008. As part of its hospitality, Otsuka Pharmaceutical Company provided meeting rooms and other in-kind support, such as local transport, telecommunications and copying, and also food and beverages.

The global use of CFCs to manufacture metered dose inhalers (MDIs) in 2007 is estimated to be about 3,400 tonnes, a reduction of 600 tonnes from 2006, of which about 64 per cent of the total is used by Article 5 Parties. In 2007, non-Article 5 Parties used 1,221 tonnes of CFCs in MDI manufacture under essential use exemptions. This represents a 42 per cent reduction in use compared to 2006, demonstrating acceleration in the CFC MDI transition in non-Article 5 Parties. Stockpiles in non-Article 5 Parties now stand at about 160 per cent of annual use of CFCs, contrary to Parties' commitments to keep stocks to one year's operational supply and highlighting the importance of flexible stockpile management in the final stages of phase-out. In 2007, MTOC estimates that Article 5 Parties used about 2,100 tonnes of CFCs for MDI manufacture. The majority of this was for manufacture by locally owned companies; multi-nationals operating in Article 5 Parties account for a small proportion of CFC use for MDIs.

Technically satisfactory alternatives to CFC MDIs are available for all therapeutic categories for asthma and chronic obstructive pulmonary disease (COPD), with significant progress towards transition in Article 5 Parties for certain key moieties. However, the development and registration of CFC-free products cannot alone lead to a full uptake in the market without additional regulatory action, appropriate pricing and a clear national transition strategy.

3.2 Global Use of CFCs for MDIs

The global use of CFCs to manufacture MDIs in 2007 is estimated to be about 3,400 tonnes, a reduction of 600 tonnes from 2006, of which about 64 per cent of the total is used by Article 5 Parties.

Figure 3-1 and Table 3-1 show the use of chlorofluorocarbons (CFCs) for the manufacture of MDIs for asthma and COPD in non-Article 5 Parties for essential uses. In 2007, 1,221 tonnes of CFCs were used by non-Article 5 Parties in MDI manufacture under essential use exemptions, as reported through accounting frameworks. This represents a 42 per cent reduction in use compared to 2006, and an 86 per cent reduction in use compared with the year of maximum use in 1997 (8,905 tonnes), demonstrating acceleration in the CFC MDI transition in non-Article 5 Parties. Stockpiles in non-Article 5 Parties now stand at about 160 per cent of annual use of CFCs, contrary to Parties' commitments to keep stocks to one year's operational supply and highlighting the importance of flexible stockpile management in the final stages of phase-out.

Figure 3-1 Quantities of CFCs for MDI manufacture in non-Article 5 Parties

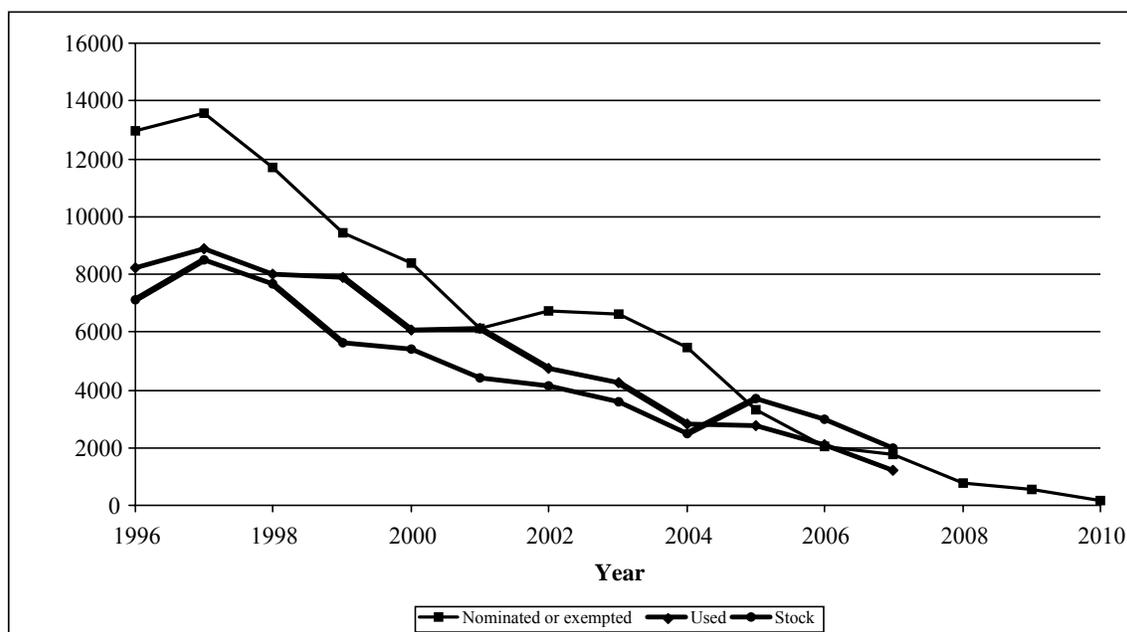


Table 3-1 Quantities (in tonnes) of CFCs for MDI manufacture in non-Article 5 Parties

Year of Essential Use	Amount Exempted/ Nominated for year of Essential Use	Used for Essential Use	On Hand End of Year
1996	12,987.20	8,241.13	7,129.59
1997	13,548.00	8,904.99	8,515.24
1998	11,720.18	8,013.60	7,656.63
1999	9,442.13	7,906.35	5,653.95
2000	8,364.95	6,062.75	5,433.32
2001	6,126.53	6,121.62	4,402.59
2002	6,714.75	4,751.92	4,133.71
2003	6,641.55	4,261.91	3,570.27
2004	5,443.12	2,840.82	2,460.10
2005	3,321.10	2,735.40	3,671.01 *
2006	2,039.00	2,107.10**	2,957.37 *
2007	1,778.00	1,220.90	1,987.97 *
2008	797.00	-	-
2009	568.00	-	-
2010	182.00	-	-

*Includes pre-1996 stock

**Includes material approved in 2005 but used in 2006 in the Russian Federation

Technically satisfactory alternatives to CFC MDIs are available for all therapeutic categories for asthma and COPD. The availability of CFC stocks coupled with the wide range of alternatives assures patient safety during the transition in most non-Article 5 Parties. Transition in non-Article 5 Parties is achievable by about 2010. However, the Russian Federation has indicated that lack of financial resources and regulatory processes are causing delays in the conversion of the local manufacture of affordable salbutamol CFC MDIs. Any non-Article 5 Parties that have not achieved transition by the end of 2009, will need to consider the uncertainty of supply of pharmaceutical-grade CFCs from 2010 onwards and participate in any global production strategy, such as a final campaign production, along with Article 5 Parties. These issues are elaborated later in this report.

The flexible management and transfer of stockpiles in non-Article 5 Parties at this final stage of the phase-out will be extremely important to avoid unnecessary production of CFCs and the need for large quantities of CFCs to be destroyed. To ensure transparency, any pre-1996 stocks should be accounted for in the Reporting Accounting Framework for Essential Uses. In addition, Decision IV/25 (*Report of the TEAP, May 2005, Progress Report*, section 1.1.4.1, page 35) requires companies that hold pre-1996 stocks to use them first before using newly produced CFCs. This means that in principle no company that has received an essential use allowance can claim that its surplus CFC is pre-1996 stock. The only exception could be if the company could prove that the essential use allowance was for a different type of CFC than the one it has in its pre-1996 stock (although CFC types have been aggregated in essential use decisions for many years).

In 2007, MTOC estimates that Article 5 Parties used about 2,100 tonnes of CFCs for MDI manufacture. The majority of this was for manufacture by locally owned companies; multi-nationals operating in Article 5 Parties account for a small proportion of CFC use for MDIs. With increasing use of CFCs for MDIs in Article 5 Parties, and declining use in non-Article 5 Parties, in 2007 CFC use for the manufacture of MDIs in Article 5 Parties exceeded that in non-Article 5 Parties.

3.3 Transition to alternatives to CFC MDIs

Technically satisfactory alternatives to CFC MDIs are available globally for short-acting beta-agonists and a wide array of other therapeutic categories for asthma and COPD.

Progress in the transition to CFC-free alternatives has been evaluated by comparing the most recent data provided by the International Pharmaceutical Aerosol Consortium (IPAC)¹, on available products manufactured by its constituent member companies, with that previously summarised by MTOC in its 2006 Assessment Report. Data from 3M (which no longer markets inhalers) and Teva (which is not an IPAC member) were not available on this occasion.

Table3-2 lists the HFC MDI replacement products that have been developed and registered for each moiety as of February 2008. This does not include a number of new products developed directly as HFC MDIs, for which a CFC version did not exist.

¹ The International Pharmaceutical Aerosol Consortium is a group of companies (Abbott, Astrazeneca, Boehringer Ingelheim, Chiesi Farmaceutici, Glaxosmithkline, Inyx, Inc. and Sepracor, Inc.) that manufacture medicines for the treatment of respiratory illnesses, such as asthma and COPD.

It is clear that progress has continued in the development and registration of HFC MDIs and DPIs, with a number of the IPAC member companies well underway in phasing out their CFC MDIs. However, while some companies such as GlaxoSmithKline and Chiesi have made continuing progress over the past two years, transition for other companies appears to have reached a plateau.

Device approvals and subsequent launches for both DPIs and MDIs are presented for each moiety in Table 3-3. This shows that in many countries, more than one product is widely available for certain moieties. Taking salbutamol as an example, there are 64 countries where there are CFC-free products available from multiple IPAC producers, with a further 105 countries where a single CFC-free inhaler is on the market. In total, there are 73 countries where there is more than one short-acting β -agonist available from more than one company, an increase of 13 in the last two years. Furthermore, the corresponding numbers for corticosteroids, long-acting β -agonists and combinations thereof (not shown in Table 3-3), are 93, 48 and 62 respectively. Therefore, there are technically feasible alternatives that are widely available.

As may be seen from Table 3-4, significant progress has been made towards transition in Article 5 Parties for certain key moieties. In many Article 5 Parties, more than one CFC-free product is available; for example, there are 33 countries where there is more than one short-acting β -agonist available from more than one IPAC company. Furthermore, the corresponding number of countries for corticosteroids, long-acting β -agonists and combinations thereof (not shown in Table 3-4) are 49, 13 and 26 respectively.

Nonetheless, the pace of progress in availability of CFC-free products from IPAC companies in Article 5 Parties appears to have been slower in the last two years in contrast to the global picture. However, this takes no account of CFC-free products that have been introduced by non-IPAC members companies. For example, Cipla in India lists on its web-site (<http://www.cipla.com>) over 100 respiratory products that do not contain CFCs, including CFC-free MDIs for beclomethasone, budesonide, fluticasone propionate, formoterol, ipratropium bromide, salbutamol, salmeterol, terbutaline sulphate and various combinations of the above. According to data available on the Ozone Secretariat's website (<http://ozone.unep.org>), many of these products were approved 6 years ago and are produced for export. However, the detail behind these exports, together with DPI and oral alternatives, is not well documented. It is important that Article 5 Parties collect their own basic data on CFC and CFC-free inhaler use annually and provide it to the Ozone Secretariat by 28 February each year in accordance with Decision XIV/5 to be posted on its website. This will aid in the development of effective transition plans within each country and in the determination of any essential use nominations for Article 5 Parties beyond 2010.

Based on these data, transition is well under way in many Article 5 Parties. However, it is clear from accumulating experience in non-Article 5 Parties that the development and registration of CFC-free products cannot alone lead to a full uptake in the market without additional regulatory action, appropriate pricing and a clear national transition strategy.

Table 3-2 Number of countries where HFC MDIs are launched, by moiety and company (IPAC companies only)

Moiety	Company	Launched by Dec 05	Launched by Feb 08
Beclomethasone	3M	22	N/A
	Chiesi	22	38
	GlaxoSmithKline	19	23
	Ivax	27	N/A
Budesonide	Chiesi	15	25
Fenoterol	Boehringer Ingelheim	20	21
Fenoterol and Ipratropium	Boehringer Ingelheim	19	22
Fluticasone	GlaxoSmithKline	111	130
Formoterol	Chiesi	11	19
Ipratropium	Boehringer Ingelheim	28	28
Nedocromil	Sanofi-Aventis	9	9
Salbutamol	3M	30	N/A
	GlaxoSmithKline	96	168
	Ivax	34	N/A
Salmeterol	GlaxoSmithKline	1	41
Sodium cromoglycate	Sanofi-Aventis	*14	*14

*Includes one launch of sodium cromoglycate in combination with reproterol.

**Table 3-3 Device approvals and subsequent launches (IPAC companies only) in all countries:
table data refer to numbers of countries**

Moiety	Device	Marketed Oct 06	Marketed Feb 08	Approved, but not launched Feb 08	One product marketed in country	More than 1 product from more than 1 company
Beclomethasone	DPI	39	16	26	} 42	} 32
	HFC MDI	61	112	23		
Budesonide	DPI	76	79	6	} 63	} 20
	HFC MDI	15	25	1		
Fenoterol	DPI	-	-	-	} 25	} 0
	HFC MDI	25	25	1		
Fenoterol and Ipratropium	DPI	-	-	-	} 27	} 0
	HFC MDI	27	27	1		
Fluticasone	DPI	77	64	41	} 122	} 0
	HFC MDI	111	131	21		
Formoterol	DPI	52	59	2	} 44	} 19
	HFC MDI	11	24	-		
Ipratropium	DPI	-	-	-	} 40	} 0
	HFC MDI	40	40	1		
Nedocromil	DPI	-	-	-	} 9	} 0
	HFC MDI	9	9	-		
Salbutamol	DPI	66	56	32	} 105	} 64
	HFC MDI	112	236	33		
Salmeterol	DPI	65	54	42	} 61	} 0
	HFC MDI	1	41	13		
Sodium cromoglycate	DPI	2	2	-	} 16	} 0
	HFC MDI	**14	**14	-		
Terbutaline	DPI	51	56	17	} 56	} 0
	HFC MDI	-	-	-		

**Includes one launch of sodium cromoglycate in combination with reproterol.

Table 3-4 Device approvals and subsequent launches in Article 5 Parties from IPAC companies only: table data refer to numbers of countries

Moiety	Marketed Oct 06	Marketed Feb 08	One product marketed in country	More than 1 product from more than 1 company
Beclomethasone	37	37	24	13
Budesonide	39	42	36	6
Fenoterol	4	4	4	0
Fenoterol and Ipratropium	3	5	5	0
Fluticasone	75	78	56	22
Formoterol	21	26	23	3
Ipratropium	3	3	3	0
Nedocromil	0	0	9	0
Salbutamol	91	110	77	33
Salmeterol	37	23	20	3
Sodium cromoglycate	0	0	0	0
Terbutaline	23	26	26	0

3.4 Transition strategies

Transition strategies from only 6 Parties are listed on the Ozone Secretariat's web site. Pursuant to Decision XV/5(4), plans of action regarding the phase-out of the domestic use of CFC-containing MDIs from the European Community, the Russian Federation and the United States are also listed on the Ozone Secretariat's web site².

² http://ozone.unep.org/Exemption_Information/Essential_Use_Nominations/index.shtml

According to Executive Committee Decision 45/54, Low Volume Countries (LVCs) submitting Terminal Phase-Out Management Plans (TPMPs) can obtain up to US\$30,000 for MDI transition strategies upon provision of basic data demonstrating the need for such a strategy. However, there is the additional issue of whether funding can be extended to countries that have either submitted their TPMPs before the 45th Meeting of the Executive Committee or are not LVCs. Furthermore, a number of Article 5 Parties with major manufacture of CFC MDIs are still in the process of preparing transition strategies. It should be noted that some transition strategies have been approved under national ODS/CFC phase-out plans; others have been approved as part of MLF-funded MDI investment projects; and yet others as stand alone projects. Transition strategies have been approved at least in the following countries: Bangladesh, Colombia, Cuba, Egypt, Iran, Malaysia, Mexico, Moldova, Nicaragua, Thailand, and Uruguay. However, none of these appear on the Ozone Secretariat's web site.

It is important that Article 5 Parties develop their own national transition strategy and provide them to the Secretariat, to be posted on its website, and then to report each year on progress in transition, both in accordance with Decision XII/2. Parties may also wish to consider making a national transition strategy a requirement for Article 5 Parties nominating for an essential use exemption to produce CFCs for MDIs, as has been the case for Parties not operating under Article 5.

3.4.1 Progress reports on transition strategies under Decision XII/2

Under Decision XII/2, Parties are required to report to the Secretariat by 31 January each year on progress made in transition to CFC-free MDIs. In 2008, one report was received from the People's Republic of China on the Hong Kong Special Administrative Region (HKSAR).

In 2002, the Government of the HKSAR submitted its strategy to facilitate transition to CFC-free MDIs. All MDIs in the HKSAR are imported products. Major registered substitutes available on the market include dry powder inhalers (DPIs) and hydrofluorocarbon (HFC) MDIs. Public health care services are progressively phasing out CFC MDIs in favour of CFC-free alternatives, while some multinational pharmaceutical companies have discontinued the marketing of a number of CFC MDIs for which direct replacements have been developed. As a result of these combined actions, there has been a sizeable reduction in CFC MDI consumption. In 2006, the percentages of consumption of CFC MDIs, CFC-free MDIs and DPIs were 13, 84 and 3 per cent respectively. However, the Government of the HKSAR reports that some CFC MDIs are still considered to be essential as their practical alternatives are not yet fully available.

3.5 Global database in response to Decision XIV/5

Under Decision XIV/5, Parties are requested to submit information on CFC and CFC-free alternatives to the Secretariat by 28 February each year. In 2008, reports were only received from Canada, the European Community, and Uruguay³. Twenty-two Article 5 Parties have submitted data pursuant to Decision XIV/5 since its inception, but in many cases the data have not been updated annually. These Parties are Argentina, Australia, Belize, Bosnia and Herzegovina, Brazil, China, Croatia, Cuba, Eritrea, Georgia, Guyana, India, Indonesia, Jamaica, Macedonia, Malaysia, Mauritius, Moldova, Namibia, Oman, Romania, Sri Lanka, and Uruguay.

³ http://ozone.unep.org/Exemption_Information/Essential_Use_Nominations/index.shtml

It is important that Article 5 Parties collect their own basic data on CFC and CFC-free inhaler use annually and provide it to the Secretariat by 28 February each year, to be posted on its website, in accordance with Decision XIV/5. Decision XII/2(3) also requests Parties, including Article 5 Parties, to notify the Ozone Secretariat of any MDI products determined to be non-essential, and for nominating Parties to take this information into consideration. The Ozone Secretariat website only has information from the European Community. Collection of such data is needed to successfully implement transition strategies. Given the complexity and fluidity of export markets, Parties may wish to consider a requirement for all Parties, including those operating under Article 5, to make annual declarations of any MDI products determined to be non-essential within their own country, and that these declarations accompany essential use nominations from Parties manufacturing and exporting CFC MDIs to these countries.

4 Chemicals Technical Options Committee Progress Report

4.1 Executive Summary

The 2008 CTOC Progress Report covers issues and progress on all the sub-sectors for which the CTOC is responsible. It includes chapters on matters that have been requested by the Parties: process agents, n-PB updates, reconsideration on carbon tetrachloride emissions and essential use nominations of CFC-113 by the Russian Federation.

Process Agents

The CTOC reviewed the reported information from Israel, Netherlands and China under decision XVII/6(7) and affirmed that the information reported by Israel and the Netherlands has been included in Table A of Decision XIX/15, listed as #1 (Elimination of NCl₃ in chlor-alkali production) and #8 (Production of aramid polymer (PPTA)), respectively. Regarding the information from China, the CTOC assessed that three applications could be added in Table A of Decision XIX/15. Those process agent applications include CTC as a dispersant or diluting agent in the production of polyvinylidene fluoride, CTC as a solvent for esterification in the production of tetrafluorobenzoyl ethyl acetate and CTC as a solvent for bromination and purification in the production of 4-bromophenol. Also the CTOC confirmed that the process agent use in production of Dicofol (#6 in Table A of Decision XIX/15) had ceased in India in 2007 and recommend to delete this application from Table A.

Under the Decision XVII/6(8), the TEAP was requested to review emissions in Table B of the Decision X/14, taking into account information and data reported by the Parties and to recommend any reductions to the make-up and maximum emissions on the basis of that review. However, the TEAP/CTOC could not make any recommendation regarding the revision of Table B due to the fact that not all the data were available. Only three Parties, EC, USA and Brazil submitted data to the Ozone Secretariat. The data from Brazil are 'in confidence' due to the fact that only one plant was reporting in each case, while EC and USA data were public.

Feedstocks

The CTOC reported a detailed summary of feedstock applications in the TEAP May 2005 Progress Report under the Decision X/12 and no further studies were requested by the Parties in 2008. The CTOC updated the list of feedstocks and estimated that the emissions from feedstock uses of ODS were of the order of 4,250 metric tonnes or 1,650 ODP tonnes in 2005.

Laboratory and Analytical Uses

Decision XIX/18 requested the TEAP/CTOC to provide, by the 21st MOP (2009), a list of laboratory and analytical uses of ODSs, indicating those for which alternatives exist and which are therefore no longer necessary and describing those alternatives.

The CTOC has produced an interim report this year on analytical uses and standard analytical methods such as infrared analyses, iodometric titrations, bromine index determinations, etc.

The Latin America and Caribbean Ozone Officers Network provided information about analytical uses of ODS with quantitative data for Argentina and Chile. While analytical uses were identified in Bolivia and Mexico, no quantitative data were available.

As far as the CTOC was able to ascertain, the use of ODS in analytical procedures has ceased in non-Article 5 Parties, but such Parties may wish to ascertain whether this is correct. Replacement with non-ODS alternatives has occurred in some but not all Article 5 Parties. The cost of alternatives may be high in some cases, but work is underway in at least one Article 5 Party to test alternatives and make the transition away from ODS, so 'casebook' studies should be available by the time the CTOC completes its report in 2009.

Solvents and n-PB Updates

No new alternatives for solvent applications have been developed since the last report in 2006. Currently HFCs, HCFCs and HFEs still lead the field of in-kind solvent applications.

Decision XIII/7 requested the TEAP to report annually on n-PB use and emissions. The following is a summary of the investigations by the CTOC this year.

- The ODP values of n-PB calculated by a three dimensional (3-D) model are consistent with the previous calculations by a two dimensional (2-D) model, and fall between 0.013 and 0.105.
- The global production of n-PB is estimated to be around 20,000-30,000 metric tonnes of which 5,000 tonnes are probably used as pharmaceutical and chemical intermediates or feedstock. Its consumption as a solvent is growing at a rate of 15-20 % per year in the USA (5,000 tonnes in 2006) and other Asian countries, but has begun to level off in Japan (1,310 tonnes in 2006). There is no information for other regions.
- Obtaining more complete and accurate data on production and uses of n-PB, as well as its emissions, continues to be difficult owing to business confidentiality.
- The Parties may wish to establish a reporting system so that accurate data for n-PB can be considered by the TEAP/CTOC.
- The situation of its toxicity remains the same as described in the 2006 CTOC Progress Report. The major areas of concern regarding its toxicity are chronic toxicity, reproductive toxicity and genotoxicity.

Reconsideration of carbon tetrachloride emissions

The Parties requested the TEAP/CTOC to prepare a final report for the 27th OEWG for the consideration of the 19th MOP in 2007 under the Decision XVIII/10, but the CTOC could not complete the task mainly due to difficulties in accessing relevant information.

The TEAP decided to complete this study with a Task Force and the final report will be published by the Task Force and presented at the 28th OEWG in Bangkok in July 2008.

Essential Use Nomination of CFC-113 by the Russian Federation

Decision XIX/14 noted the readiness of the Russian Federation to receive a small group of experts nominated by the TEAP/CTOC. The arrangement for their visit to Russia is now under negotiation among the Russian Federation, the Ozone Secretariat in Nairobi and the TEAP/CTOC.

The TEAP/CTOC will report the results of the discussion at the upcoming 28th OEWG in Bangkok in July 2008.

Recovery, Recycling and Destruction

Updated information was obtained from Japan and the Russian Federation with regard to recovery and recycling. In Japan, 4,384 metric tonnes of refrigerants including ODSs and HFCs were recovered from commercial air-conditioning and refrigeration equipment and mobile air-conditioners under the Fluorocarbon Recovery and Destruction Law in 2005. The Russian Federation reported the function of the Centers for CFC Recovery and Reclaiming that give service mainly for commercial and domestic refrigeration equipment and established the Center for Halon Recovery and Reclaiming (H-CRR) with a total capacity of approximately 2,000 metric tonnes per year.

Regarding ODS destruction activities, the Russian Federation opened facilities in fluorochemical manufacturing companies to destroy any kinds of CFCs, HCFCs, HFCs and PFCs.

In Article 5 Parties, two cases were reported from Indonesia and Fiji. The Indonesian cement industry through technical assistance provided by the Japanese Government has developed a facility to destroy CFC wastes, and its operation will start by July 2008. The National Ozone Unit of the Department of Environment in Fiji exported a container containing halons to DASCEM Holdings in Melbourne in Australia for destruction in 2007 since Fiji did not have a disposal facility to destroy ODS.

4.2 Introduction

The CTOC met on February 19-21, 2008 in Shanghai, China, where the meeting was hosted by the co-chair, Professor Jiang Biao. The courtesy of the Shanghai Institute of Organic Chemistry (SIOC) was highly appreciated. Fifteen out of twenty CTOC members participated in the meeting. Attending members were seven from the Article 5 Parties (Chile, China, India, Kuwait, Mauritius and Tanzania) and eight from the non-Article 5 Parties (Australia, Japan, Netherlands, Russia and USA).

The agenda of the meeting covered issues on all the sub-sectors for which the CTOC is responsible, including process agents, feedstocks, laboratory and analytical uses, emissions of carbon tetrachloride, update of n-propyl bromide, solvents, non-medical aerosols and destruction technologies.

The main purpose of the meeting was to respond to the requests in the relevant decisions from Meeting of the Parties to the Montreal Protocol, and the conclusions of the meeting have been summarised in the following chapters.

4.3 Process Agents

The 19th Meeting of the Parties, held in Montreal, Canada in September 2007, adopted a new Table A in the Annex to the Decision XIX/15 as a list of process agent applications to replace Table A of Decision X/14 as it was amended in Decision XVII/7 and to replace Table A-bis in Decision XVII/8.

The Decision XVII/6(7) requests the TEAP to review the information submitted in accordance with Decision XVII/6(4) and to report and make recommendations to the Parties at the 20th MOP in 2008, and every other year thereafter, on process-agent use exemption: on insignificant emission associated with a use, and process-agent uses that could be added to or deleted from

Table A of Decision X/14 (which has now been replaced by the new Table A of Decision XIX/15).

Further, the Decision XVII/6(8) requests Parties with process agent uses to submit data to the TEAP by 31 December 2007 and 31 December of each subsequent year on opportunities to reduce emissions listed in Table B of the Decision X/14 and for the TEAP to review in 2008, and every other year thereafter, emissions in Table B, taking into account information and data reported by the Parties and to recommend any reductions to the make-up and maximum emission on the basis of that review. On the basis of these recommendations, the Parties shall decide on reductions to the make-up and maximum emissions with respect to Table B.

The new Table A in Decision XIX/15 approved 42 uses of controlled substances as process agents based on the detailed CTOC review of previous Table A and Table A-bis requested by the decisions XVII/6(7) and XVII/8, respectively, as well as a potential list of process agents applications from China (see pp 27-42 in the TEAP April 2007 Progress Report).

By the time of the 2008 CTOC meeting, the Ozone Secretariat in Nairobi or the TEAP/CTOC received new information from Israel, Netherlands and EC, and the information from China was received by the Ozone Secretariat after the CTOC meeting. All of the information has been reviewed by the CTOC as shown in Section 4.3.1. Regarding the emissions listed in Table B, the CTOC received information only from EC, USA and Brazil. The data from Brazil are 'in confidence' due to the fact that only one plant was reporting in each case. The review by the CTOC is described in Section 4.3.2.

4.3.1 Review of information from Israel, Netherlands and China

The CTOC reviewed the information from Israel. There are two identical installations that use carbon tetrachloride (CTC) for the elimination of nitrogen trichloride (NCl₃) in the production of chlorine with the capacities of 7.2 metric tonnes of CTC. The CTC quantities used were 3.5 metric tonnes but there were no direct emissions to the atmosphere although some losses of CTC occurred through an entrainment by chlorine gas. This application is included as #1 in the list of Table A in Decision XIX/15.

The Netherlands reported the process agent use of CTC in the manufacturing process of poly-phenylene-terephthal-amide (PPTA) during 2006. The usage of CTC was 6.9 metric tonnes and its emission was reported as 2.86 metric tonnes with destruction of 4.0 metric tonnes. The Party expects to reduce the emissions of CTC below 1.0 metric tonnes over 2007 and the following years. This application is included as #8 in the list of Table A in Decision XIX/15.

India had indicated the process agent use in production of Dicofol (#6 in Table A of Decision XIX/15) would cease by 31 December 2007. In response to confirmation by the CTOC, India reported that the process agent use (CTC) in production of Dicofol has ceased in India. Therefore the #6 application could be deleted from Table A of Decision XIX/15. Also, information was received from UNIDO that the process agent use for production of Sultamicillin (#31 in Table A of Decision XIX/15) in Turkey has ceased but that the process is still operated in South Africa so this process agent use needs to remain in Table A.

The CTOC investigated a potential list of process agent applications from China in 2007 and commented that more information was needed to assess the listed applications, No. 8, 10, 12, 13, 15, 16, 17, 19, 20 and 22 in the Table 4.3 on pp 36-37 in the TEAP April 2007 Progress Report.

China submitted information on those ten applications to the Ozone Secretariat on March 4, 2008. The CTOC examined this information and its findings are summarised in Table 4-1.

Table 4-1 Findings by CTOC for the additional information submitted by China

Nos. in Table 4-3	Applications	Information from China	CTOC Findings
No.8	Chlorofluazuron	No production	Not a Process Agent
No.10	Dope	No information available	Not a Process Agent
No.12	Ethyl-4-chloroacetoacetate (one of the two facilities)	No production	Not a Process Agent
No.13	GCLE	No production	Not a Process Agent
No.15	Ozagrel	No production	Not a Process Agent
No.16	PVdF	CTC as a dispersant or diluting agent	Meets process agent technical criteria
No.17	Tetrafluorobenzoyl ethyl acetate	CTC as a solvent for esterification	Meets process agent technical criteria
No.19	Using as G.I	No information available	Not a Process Agent
No.20	Beta-Bromopropionic acid	No production	Not a Process Agent
No.22	4-Bromophenol	CTC as a solvent for bromination and purification	Meets process agent technical criteria

The CTOC assessed the following three applications, No.16 (PVdF), No.17 (Tetrafluorobenzoyl ethyl acetate) and No.22 (4-Bromophenol) as process agent uses and these could be added in Table A of Decision XIX/15.

4.3.2 Attempted review of Table B of Decision X/14

Table 4-2 shows an updated Table B of Decision X/14 by adding reported data in 2006. Not all the data have been available, but the reported data by EC and USA are in line with the Table B of Decision X/14. For the EC it should be taken into account that not all data of the new Member States are included in the reported data. Due to the fact that not all the data are available, the CTOC can not make any recommendation on reductions to the make-up and maximum emissions regarding the Table B of Decision X/14.

Table 4-2 Updated Table B of decision X/14

Countries/Regions	Make-up or consumption	Make-up or consumption (2006)	Maximum emissions	Emissions (2006)
European Community	1000	594*	17	5*
United States of America	2300	No data	181	47**
Canada	13	No data	0	No data
Japan	300	No data	5	No data
Russian Federation	800	No data	17	No data
Australia	0	No data	0	No data
New Zealand	0	No data	0	No data
Norway	0	No data	0	No data
Iceland	0	No data	0	No data
Switzerland	5	No data	0.4	No data
TOTAL	4501	594	221	52

Updated table B in metric tonnes; *European Commission DG Environment and CTOC data ** EPA data

4.4 Feedstocks

The CTOC reported a detailed summary of feedstock applications in the TEAP May 2005 Progress Report (pp 85-87) under the Decision X/12 and additional information on a feedstock use of trifluoromethyl bromide (halon 1301) as a trifluoromethylating agent useful for manufacturing pharmaceuticals and of CTC for manufacturing various HFC compounds in the TEAP May 2006 Progress Report (pp 67-69 and pp 80-81, respectively).

Further studies on feedstock uses were not requested by the Parties in 2008, but the CTOC updated the list of common feedstock applications and the estimated emissions from feedstock uses of ODSs.

4.4.1 Important feedstock applications

CTC, CFCs and HCFCs can be feedstocks either by being fed directly into the process as a raw material stream, or by being produced as an intermediate in the synthesis of other desired products. Losses can occur during production, storage, transport and transfers. Intermediates are normally stored and used at the same site, so fugitive leaks are somewhat lower in this case.

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

- Conversion of HCFC-21 in the synthesis of HCFC-225 which finds application as a solvent
- Conversion of CFC-113 to chlorotrifluoroethylene. The latter is subsequently polymerized to polychlorotrifluoroethylene, a barrier resin used in moisture-resistant packaging.
- Conversion of CFC-113 and CFC-113a to HFC-134a and HFC-125. As this is the route to much of the HFC volumes, it is a high volume use.
- Conversion of HCFC-22 to tetrafluoroethylene (TFE). TFE forms the building block of many fluoropolymers both by homopolymerization and copolymerization. This is a very high volume use.
- Conversion of 1,1,1- trichloroethane as a feedstock in the production of HCFC-141b and HCFC-142b. This can continue until 2030 at high volume for emissive uses of these products and can continue long-term for uses related to conversion to polymers as noted below.
- Conversion of HCFC-142b to vinylidene fluoride, which is polymerized to polyvinylidene fluoride or to copolymers. These are specialty elastomers. This use of HCFC-142b is not subject to phase-out and is likely to continue long term.
- 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 and becomes limited to only essential uses, volumes of CTC for this application will diminish significantly.
- Conversion of CTC to chlorocarbons, which, in turn, are used as feedstocks in production of HFC-245fa and other fluorochemicals.
- Reaction of CTC with 2-chloropropene to eventually lead to production of HFC-365mfc.
- CTC is used in the reaction with vinylidene chloride for preparation of HFC-236fa with production volumes under 1 million pounds annually.
- Consumption of CTC in the production of DV acid chloride, a precursor of synthetic pyrethroids.
- By-product CTC can be produced in the manufacture of chloroform, which is a feedstock used in production of HCFC-22, a long-term high volume operation.
- Conversion of HCFC-123, HFC-123a and HFC-133a in manufacture of pharmaceuticals, which is a long term use not subject to phase-out.
- Conversion of HCFC-123 in the production of HFC-125. While this usually occurs as an intermediate, it is possible that this could be done using HCFC-123 as a starting material. We are not aware of using HCFC-123 as a starting material at this time.
- HCFC-124 can be used as a feedstock to prepare HFC-125.

4.4.2 Estimated emissions of ODS

The IPCC recommends that emissions can be estimated from production facilities at 0.5% for HFCs and 0.2% for SF₆. This includes fugitive and transport emissions. If one accepts that 0.5% is an appropriate guidance level for products transported and used as raw materials, calculations from 2002 production data suggest that:

ODS used in production of HFCs = 293,000 tonnes
Emission volume of ODS = 1,465 tonnes
ODP impact of emissions = 1,172 ODP tonnes

Production of fluoropolymers = 225,000 tonnes
Emission of ODS = 1,125 tonnes
ODP impact of emissions = 62 ODP tonnes

TCE used in production of HCFCs = 282,175 tonnes
Emission volume of ODS = 1,411 tonnes
ODP impact of emissions = 141 ODP tonnes

CTC used in production of CFCs = 50,000 tonnes
Emission of ODS = 250 tonnes
ODP impact of emissions = 275 ODP tonnes

These data are only for emissions associated with manufacture and do not include any emissions related to uses. Therefore, total emissions from feedstock use are on the order of 4,250 metric tonnes and contribute about 1,650 ODP tonnes in 2005.

4.5 Laboratory and Analytical Uses

The use of ozone depleting substances (ODS) in laboratory and analytical procedures has been a concern of the Parties. The 2006 TEAP report included information provided by the CTCOC on the development and availability of laboratory and analytical procedures that can be performed without using ODS under the Decision XV/8.

Decision VII/11, taken in 1995 following receipt of a report by the Laboratory and Analytical Uses Working Group, urged Parties to move to alternatives to the ODS currently used in laboratories and the TEAP to evaluate possible alternatives and to report progress in their adoption. Decision IX/17 continued the exemption and asked Parties to report annually on such uses. At the following Meeting of the Parties (Decision X/19) this provision was extended to 31 December 2005 and this was subsequently (Decision XV/8) extended to 31 December 2007. Two further Decisions (Decision XVI/16 and XVII/13) addressed the general issues and, in particular, noted the continuing use of CTC in analytical procedures, which caused the consumption targets to be exceeded.

Before then, however, Parties had agreed (Decision XI/15) to eliminate the use of ODS in some specific analytical applications, among which was 'testing of oil, grease and total petroleum hydrocarbons in water'. In a related Decision XIX/18, Parties later agreed to eliminate the testing of organic matter in coal from the global exemption for laboratory and analytical uses of controlled substances, since the TEAP had reported that an alternative procedure was available.

The most recent Meeting of the Parties also made Decision XIX/17, which included the deferral until 2010 consideration of the compliance status in relation to the control measures for CTC of Parties operating under Article 5, which provide evidence to the Ozone Secretariat with their data reports, submitted in accordance with Article 7, showing that any deviation from the respective consumption target is due to the use of CTC for analytical and laboratory processes. The Decision also urges these Parties to minimise the consumption of CTC in laboratory and analytical uses by applying the global exemption criteria and procedures for laboratory and analytical uses of carbon tetrachloride currently established for Parties not operating under Article 5 (that is, developed countries, which have agreed consumption quotas).

Decision XIX/18 extended the global laboratory and analytical-use exemption until 31 December 2011, under the conditions set out in earlier Decisions, and requested the TEAP and its CTOC to provide, by the Twenty-first Meeting of the Parties (2009), a list of laboratory and analytical uses of ozone-depleting substances, indicating those for which alternatives exist and which are therefore no longer necessary and describing those alternatives.

This report describes the progress of the CTOC studies. A final list will be submitted to the 21st MOP in 2009 under Decision XIX/18. This report concentrates on analytical uses.

4.5.1 Usage surveys

The Nordic Council of Ministers conducted a review of the use of ODS in analytical procedures in 2001, and published it in 2003 (TemaNord 2003:516, 'Use of ozone depleting substances in laboratories', www.norden.org/pub/ebook/2003-516.pdf, accessed December 2007). Based on returns of the questionnaire, it was estimated that 205 laboratories used ODS for oil-in-water assays and 44 other procedures. Alternative solvents and also gravimetric procedures were reported and so, although a little dated, the review provides much valuable information. A subsequent report placed more emphasis on alternatives (TemaNord 2005:580, 'Potential Ozone Depleting Substances. Uses and Alternatives in the Nordic Countries, www.norden.org/pub/miljo/miljo/uk/TN2005580.pdf' accessed December 2007).

In seeking to get some idea of the nature and scale of ODS uses that might need replacement, CTOC members from a number of countries and regions were able to provide data. In the Russian Federation, the standard method for Determination of Petrochemicals in Potable Water (GOST P 51797-2001) employs CTC as the extracting solvent, which is used for infrared determination, although CFC-113 may be used as a substitute. At present, the gravimetric method is preferred so that the use of ODS can be avoided.

A CTOC member reported that ODSs are no longer used in these analyses in Tanzania. Work is in progress to gather information from countries in the Arabian Gulf, where the petroleum industry has an appreciable presence, and also in other Article 5 Parties.

The Latin America and Caribbean Ozone Officers Network provided information about analytical uses of ODS by a number of Latin American countries. In each case, the major reason for using ODSs (CTC and CFC-113) was the analysis of petroleum residues in water, using a number of standard methods that relied on infrared spectroscopy. Some TCA was also used in petroleum analyses, while CTC is used also as a standard for chemical analysis and as a solvent in student laboratories. While these uses were identified in Bolivia and Mexico, no quantitative data were available. Quantitative data for Argentina and Chile are shown in the Table 4-3.

Table 4-3 Analytical Uses of ODSs in Latin American Countries (liters/year)

Country	CTC	CFC-113	TCA
Argentina	845	Nil	426
Chile	212.8	122.5	13

4.5.2 Standard analytical methods

There is a considerable body of standard analytical methods used in a range of industry sectors. Standard methods are followed because they allow comparisons over time and between different laboratories. The use of a standard method is often required by a customer as a form of quality assurance for a product, or by a regulatory authority. Considerations such as the ease and reliability of the assay, workplace health and safety, or the availability of substances under intergovernmental agreements such as the Montreal Protocol can cause new standards to be written. The production of new standards takes time and care and often lags behind the identification of the need for change. In addition, users can be slow to adopt new standards for a number of reasons, including cost, familiarity with techniques, availability of equipment and comparability of results measured using previous and new methods.

In the case of Article 5 Parties, the use of standard methods continues because of the need for quality assurance and quality control in certified laboratories. Many of the laboratories are part of international companies, and standard methods apply world-wide. In addition, some countries have their own norms or regulations that require the use of standard methods or local adaptations of standard methods. Thus the situation is extremely complex and varies from country to country. Non-Article 5 Parties may also specify specific analytical techniques: the Russian Federation, for example, specifies three methods for oil-in-water analysis, one of which uses CTC as the solvent for extraction and infrared analysis (see below).

4.5.3 Infrared analyses of hydrocarbon residues

A number of assays for hydrocarbon materials (often petroleum-derived) that use CTC or CFC-113 consist of collecting the hydrocarbon from the sample – often contaminated water with a small amount of oily phase – in a solvent that is immiscible with water and not possessed of C-H units in its structure. An infrared spectrum of the solution will show the C-H vibrations of the hydrocarbon solute, near $3\mu\text{m}$ (3000 cm^{-1}), and the assay may be quantitated by the use of standards. Oil mists in air can be analysed by drawing the contaminated air through a filter, which retains the hydrocarbon material, and then dissolving this in the appropriate solvent and performing the infrared assay.

CTC was the solvent of choice for such assays in methods such as ASTM D-3921 (total hydrocarbons extracted from water, wastewater and sediments), and in method APHA AWWA-WPCF 5520C (IR method) for hydrocarbon extraction from water and soils. However, concerns with the possible carcinogenicity of CTC, and later its listing as a controlled substance under the Montreal Protocol, led to its replacement in many assays by CFC-113. Despite the fact that CFC-113 was already a controlled substance, ASTM method D3921-96, proposing its use, was introduced in 1996, and revised in 2003 (ASTM D3921-96(2003)). Other standard methods also described the use of CFC-113 (APHA, AWWA and WEF (2000), *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association, 20th edition, Washington, DC. Method 5520C (Partition-infrared), USEPA (1978), Method 5520B

gravimetric method, US EPA (1978), *Method 418.1: Petroleum Hydrocarbons, Total Recoverable*, Storet No. 45501, ASTM (2003), *Method D 3921-96: Standard Test Method for Oil and Grease and Petroleum Hydrocarbons in Water*, ASTM International, ASTM (2003)). CTC is also used in US EPA method 418.1, to extract total petroleum hydrocarbons from water samples, for analysis by infrared spectroscopy.

Use can be envisaged of a number of non-controlled chlorofluorocarbons that meet the requirements of solvency, liquid range and absence of C-H infrared absorptions, and which are not controlled substances and are unlikely to become controlled. Only one such chemical has come into commercial use, a reaction product of chlorotrifluoroethylene known as S-316. It is produced by the Japanese company Daikin and marketed by another company, Horiba, for use in FT-IR assays of oil-in-water.

There is some uncertainty concerning the composition of S-316, which is formed by polymerization of chlorotrifluoroethylene. Further information (TemaNord 2005:580, pages 37-39) is that several isomers of tetrachlorohexafluorobutane are present in S-316, but in some publications it is described as 'dimer/trimer of chlorotrifluoroethylene', and some researchers believe that one or more cyclodimers (dichlorohexafluorocyclobutanes) may be present, also. Provided the product has consistent composition and that satisfactory calibrations can be established, the exact composition of S-316 is probably irrelevant.

A new standard method ASTM D 7066-04 (*Test Method for Dimer/Trimer of Chlorotrifluoroethylene S-316 Recoverable Oil and Grease and Nonpolar Material by Infrared Determination*) (Rintoul, S. (2005), 'New ASTM Test method Offers Quick and Easy Oil and Grease Measurement for Water and Soil Samples', www.eco-web.com/editorial/02675-01.html, accessed December 2007.) describes the use of this solvent. One reason for persisting with the search for a replacement for CFC-113 is that, given the availability of portable infrared analysers, analysis can be performed in the field. Alternative methods that rely on gravimetric analysis require sensitive equipment that would only be found in a laboratory.

The new solvent S-316 is more expensive than those it is designed to replace, but it is being adopted in developed countries. One laboratory reported paying US\$ 450 for a 1.5 kg bottle (April 2006 data). The method employed was developed in-house, based on NIOSH method 5026 (which specified CTC as solvent) and OSHA ID178SG (which specified CFC-113).

The US National Aeronautics and Space Administration (NASA) reported in 1995 that tetrachloroethylene (also known as perchloroethylene, PCE) was a useful substitute for CFC-113 in certain applications at the Kennedy Space Center (NASA (1995)). In these applications, CFC-113 was used to degrease components and then to validate their cleanliness by a further treatment with the solvent. Fourier Transform infrared spectroscopy was used to measure the amount of hydrocarbon removed in the validation step. Calibration curves were prepared for a series of standard dilutions of hydraulic fluids in TCE and they showed that detection down to 20 ppm was possible, using the infrared absorbance of selected peaks in the analyte.

Some laboratories have rejected the use of PCE on the grounds that it was a suspected carcinogen (as is CTC), but its widespread use as a dry-cleaning solvent has been sufficient to reassure others that it can be safely used under controlled conditions. A group from the Athens Water Supply and Sewerage Company has recommended the use of PCE following their detailed study of its use for FT-IR analysis of oil and grease in contaminated water (Farmaki, E., Kaloudis, T., Dimitrou, K., Thanasoulis, N., Kousouris, L and Tzoumerkas, F. (2005, 2007), 'Validation of an FT-IR method for the Determination of Oils & Greases in Water, with the use of tetrachloroethylene as the

extraction Solvent', *Proceedings of the 9th International Conference on Environmental Science and Technology*, Rhodes Island, Greece, 1-3 September 2005. Farmaki, E., Kaloudis, T., Dimitrou, K., Thanasoulis, N., Kousouris, L and Tzoumerkas, F., 'Validation of an FT-IR method for the Determination of Oils & Greases in Water, with the use of tetrachloroethylene as the extraction Solvent', *Desalination*, 2007, 210 (1-3), 52-60.. Calibration with a mixture of iso-octane and n-hexadecane was established over the range 0.6 to 50 mg/L.

The isomer of CFC-113, CFC-113a (1,1,1-trichloro-2,2,2-trifluoroethane) is not a controlled substance, although the possibility has been raised that it was simply overlooked when the list of controlled substances was drawn up (TemaNord 2005:580, page 35). Notwithstanding this objection, the substance meets other criteria for the FT-IR analysis since it is a good solvent with no C-H absorption in the infrared spectrum. There is a problem, however, with its liquid range – between m.p. 14° and b.p. 46°C (compare CFC-113 m.p. -35°, b.p. 48°C). Its melting temperature means it would be solid at temperatures only a little below those of most laboratories and possibly in the field.

In response to the inappropriateness of using CFC-113 as extractant for the FT-IR method, a gravimetric method was developed (APHA, AWWA and WEF (2000). This involved the use of n-hexane as the solvent with which the hydrocarbons are extracted, and which is later evaporated, leaving the oil and grease as a residue that can be weighed. Great care is needed to ensure that volatile components of the total petroleum hydrocarbons are not lost in removal of the n-hexane. Another example of such an assay is the US EPA Method 1644A. In cases where the volatile components of the total petroleum hydrocarbons have been lost to the atmosphere – for example, from contaminated water that is exposed to the environment for a time – then only the fixed hydrocarbons remain and the gravimetric method is appropriate.

In the medical field, the use of CFC-113 is also described in the British Pharmacopoeia. The apparatus to be used in connection with 'medical air' is to be washed with CFC-113 prior to trapping oil contaminants in a glass fibre filter, followed by extraction with CFC-113 and measurement of infrared absorbance of the solution of oil in CFC-113 solution. The toxicity of tetrachloroethylene would preclude its use in this application, but S-316 should be suitable.

4.5.4 Iodometric titrations

An analytical method that uses CTC is the titration of iodine in solution by the addition of sodium thiosulfate. The end point of the titration - the disappearance of the last traces of iodine – can be detected by the fading of the blue color produced by adding starch solution to the mixture. In an alternative detection method, the iodine is dissolved in an organic liquid (one with no oxygen in the molecule). In such solutions the iodine color is strong purple whereas in water alone it is pale yellow. CTC is commonly used as the organic liquid but other organic liquids with relative density >1, and in which the iodine can dissolve, could be used. Occupational Health and Safety (OHS) and Montreal Protocol considerations would still apply, but dichloromethane (d 1.33), chloroform (d 1.48), trichloroethylene (d 1.46) and tetrachloroethylene (d 1.62) could all be considered. One of the older standard texts on analytical chemistry (Vogel, A.I. (1951), *A Textbook of Quantitative Inorganic Analysis. Theory and Practice*, second edition (Longmans Green, London), page 331) comments, during discussion of the use of CTC, that 'equally satisfactory results can be obtained with chloroform', but in today's workplace environment chloroform may be discriminated against on the grounds of toxicity.

4.5.5 Bromine index determination

The use of 1,1,1-trichloroethane or methyl chloroform (TCA) was mentioned in the 2006 TEAP Progress report. The Bromine Index is the amount of bromine (mg) taken up in a 100 grams sample of a hydrocarbon mixture in which there are some unsaturated (= olefinic) components.

There are several ASTM methods for this assay. Method D2710-99 involves generation of bromine *in situ* by electromeric methods from bromide and bromate ions in a suitable solvent mixture. The procedure closely resembles that used for Karl Fischer determination of traces of water, and the same apparatus may be used for both determinations, and is available commercially. A similar method is ASTM D1159, which employs a mixture of glacial acetic acid, methanol, sulfuric acid and 1,1,1-trichloroethane. The last of these, an ODS, is a co-solvent that ensures that higher hydrocarbon fractions will be soluble in the mixture.

An instrument company seems to be leading in the development of alternatives to the use of 1,1,1-trichloroethane. One bulletin (Metrohm. Method 9 – Bromine index of heptane. www.metrohm.com/products/01/pac/oilpac/e/oilpac_method9_e.pdf, accessed January 2008.) describes a mixture of glacial acetic acid, 1-methylpyrrolidone, methanol and sulfuric acid. A bulletin from another branch of the company (Metrohm Application Bulletin 177/4e. Automatic determination of the bromine index and/or bromine number in petroleum products. (www.metrohm.co.uk/bulletins/177_e.pdf), accessed January 2008.) describes the use of 1,1,1-trichloromethane but also comments that ‘if possible one should refrain from using chlorinated solvents. Our investigations have shown that carbon tetrachloride and 1,1,1,-trichloroethane can be replaced by diethyl carbonate’.

Thus, two alternatives to the use of an ODS – 1-methylpyrrolidone and diethyl carbonate – are available for use in this method.

4.5.6 Iodine number

A similar analysis, but in a different field of chemistry, is used for determination of unsaturation in hydrocarbon chains. The Official Methods of Analysis of AOAC International (formerly the Association of Official Analytical Chemists) 18th edition (2005) describes the use of CTC as an organic solvent in the procedure for determination of iodine number, but CTC is only one of a number of alternatives. The AOAC Official method 920.158 (Hanus Method) dates from 1920 and uses iodine bromide prepared *in situ* to react with the unsaturated linkages, after which the excess reagent is estimated by means of titration with sodium thiosulfate and starch indicator. The solvent for the iodine reaction is a mixture of acetic acid and chloroform.

However, also dating from 1920 is an alternative procedure 920.159 (Wijs method) which uses *in situ* iodine chloride in a mixture of acetic acid and CTC. In 1993 and 1996 the AOAC published Official Method 993.20 (also described as the IUPAC-AOCS-AOAC Method) and this uses pre-formed iodine chloride as reagent, and as solvent a mixture of acetic acid and cyclohexane. This Official Method also includes a table of correlations between results obtained with CTC and cyclohexane, respectively, as co-solvent with acetic acid. The clear intention of the latest method 993.20 is to avoid the use of CTC. The AOCS (American Oil Chemists Society) method referred to is #Cd 1-25, which was revised in 1988 and reapproved in 1989. Imperial Industrial Chemicals (Thailand) (www.iic.co.th/products/iodine.htm accessed February 2009) used CTC as co-solvent with acetic acid, but made the following observation:

At the time of the revision of this method in 1989, studies were under way to find a replacement for CTC in this method. The most satisfactory replacement found to date has been cyclohexane (see AOCS Recommended Practice CD 1b-87 and JOQCS 65:745 (1988)), although erratic results may be obtained for oils with iodine values 100-120, and especially marine oils. Owing to environmental concerns, CFC-113, is not recommended. Acetic acid alone and a mixture of acetic acid and cyclohexane (1:4 ratio, respectively), have been shown to be satisfactory.

Such analyses are often performed in the food industry, a sector that can be overlooked when concentrating on petroleum hydrocarbons in industry and the environment. For example, Bolivia (see above) reported the use of CTC in determination of the iodine index.

4.5.7 Extraction of natural products

Some pharmaceutical products are prepared from natural materials, usually of vegetable origin, and assays are required to determine the proportion of the active component in the natural mixture. The laxative effect of cascara bark is assayed by repeated extraction with CTC, following a method in the US Pharmacopoeia and the British Pharmacopoeia. Following this extraction procedure, the amount of (coloured) material in the CTC is determined by a chromatographic procedure. Although CTC may be recovered and reused, a proportion is lost with each recycling. However, there seems to be no specific reason for the use of CTC. Suitable replacements would be dichloromethane, ethyl acetate or acetone, but comparative assays would need to be performed on batches of material until their equivalence could be demonstrated, since other solvents may extract more or less of the active principle than CTC does.

4.5.8 Estimation of CTC contamination of pharmaceutical products

Small quantities of CTC and other solvents may be present in pharmaceutical materials if these substances have been used as solvents at some stage in the synthetic sequence that leads to the production of the material. The assay for trace contamination by solvents is conducted by gas chromatography, and it is necessary that CTC be available – albeit in microlitre quantities – to allow calibration of the assay. Unless it could be shown that the detector use in the gas chromatography responded equally to CTC and an alternative standard, the use of CTC is essential, although consumption would be small.

In the British Pharmacopoeia, CTC is listed as a possible impurity and included as one component of a reference solution for use in gas liquid chromatography (contains – in order of emergence from the column - CTC, 1,1,1-trichloroethane (TCA), dichloromethane, chloroform, ethanol, bromochloromethane, and propan-1-ol).

Until CTC is no longer used in chemical reactions to produce pharmaceutical products, this analytical method will need continuation in usage.

The Pharmacopoeia also includes an extensive guide to residual solvents in four groups, based on risk assessment: to be avoided, to be limited, low toxic potential, and no adequate toxicological data available. In the first of these categories are: benzene (carcinogenic), CTC (toxic and environmental hazard), 1,2-dichloroethane (toxic), 1,1-dichloroethene (toxic) and 1,1,1-trichloroethane (environmental hazard).

4.5.9 *Simeticone*

According to the British Pharmacopoeia (2007), the polydimethylsiloxane content of this pharmaceutical is assayed by infrared spectroscopy of a solution in toluene (intensity of absorption band at 1261 cm⁻¹ (7.93 μm) is measured). In earlier editions of the British Pharmacopoeia (up to 2004) the recommended solvent was CTC. Since toluene is satisfactory, there is no case for the continued use of CTC.

4.5.10 *Miscellaneous uses*

The British Pharmacopoeia describes the use of a solution of the reagent dithizone in CTC for pre-treatment of acetate buffer. The purpose of this is presumably to remove metal ions from the buffer solution, since dithizone is a typical metal sequestering agent and CTC a common solvent for it. There should be no difficulty in finding another non-ODS solvent to use in this application.

The British Pharmacopoeia describes the use of CFC-113 as internal standard in the gas chromatographic analysis of the anesthetic, Halothane (1-bromo-1-chloro-2,2,2-trifluoroethane). It should not be difficult to find another standard that is not an ODS.

4.5.11 *Cement analysis*

Little information is available about the extent to which CTC is used in cement analysis ('specific weight of cement'), but there is a standard method for this determination (Kemp, B.G. (1981). 'Investigation of ASTM Paste and Mortar Bleeding Tests'. Published on line at www.astm.org/cgi-bib/SoftCart.exe/DIGITAL_LIBRARY/JOURNALS/CEMENT/PAGES/433.htm?E+mystore, accessed January 2008.

In the cement literature is a paper by King and Raffle (King A. and Raffle, J.F. (1976), 'Studies on the settlement of hydrating cement suspensions', *J. Phys. D: Appl. Phys.*, 9, 1425-35.) in which the authors observe that:

Concentrated particulate suspensions tend to settle in a hindered settling mode in which all particles whatever their size settle at the same rate. Normally this phenomenon is studied by observation of the movement of the upper interface between the solids and the free water. In the case of cement suspensions, hydration reactions between the solids and the suspending fluid lead to a reduction of the total volume of the system and a suction of water into the settling mass that continues long after a fully self-supporting structure has been formed.

The methods of measurement of the settling velocity of the upper interface are either to follow the fall of a small float that rests on the surface of the suspension *or to flood the surface of the suspension with carbon tetrachloride, which sinks with the interface and the free water rising through it.*

The replacement of CTC by TCA – unfortunately, also an ODS – was investigated by ASTM and their test, ASTM C 243-95 Standard Test Method for Bleeding of Cement Pastes and Mortars, was withdrawn in 2001 and no replacement was offered.

The method using CTC is described in a sales brochure from the Humboldt company (Humboldt (2002). H-3600 Instruction Manual. Cement Bleeding Apparatus. www.ehumboldt.com/pdf/H-

3600_man.pdf, accessed January 2008.) for their cement bleeding apparatus H-3600. Approximately 500 ml of CTC is used in each test.

The use of benzene in place of CTC for cement analysis has been described by ASTM C 188-44 (revised in 1967) and it was established that this method has been used in Chile (under the heading Chilean Norm NCh 154 of '69) by the cement industry. This is likely to be the situation in non-Article 5 Parties. Further information is being sought about Article 5 Parties, but since the replacement standard method has been available for over 30 years it is likely that CTC has been phased out of this use world-wide.

4.5.12 Conclusion

As far as the CTOC was able to ascertain, the use of ODS in analytical procedures has ceased in non-Article 5 Parties, but such Parties may wish to ascertain whether this is correct. Replacement with non-ODS alternatives has occurred in some but not all Article 5 Parties. The cost of alternatives may be high in some cases, but work is underway in at least one Article 5 Party to test alternatives and make the transition away from ODS, so 'casebook' studies should be available by the time the CTOC completes its report in 2009.

4.6 Solvents

As reported in the 2006 CTOC report, the phase-out of the widely used CFCs and TCA is complete in non-Article 5 Parties and in many Article 5 Parties. The new fluorinated alternatives are hydrofluoroethers (HFEs), hydrofluorocarbons (HFCs), and low ODP HCFCs. With Decision XIX/6 at the 19th MOP in Montreal in 2007, the phase-out of HCFC will be accelerated by ten years.

HFEs and HFCs are generally used with some additives such as alcohol, chlorocarbons and/or hydrocarbons as azeotropic or pseudo-azeotropic mixtures in many applications to achieve desired cleaning efficacy and at the same time non-flammability and improved compatibility. Also, the low cost additives help in reducing over all cost of the solvents as the fluorinated components are considerably more expensive.

HCFC-225 has been used in niche applications including aerospace and military programs in the US in the replacement of CFC-113 where no other alternatives are available.

The most common substitute for TCA are other unsaturated chlorocarbons such as trichloroethylene (TCE) and tetrachloroethylene (PCE), and methylene chloride. In some cases higher boiling hydrocarbons, alcohols, and ketones are also used either neat or in blends for specific applications. Normal propyl bromide (n-PB) has captured some of aggressive cleaning applications in spite of its high toxicity and lack of adequate exposure guidelines. This is a result of heavy promotion by the n-PB industry and no reporting requirement of n-PB uses. (See Chapter 5.1) Volatile methyl siloxanes and chlorinated aromatics have also been used in niche applications.

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 are used for critical cleaning applications appears small at this time.

Stockpiles of critical cleaning solvents (CFC-113, TCA and HCFC-141b) continue to decline and hence their use is decreasing. Of course when the supply is depleted a critical situation again arises and stockpiling only delays the inevitable need to adopt alternatives.

No new alternatives have been developed since the last report. Further, it is unlikely that there will be a new solvent alternative break through because of a reduced market size, high cost, lengthy and expensive research projects, toxicological testing, and uncertainties associated with the market and regulations. Thus far only the HFCs, HCFCs and HFES are leading the field in solvent replacements.

4.6.1 *n*-Propyl Bromide (*n*-PB) Update

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

n-PB is a non-flammable, brominated alkane. Its high solvent strength makes it effective in a variety of cleaning applications including both vapour degreasing and cold cleaning. Its application area continues to expand from vapour degreasing in the metal finishing industry to precision cleaning, electronics cleaning, glass and ceramics cleaning, and others. The suppliers advertise *n*-PB to be a replacement of trichloroethylene, perchloroethylene, methylene chloride and HCFC-141b, in spite of the concern exhibited by the Parties to limit its use to only where more economically feasible and environmentally friendly alternatives are not available (see Decisions XIII/7(1) and XIII/7(2)).

The ODP of *n*-PB varies depending upon the latitude at which it is emitted. ODP values for Short-Lived Gases from 2-D and 3-D model studies for mid-latitudes / tropics emissions scenarios showed that the 3-D model agree well with the 2-D model and previous studies and that the ODP for *n*-PB remains the same as reported by SAP ranging from 0.013 to 0.105.

The US EPA in its Significant New Alternatives Policy (SNAP) program, made a ruling on *n*-PB as an acceptable substitute for ozone-depleting substances in some applications such as in metals, electronics, and precision cleaning. The US EPA is also issuing a separate proposal for other uses and is proposing that the use of *n*-PB for coatings is acceptable subject to a use condition, but for aerosol solvent and adhesive carrier solvent it is unacceptable.

The global production of *n*-PB is estimated to be around 20,000-30,000 metric tonnes, of which about 5,000 metric tonnes are probably used as pharmaceutical and chemical intermediates or feedstock. It is assumed to be produced in China, France, India, Israel, Japan, Jordan and the USA. China is estimated to have produced 16,000 metric tonnes, of which 12,000 metric tonnes were exported and it is available in most regions. The use, as a solvent is growing at a rate of 15-20% per year in USA (5,000 t) and other Asian countries, but began to level off in Japan (1,310, metric tonnes). No information is available for other regions.

Obtaining more complete and accurate data on production and uses of *n*-PB, as well as its emissions, continues to be difficult. The CTOC's attempt to obtain production, uses and emission data from the manufacturer/supplier failed as they claim business confidentiality. No governmental records are available on emission or uses due to *n*-PB being not classified or registered as a chemical substance such as CFC, and HCFC (ODS class I and II) nor designated as a hazardous air pollutant in the Clean Air Act in the USA or reportable compound for pollution release (emission) and transfer (PRTR) in Europe and Japan. Thus there is a dilemma. Although *n*-PB has a finite ODP range of 0.02-0.1 similar to other HCFC and halogens, its use is unchecked

and continues to grow with no accurate data due to no reporting requirements. Thus, Parties may wish to establish a reporting system so accurate data for n-PB can be considered by the CTOC and TEAP.

The situation of n-PB toxicity study remains the same as described in the 2006 CTOC Progress Report. It has low acute toxicity but its complete toxicological profile necessitates a low exposure guideline. The major areas of concern regarding its toxicity are chronic toxicity, reproductive toxicity and genotoxicity. Several toxicological studies on n-PB have indicated that the substance is potentially toxic to reproduction in animals and, while not showing blood effects, it has demonstrated neurological effects in rats. Owing to the known serious toxicity of its isomer, isopropyl bromide (i-PB), which has caused serious reproductive function problems and blood effects in Asian workers while handling i-PB as a degreasing agent, it raises concern about n-PB. Based on limited available (no 1-2 year chronic studies) chronic toxicity data, ACGIH and Israel have set exposure guide line of 10 ppm, with Europe setting the lowest 8-hour occupational exposure limit (OEL) value in humans and enforcing the tightest labeling classification. The US EPA has set the exposure guideline of 25 ppm similar to the guidelines set by most n-PB manufacturers at 25ppm (except one at 5ppm).

4.7 Reconsideration of sources of CTC emissions

Under the Decision XVI/14 entitled “Sources of carbon tetrachloride emissions and opportunities for reductions”, the TEAP and CTOC made a comprehensive review on various sources of CTC emissions, concluding a significant discrepancy between reported emissions and the observed atmospheric concentrations on the order of approximately 33 kilo tonnes in 2002, as seen in the TEAP May 2006 Progress Report, pp 78-90.

Following these results, the Parties requested the TEAP to continue its assessment of global emissions of CTC and to prepare a final report for the 27th Open-ended Working Group for the consideration of the 19th Meeting of the Parties in 2007 under the decision XVIII/10.

The CTOC could report only the effect of CTC emissions from landfills (pp 52-54, in the TEAP April 2007 Progress Report), but could not complete the task, mainly due to difficulties in accessing relevant information.

With these backgrounds, the TEAP organised a small Task Force to reconsider any missing estimations of associated emissions of CTC, especially in the manufacture of chloromethanes and perchloroethylene other than the consideration of CTC as feedstock for CFCs and HFCs and emissive process agent uses as already studied in the 2006 TEAP/CTOC assessment. Its objective is to study possible emissions of CTC from production and consumption of CTC with particular emphasis on these feedstock uses with the goal to estimate emissions and try to reconcile them with values calculated by atmospheric scientists with a focus on 2006.

The following consideration will be necessary to complete this task:

- Better or improved assumptions and calculation
- Search for other CTC sources (such as production of other chlorocarbons)
- Studies on lifetime uncertainties of CTC
- Necessary check of UNEP data (inventory and replenishment etc.)

The final report will be published by the Task Force separately and will be reported at the 28th OEWG in Bangkok in 2008.

4.8 Essential Use Exemptions of CFC-113 for aerospace applications in the Russian Federation

The comprehensive studies on this issue were summarised in the TEAP April 2007 Progress Report (pp 42-49) and reported at the 27th OEWG in 2007 according to the request by the Parties under Decision XVIII/8(4).

Decision XIX/14 noted the readiness of the Russian Federation to receive prior to February 2008 a small group of experts in replacing zone-depleting solvents in the aerospace industry nominated by the TEAP/CTOC with the aim of evaluating the applications and recommending proven alternatives where possible,

- (1) To authorise the levels of production and consumption of CFC-113 for essential-use exemptions in the amount of 140 metric tonnes in 2008;
- (2) To authorise the volume of 130 metric tonnes of CFC-113 nominated for 2009 provided that no alternatives are identified by the TEAP that can be implemented by 2009;
- (3) To request the Russian Federation to explore further the possibility of importing CFC-113 for its aerospace industry needs from available global stocks in accordance with the recommendations of the TEAP/CTOC.

The TEAP/CTOC could not send a small group of experts to the Russian Federation by February 2008, but has identified two experts in this field. The TEAP is continuing dialogue with the Russian Federation to set up a new date and also to reconcile the agenda during their stay so that the TEAP/CTOC could report the results in the coming 28th OEWG in Bangkok, Thailand and the 21st MOP.

4.9 Recovery, Recycling and Destruction

4.9.1 Recovery and recycling

Recovery and recycling of ODSs continue as reported in the previous progress report. Recent information has been obtained from Japan and Russia. In Japan, refrigerants including ODSs and HFCs have been recovered from commercial air-conditioning, refrigeration equipment and mobile air conditioners on the basis of the Fluorocarbon Recovery and Destruction Law. Since enforcement in 2001, the total refrigerants recovered were 4,384 metric tonnes in 2005.

Regarding mitigation of global warming, it is noteworthy that the amount recovered corresponds to 12.05 million tonnes of CO₂ if global warming potential of ODSs such as CFCs is taken into account.

Table 4-4 Refrigerants recovered from waste appliances in Japan

Recovery at disposal		2000	2001	2002	2003	2004	2005
For commercial use	ton	0	1,225	1,958	1,889	2,102	2,298
For household use	ton	0	603	1,041	1,147	1,306	1,410
Mobile air conditioners	ton	0	0	389	638	637	676
Total	ton	0	1,828	3,388	3,674	4,045	4,384
	Million-ton CO ₂ eq	0	5.37	10.75	12.09	12.05	12.05
HFCs of the above total	ton	0	0	389	638	637	676
	Million-ton CO ₂ eq	0	0	0.24	0.44	0.62	0.75

Japan Refrigeration and Air Conditioning Industry Association and Japan Industrial Conference for Ozone Layer and Climate Protection

The Russian Federation reported that there are Centers for CFC Recovery and Reclaiming (CFC-CRR) comprised of 24 enterprises belonging to the association “Torgtechnika”, which service mainly commercial and domestic refrigeration equipment. CFC-12 in commercial, transport and industrial refrigeration systems is estimated to exceed 6,000 metric tonnes in Russia. Technicians for systems with more than 2,000 from each refrigeration sector are educated and trained in CFC-CRR regarding recovery and reclamation of CFC in old equipment, and replacement with non-ODS refrigerants. The specialists from 24 CFC-CRRs require certificates and permission for training the technicians. The Center for Halon Recovery and Reclaiming (H-CRR) was established by a number of enterprises. Major organisations and their capacities are JSC Halon 1,400 metric tonnes/year, JSC Ozone metric 200 tonnes/year, RSC “Applied Chemistry” (state-owned) 200 metric tonnes/year, JSC GosNIIGA 50 metric tonnes/year, and JSC Promkomplekt-NN 200 metric tonnes/year. The total of halons in fire extinguishing equipment was assessed to exceed 3,000 metric tonnes that may be subjected to recovery and reclamation.

4.9.2 Destruction

ODS destruction facilities were listed in a previous report, TEAP Vol. 3B, Report of the Task Force on Destruction Technologies, April 2002. Recently, the Russian Federation opened ODS destruction facilities, as shown in Table 4-4. These facilities are installed in fluorochemical manufacturing companies to destroy any kinds of CFCs, HCFCs, HFCs and PFCs. The argon plasma facility in the table with a capacity of 150 metric tonnes/year was constructed by a China/Russia joint venture in Zhejiang province in China.

Table 4-5 ODS Destruction Facilities in Russia

Company	Process	Capacity (tonnes/y)	Notes
Halogen	Incineration with methane	1,000	Finish product CaF ₂
KChChK	Incineration with hydrogen	500	Finish product CaF ₂
VOCCO	Incineration with methane	200	Finish product CaF ₂
RSC ACh	Argon plasma	150	Pilot plant

Regarding ODS destruction activities in Article 5 Parties, the following two cases were reported from Indonesia and Fiji.

The Indonesian cement industry through technical assistance provided by the Japanese Government, has developed a facility to destroy CFC wastes and its operation will start by July 2008.

The National Ozone Unit of the Department of Environment in Fiji exported a container containing halons to DASCEM Holdings in Melbourne in Australia for destruction in 2007. DASCEM Holdings Pty Limited is a company formed from the privatisation of the Department of Administration Service Centre for Environment Management, the Australian Government body that established the National Halon Bank. Currently DASCEM stores and destroys halons from Government Agencies and industry at a cost. The Australian Government offered to support Fiji in destroying the halons, since Fiji does not have a disposal facility to destroy ODS.

5 Halons Technical Options Committee (HTOC) Progress Report

The HTOC met on January 21-23, 2008 in Altrincham, England. Attending HTOC members were from the following countries: Bahrain, Canada, China, India, Japan, Jordan, Italy, Russia, Singapore, South Africa, UK, USA, and Venezuela. A representative from the Polish Ministry of Defence also attended, and the contractor for UNEP's Study on Challenges Associated with Halon Banking in Developing Countries attended for the discussion on this study.

The primary purpose of the meeting was to discuss Decision XIX/16 and its mandate for a further study on the projected regional imbalances in the availability of halons 1211, 1301, and 2402, and investigation into mechanisms to better predict and mitigate such imbalances in the future.

5.1 Update on Decision XIX/16

Decision XIX/16: Follow-up to the 2006 assessment report by the Halons Technical Options Committee is as follows.

Welcoming the 2006 assessment report of the Halons Technical Options Committee of the Technology and Economic Assessment Panel,

Welcoming also the continuing reduction in global halon use,

Noting the concern expressed by the Halons Technical Options Committee about the availability of certain halons around the world,

1. To request the Technology and Economic Assessment Panel to undertake a further study on projected regional imbalances in the availability of halon 1211, halon 1301 and halon 2402 and to investigate and propose mechanisms to better predict and mitigate such imbalances in the future;
2. To request the Technology and Economic Assessment Panel, when undertaking the study, to consult with the Secretariat of the Multilateral Fund on the outcomes of its study on the operation of halon banks around the world and to use such information from that study as may be relevant to its own review;
3. To request the Ozone Secretariat to make available 2004, 2005 and 2006 halon consumption figures by type of halon to the Technology and Economic Assessment Panel for its study;
4. To request the Technology and Economic Assessment Panel to submit its study in time to allow the Twentieth Meeting of the Parties to consider its results;
5. To encourage Parties which have requirements for halon 1211, halon 1301 and halon 2402 to provide the following information to the Ozone Secretariat by 1 April 2008 to assist the Technology and Economic Assessment Panel with its study:
 - (a) Projected need for halon 1211, halon 1301 and halon 2402 to support critical or essential equipment through the end of its useful life;

(b) Any difficulties experienced to date, or foreseen, in accessing adequate halons to support critical or essential equipment;

6. To encourage Parties, on a regular basis, to inform their critical users of halons, including the maritime industries, the aviation sector and the military, of the need to prepare for reduced access to halons in the future and to take all actions necessary to reduce their reliance on halons;

7. To request the Ozone Secretariat to write to the International Maritime Organization secretariat and to the secretariat of the International Civil Aviation Organization to draw their attention to the decreasing availability of halons for marine and aviation uses and to the need to take all actions necessary to reduce reliance on halons in their respective sectors.

The HTOC co-chairs assisted the Ozone Secretariat in drafting their letters to the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO) and the Parties. To date, responses have been received from IMO, ICAO and 12 Parties.

The Ozone Secretariat has provided the HTOC with 2004, 2005, and 2006 halon production and consumption figures by type of halon as reported by the Parties.

The HTOC has decided to divide its investigative Study into the following major sectors: All halons - Aviation, Merchant Shipping; Halons 1211 and 1301 - Asia, Europe, Middle East, North & West Africa, South & Central Africa, North America & Australia, South America; and Halon 2402. A summary of the presently reported information for each sector is as follows.

5.1.1 Aviation

ICAO resolution A36-12, adopted at their 36th Session, September 2007, will encourage a move away from halons in new aircraft in the post-2011 timeframe. In line with this resolution and their business plan for 2008, ICAO has issued a letter to all their member States urging them to advise their aircraft manufacturers, airlines, chemical suppliers and fire-extinguishing companies to move forward at a faster rate in implementing halon alternatives in engine and auxiliary power units, hand-held extinguishers and lavatories; and investigating additional halon replacements for engines/auxiliary power units, and cargo compartments. These cargo compartments remain a problem with no alternatives currently available that meet the regulatory authorities' minimum performance standards. Cargo compartments are the largest use of halon on civil aircraft. For example, lavatory halon 1301 systems are in the range of 0.1- 0.5 kg; auxiliary power unit halon 1301 systems are in the range of four to five kg; portable halon 1211 extinguishers contain five to ten kg each, with the total depending on the passenger capacity of the aircraft; engine nacelle halon 1301 systems are in the range of 20 to 50 kg; and cargo compartment halon 1301 systems range from as little as 14 kg in small cargo compartments to more than 500 kg in freighter aircraft cargo compartments.

Many experts believe that a key issue for long-term aircraft fire protection sustainability is halon 1211, which some members of the International Fire Systems Working group believe may be in severely short supply for the world-wide fleet within five years. This appears to be in contradiction to the emerging situation within China (see section 1.1.3) and may be an indication of regional imbalances that need to be addressed. Nevertheless, alternatives for the primary aircraft use of halon 1211, in cabin portable extinguishers, are commercially available; a shortage of halon 1211 supplies may incentivise the conversion of in-service fleets.

5.1.2 Merchant Shipping

IMO has been asked to encourage its member states to collect data on the number of halon systems, the number of ships so equipped, and the total amount of halon installed on merchant fleets. This sector is fully prepared for the future with several alternatives systems being used in new construction and most retrofitted systems going to CO₂. Demand for halon is declining and discharge rates are low. It is believed that enforced decommissioning without incentives could lead to halon venting owing to the cost of handling the decommissioning of the systems and recovery of the halon. Responsible authorities should therefore consider carefully the potential consequences of mandatory decommissioning and implement policies that make recovery, reuse, and destruction of halon attractive.

5.1.3 Asia

Japan has very low halon emission rates and has collected and destroyed about 30MT of halon 2402 from floating roof tank protection in the petrochemical industry.

In China, halon 1211 is coming out of service as portables reach 10-year servicing dates and recharge is not permitted - the HTOC is trying to determine what is happening to the halon in those portables. In addition, approximately 2,400 MT of halon 1211, manufactured prior to the cessation of production in 2006, has been warehoused. Of this, only approximately 50MT has been used and/or exported in the last year. China's current low rate of use and export suggests that they have more than enough banked halon 1211 to support their needs.

In 2006, there were 1,046 commercial aircraft in China and this number increased by 158 in 2007 – further increases are anticipated annually for at least the next 5-10 years. Most new aircraft are designs that rely totally on halon, e.g., 737s, A320s, etc.

5.1.4 Europe

Good data are available on critical uses of halons by sector within the European Union because of mandatory annual reporting by Member States. These quantities are, however, substantially smaller than expected from HTOC estimates of the installed base so some uses may not yet be accounted for. Shortages are claimed by the European aviation sector but it is not clear whether or not these are simply a case of the price being higher than the industry is prepared to pay for it.

5.1.5 Middle East, North & West Africa

Data on the installed base of halon is not readily available. The Saudi Arabian Petrochemical sector has probably the largest installed base, but Egypt is probably the largest user of recycled halons. Recycling centres have been a mix of failed and successful projects. There is a perception that halon 1211 is in short supply because its current cost is much higher than it was in the past when newly produced halon was being purchased from China. The cost of fully recycled halon 1211 is now on a par with costs in other international markets – a result of China ceasing production of halon 1211. Halon 1211 is reportedly readily available in the Dubai free trade zone.

5.1.6 South & Central Africa

Johannesburg is the regional hub for airlines, and has a comprehensive aircraft repair and maintenance facility. The facility estimates that it uses about 50 kg of halon 1211 annually. It is

estimated that the inventory for the region is 10-15 MT of halon 1301 and 5-7 MT of halon 1211 and is widely distributed over a large area.

5.1.7 North America & Australia

In the U.S., halons 1211 and 1301 are readily available. Prices are steady and similar to those in other countries. There are no restrictions on halon use and the migration of halons from non-critical uses to critical uses is driven by market forces. About half the needed halon 1301 is currently being imported, but no halon 1211 is being imported because of an import tax that is currently US\$74 per kilogram, increasing annually by US\$3 per kilogram.

Canada has enough halon to meet its needs. As Canada has no destruction facilities in operation, when halons become available from decommissioned systems and end-of-life portable extinguishers they are exported for destruction or use in critical applications.

The Australian national halon bank continues to collect halon 1211 and 1301 from decommissioned non-critical uses. However, they have not destroyed any halon 1211 since 2000 and no halon 1301 has been destroyed at all. The halon is being used to support on-going critical uses.

5.1.8 South America

The total inventory of halons 1211 and 1301 is approximately 248 MT, mainly in Brazil (90MT), Argentina (60MT), and Venezuela (48MT). Halon imports have been prohibited in Argentina since 1991; Brazil since 2000, except for essential uses, with annual reductions to elimination after 2007; Colombia since 1995; and Venezuela since 1996. Halon banks are operated by private companies. Projected needs for halon are only for aviation.

5.1.9 Halon 2402

In Russia, halon 2402 is no longer being used as a process agent as there are now cheaper alternatives. The Russian bank of halon 2402 is approximately 960MT. Four Russian companies offer halon recycling services. By 2010 about 160MT of halon 2402 will need to be recycled annually to support existing equipment. By 2015, merchant shipping and commercial uses are expected to have ceased, but military demand is expected to increase. There is no surplus available for export.

In Poland, the main user is the Polish military, with a small quantity in industrial uses. Approximately 2.6MT is installed and in storage for replenishment. Poland has enough halon 2402 to meet its projected needs.

In India, halon 2402 is only used in military applications. The Army needs 50MT over the next 15 years to support ground vehicles, and the Navy is looking for 60MT over the next 15-20 years for its servicing needs. Owing to the current halon 2402 shortage within India, the military is looking at conversion to halon 1301 in the crew/engine compartments of ground vehicles, and halon 1211 pressurised with CO₂ for portables. The shortage of halon 2402 in India for servicing is a major concern, which if not addressed may lead to an essential use production exemption request.

6 Critical Military and Space Uses of HCFCs

At the time the Montreal Protocol was signed in 1987, virtually every military system in the developed countries and some military systems in developing countries relied on ODS for their manufacture, maintenance and operation. In addition, CFCs, halons, and methyl chloroform were used in Space applications, such as the manufacture of most rockets and payloads, including the scientific instruments used to monitor Earth's atmosphere and ecosystems. Since then, most countries have made impressive progress in eliminating ODS applications for these uses.¹

The primary remaining military ODS use is for halon in applications considered to be critical to operations, lacking technically or economically feasible retrofit alternatives, or not yet budgeted or scheduled for retrofit or retirement. CFC refrigerants continue to be used in some Naval vessels (ships and submarines) because: the refrigeration plants were designed specifically to use a particular ODS refrigerant, the refrigeration plants are sized according to the needs of the vessel, the acoustic signature of the vessel would be changed by using an alternative, and because the cost of removing the plant and replacing it is cost prohibitive. For example, in some vessel designs, the hull of the vessel must be opened in order to remove and replace the plant.²

The primary remaining Space applications for ODS uses are in thermal insulating foam, manufacture of solid rocket motors, and in cleaning of electronic and precision mechanical assemblies.

In non-Article 5 Parties, military and space applications continue to be satisfied by recycling existing stocks of ODS, with a small number of uses met through Essential Use Exemptions previously granted by Parties:

Poland

CFC-113 to clean torpedoes.

The Russian Federation

Halon 2402 for specific fire protection applications, and

CFC-113 for aerospace industry.

The United States

Methyl chloroform for manufacture of civilian and military rockets.

¹ See: Andersen, Stephen O. and K. Madhava Sarma, "Protecting the Ozone Layer, the United Nations History," Earthscan, London 2002 Chapter 5 and Stephen O. Andersen, K. Madhava Sarma and Kristen N. Taddonio, "Technology Transfer for the Ozone Layer: Lessons for climate Change, Earthscan, London, 2007.

² For the latest TEAP findings on critical military and space uses see: TEAP, "2006 Assessment Report of the Technology and Economic Assessment Panel," United Nations Environment Programme, Nairobi, 2006, pp. 127-137.

6.1 Military-Unique and Space-Unique Uses of HCFCs

Most current use of HCFCs by Military and Space organisations is in applications that are not unique or critical. It can be expected that ordinary HCFC uses will be replaced by the same technology that is implemented in civilian sectors.

There are a few low-volume HCFCs uses that are unique to military and space organisations and critical to safe operations. These unique uses can be: 1) phased out with new technology, 2) supplied from stockpiles or from recovered HCFCs, or 3) provided under terms of an Essential Use Exemption (if agreed by Parties).

Mission-critical HCFC uses include:

- Solvent HCFC-225 used for cleaning oxygen systems, electro-optical devices, precision navigation systems and similar components where a combination of materials must be compatible with the solvent and the solvent must remove soil with little residue left behind. Small amounts of CFC-113 and HCFC-225 will continue to be used for some in-situ cleaning of oxygen systems having complex geometries.
- HCFC refrigerants used in a battlefield environment can be replaced with existing or new no flammable or possibly mildly flammable HFCs, but cannot be replaced with non-fluorocarbon refrigerants such as hydrocarbons and ammonia due to flammability and safety concerns in a battlefield environment. However, some militaries are considering extending the use of HCFCs in some battlefield equipment for a few years by using recycled refrigerant rather than shifting to high-GWP HFCs to allow time for the technical maturity of low-GWP refrigeration systems, such as transcritical carbon dioxide. Military-unique systems tend to have very long development and operational lifetimes, lasting half a century or longer in both developed and developing countries. The systems are highly integrated, their designs are highly constrained in terms of space and weight, and modification costs are generally very high.
- HCFC-141b used for thermal insulating foam on the oxygen tank of the United States (U.S.) Space Shuttle is critical today, but is expected to be phased out when the next generation spacecraft replaces the Space Shuttle sometime in the next decade.

6.2 Continuing International Co-operation

The Montreal Protocol has benefited from close co-operation between developed and developing nation military organisations working through bilateral and multi-lateral military-to-military exchange projects.

There were four workshops on the Military Role in Implementing the Montreal Protocol. The first in 1991 in Williamsburg, VA, the second in 1994 in Brussels, Belgium, the third in Vienna, Virginia in 1997, and the latest in Brussels, Belgium in 2001.

Military-to-military technology co-operation projects were sponsored by developed countries involving Mexico, Thailand, Turkey, and Malaysia. UNEP sponsored workshops in India and Jordan that included regional military participation.

Table 6-1 ODP and GWP of HCFCs in Military and Space Applications³

Halocarbon	WMO 2003 ODP	Montreal Protocol ODP	Lifetime (years)	IPCC 2001 GWP (100 year)
HCFC-22	0.05	0.055	12	1780
HCFC-123	0.02	0.02	1.3	76
HCFC-141b	0.12	0.11	9.3	713
HCFC-225ca	0.02	0.025	1.9	120
HCFC-225cb	0.03	0.033	5.8	586

In September 1996, the US, Canada and Australia sponsored a Defence Environmental Workshop for nations of the Asia Pacific Indian Ocean region with a focus on ODS. Virtually all participating countries sent representatives of their military and environmental ministries. In June 1997, the same tri-lateral group sponsored a conference for nations of the Western Hemisphere. In November 1997, a global conference on military uses of ODSs was organised in conjunction with the annual Conference on Ozone Protection Technologies in Baltimore, Maryland. The U.S. Navy and Defense Logistics Agency provided training on the use of halon recycling equipment, halon banking strategies and halon alternatives in a number of Article 5 Parties, including India and China. There have been significant efforts over the years to spread awareness of the Montreal Protocol and the availability of measures militaries can take to manage the phase-out.

On 3-5 November 2008 in Paris, the United States Environmental Protection Agency in co-operation with the United Nations Environment Programme and military and non-government organisations from Asia, Europe, North America and elsewhere will sponsor the fifth international conference on the importance of military leadership in protecting the climate and its fragile ozone layer. For further information on the *Climate Change and Defence 2008* conference, contact Stephen O. Andersen (Andersen.stephen@epa.gov; 1-202-343-9069).

6.3 Summary

Military and space organisations have invested significant effort and funding, and have made great strides to reduce their dependence on ODS. Modifications to existing systems and practices have been made where technically and economically feasible alternatives exist. Very few new military systems continue to rely on ODS. For military and space applications that continue to need ODSs, military and space operators of reserve stocks have been diligent in preventing leakage and ensuring that ODSs are only used for approved critical applications. The following actions will further minimise ODS emissions and reduce the need for essential use nominations:

- Collection and recycling of ODSs for continuing critical uses;
- Best practices for ODS recovery/recycling, storage, reuse and destruction; and

³ IPCC/TEAP, "Safeguarding the Ozone Layer and the Global Climate System," Cambridge University Press, 2005, Table 1.2 page 125 and Table 2.6 page 160-161.

- Flexibility that will enable transnational shipment necessary to supply recycled ODS for military-critical needs.

7 Foams Technical Options Committee (FTOC) Progress Report

7.1 General

This update is the first foam sector review published since the 2006 Report of the Flexible and Rigid Foams Technical Options Committee, issued in April 2007. It highlights changes in technology and transition that have occurred in the last year and particularly focused on the impacts of Decision XIX/6 on the future direction of regional foam strategies and technology selections. The key conclusions from this update report are as follows:

7.2 Transition Status - Article 5 Parties

- Decision XIX/6 has placed new emphasis on the need to transition from HCFC-141b systems in polyurethane (PU) foams within the next 5-7 years
- Experience from non-Article 5 Parties in HCFC phase-out needs to be disseminated to assist decision-making in Article 5 Parties
- Hydrocarbon technology is being extensively used in the domestic refrigeration sector and, to a limited extent, in other insulation applications. There is still little experience globally in the handling of hydrocarbons in small/medium enterprises and further research in handling and process options is necessary. An application that deserves special mention is PU spray foam, where hydrocarbon is not an option for safety reasons.
- HFCs are (or will be) available to meet transition requirements, although efforts will need to focus on formulation cost optimisation if these blowing agents are to see widespread use in PU and extruded polystyrene (XPS) board foams.
- Some new technology options (e.g. methyl formate) show promise, particularly in integral skin applications, but there is little non-Article 5 Party experience on which to draw, especially in insulation foam applications. Some pilot projects may need to be conducted by suppliers, users and supported by other interested stakeholders to strengthen the understanding of these technologies.
- The growth of XPS board foam production in China has been field-researched further and the existence of 350 small-scale XPS plants has been confirmed. Although not fully utilised at present, these could account for over 50,000 tonnes of HCFCs (predominantly HCFC-22, but possibly with some HCFC-142b). Additional growth has been reported in Turkey, where up to 10,000 tonnes of HCFCs is also being consumed for XPS board products.
- The technology exists to replace HCFCs in these XPS board plants up to a level of about 30% using CO₂. However, it has been reported that there is currently no replacement for HCFCs in totality bearing in mind that HFCs are viewed as too expensive. Work is currently focusing on CO₂/ethanol and CO₂/hydrocarbon blends, and perhaps even pure hydrocarbon technologies if the blowing agent can be removed from the foam immediately after manufacture.
- Consideration continues to be given to ODS bank management projects in some countries although foam recovery may be difficult logistically (and therefore more costly), particularly in remote regions.

7.3 Transition Status - Non-Article 5 Parties

- The use of HCFC-141b in insulation foams is now very limited in non-Article 5 Parties (most notably Australia and Canada) and will be virtually phased out by the end of 2009.
- There is some further de-selection of HFC use in Europe as product fire standards have now been reached by modified formulations based on hydrocarbons.
- The use of HFC-134a in one-component foams is being phased-out in the EU, primarily by re-formulation around various hydrocarbons. However, where hydrocarbons cannot be used for safety and performance reasons, a new low-GWP blowing agent (HBA-1) has been launched by Honeywell, which will be commercially available in July 2008, in time to enable compliance with the requirements of the EU F-Gas Regulation.
- Insulation markets continue to grow rapidly in several markets in response to more stringent building and appliance energy efficiency requirements. The market share of foams is also growing against not-in-kind technologies such as fibrous insulation as a result of the greater thermal efficiency of foam insulation and improvements in fire performance (greater use of polyisocyanurate technologies).
- PU Spray Foam is being increasingly recognised as an efficient means of retrofitting a number of building types.
- Super-critical CO₂ spray foam technologies have become established in Japan but market penetration is no more than 10%. The technology is yet to make any significant market penetration beyond Japan. The Green Procurement Law has also promoted the greater uptake of CO₂ (water), which is particularly suited to the Japanese market and growth of this technology has exceeded that of super-critical CO₂.
- North American XPS board producers are still on course to phase-out HCFC use by the end of 2009. The alternative of choice is likely to rely on combinations of HFCs, CO₂, hydrocarbons and/or water.
- The 'green building' agenda continues to prescribe against high GWP blowing agent solutions, although often without proper reference to comparative LCCP assessments. Nevertheless, where parity of performance can be achieved and demonstrated with lower GWP solutions, uncertainties about future blowing agent containment during the lifecycle can be circumvented.

7.4 Other relevant issues

- The role of building energy efficiency in combating climate change has been highlighted in the Fourth Assessment Report of the IPCC.
- Although blowing agents can be recovered efficiently from appliances, the effectiveness of regulation varies substantially by region.
- Significant additional work has been conducted on evaluating the practicality of blowing agent recovery from building foams. Cost effectiveness depends substantially on underlying waste policy and, in particular, segregation of demolition waste. The potential of carbon finance to assist in the bank management process is under serious evaluation.

7.5 Technology Update

The following Table illustrates the main substitute technologies currently considered or already used in the polyurethane, extruded polystyrene/polyolefin and phenolic foam sectors. The strike-out items indicate the likely changes initiated by the implementation of Decision XIX/6.

Table 7-1 FOAMS TOC Update Report 2008 - Technical Options Table

SECTOR	DEVELOPED COUNTRIES		DEVELOPING COUNTRIES		COMMENTS
	CURRENT		CURRENT	FUTURE	
POLYURETHANE RIGID					
Domestic refrigerators and freezers	HCs (cyclopentane & cyclo/iso pentane blends), HFCs		Majority HCs, balance HCFC-141b or HCFC-141b/22	HCFC-141b, HFCs & HCs	HFC-134a & HFC-245fa 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-141b/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		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 ₂ , (HC)		Residual CFC-11, HCFC-141b	HCFC-141b & HFCs	Potential use of HCs in North America
Blocks	Residual HCFC-141b, HCs, HFCs,		Residual CFC-11, HCFC-141b	HCFC-141b & HFCs	HC use increasing
Pipe-in-pipe	Mainly HCs, minor HFC		Mainly HCFC-141b	HCFC-141b & HCs	Cyclopentane is main HC
One Component Foam	Mainly HCs, some HFCs		HFCs, HCs	Mainly HCs, some HFCs	HC use driven by cost and legislation
POLYURETHANE FLEXIBLE					
Slabstock & block-foam	LCD, EMT, methylene chloride		Methylene chloride, LCD	Methylene chloride, LCD, (EMT)	Regulation limits methylene chloride use in some countries
Moulded	Mainly CO ₂ (water), minor LCD		Mainly CO ₂ (water), minor LCD	CO ₂ (water)	CO ₂ (water) is industry standard
Integral Skin	CO ₂ (water), HFCs, HCs		Residual CFC-11, CO ₂ (water), some HCFCs and HFCs	CO ₂ (water), some HCFCs and HFCs	HFC-134a is main HFC
Shoe Soles	CO ₂ (water), HFCs		CO ₂ (water), HCFCs, HFCs	CO ₂ (water), HCFCs , HFCs	HFC-134a is main HFC
PHENOLIC					
Board & block	HFCs, HCs (particularly in Japan)		HCFC-141b	HCs	HFCs are used to retain fire performance in some markets
EXTRUDED POLYSTYRENE					
Sheet	HCs		Mainly HCs		Some safety issues in Art 5.1 countries
Boardstock	HCFC-142b/(22), HFC-134a, HFC-152a, CO ₂ , CO ₂ /ethanol, (HCs in Japan), blends of CO ₂ /hydrocarbons		Mainly HCFC-142b/22 but growing HCFC-22. Some minor use of HCs	HCFC-142b/22, HFC-134a, CO ₂ , blends of CO ₂ / ethanol or CO ₂ /hydrocarbons	HCFC-142b use in North America until 2010. Final choice is end-product specific
POLYOLEFIN					
Sheets, planks & tubes	HCs (iso-butane & LPG)		Mainly HCs		Some safety issues in Art 5.1 countries
NOT-IN-KIND INSULATION					
Domestic Buildings	Glass fibre, rock fibre, cellulose		Limited NIK insulation types	Awaiting new technology	Fibre insulation is default based on cost
Non-domestic Buildings	Glass fibre, rock fibre		Limited NIK insulation types	Awaiting new technology	Market share reducing on efficiency grounds
Industrial applications	Mostly rock fibre, calcium silicate		Limited NIK insulation types	Awaiting new technology	Choice driven by operating temperature

7.6 Methyl formate

In which sectors and regions is it in use?

As far as is known, methyl formate has only been used to a very limited extent in developed countries. Accordingly, relevant experience is scarce to facilitate technology transfer to Article 5 Parties.

Methyl formate has only been adopted to any significant extent in one Article 5 Party, Brazil, where it is used in steering wheel applications, bottle coolers and steel-faced panels. In each case the customers require non-ODS/low GWP product. In addition, the same producers frequently use HCFC-based systems for those customers who have no specific ozone or climate demand.

What are the product and process implications?

Experience in Brazil shows that product performance in steering wheels (integral skin foam) is similar to that achieved when using HCFC-141b. However, there are considerable reductions in viscosity of the formulation. This can provide advantage in flow, cell formation and density distribution, but may require equipment modifications in some instances. One other advantage is the ability to use higher viscosity polyols. In bottle coolers, a measurable deterioration of the foam insulation value has been detected, although customers who measure energy consumption in cabinets claim no change. In steel-faced panels, where blowing agents are normally more easily retained, no change in insulation value has been reported.

What are the cost implications?

Although opinions vary about the impact of methyl formate on foam density, its increased solubility may create challenges in maintaining dimensional stability. To counter this, high index formulations can be used or densities can be increased. An example is the case of bottle cooler applications, where a 5% increase in density has been required to keep the dimensional stability of the foam. There are, however, also some cost factors in favour of methyl formate in that it has a lower cost than HCFC-141b in some (but not all) regions and a significantly better blowing efficiency – thereby requiring less blowing agent to produce foam of a given density.

7.7 HFC usage

Sectors in which HFC use is most focused

HFCs have been adopted in the following key applications and markets:

- Domestic appliances (mostly North America)
- Spray foam (globally, where HCFCs are not allowed)
- Steel-faced panels (where fire requirements demand)
- PU boardstock (for products in regions with stringent fire requirements)
- Various SME applications (where financial constraints dictate)

Of particular note in this context, is the rapid growth of the PU Spray Foam market in China, driven by the climate policy decision to renovate domestic properties in order to improve energy efficiency. The market has reached 60,000 tonnes of PU system in 2007, but, more importantly, is estimated from one source to be growing at a Compound Annual Growth Rate of 117%. The current market would account for 6,000-8,000 tonnes of HCFC-141b based on typical formulations. This market is already comparable in size to the largest PU Spray Foam markets in the world (e.g. North America, Spain, Japan). With no widely available low GWP alternative for HCFC-141b, this could be a substantial future market for HFCs, particularly if HCFC-141b replacement is forced early under the 'worst first' approach mandated under Decision XIX/6. In such an instance, care should be taken to assess the energy efficiency benefits against the direct HFC emissions arising from the process.

Optimisation of formulations to minimise price implications

In order to optimise the cost-effectiveness of HFC-based systems, foam formulators have reformulated many HFC containing foam products to utilise higher levels of co-blowing agents than have traditionally been used with HCFC-containing formulations. The levels of HFCs used in a given formulation are carefully selected so that the foam provides the required performance at the lowest possible cost.

The most prevalent co-blowing agent used is CO₂(water), although other co-blowing agents including hydrocarbons, CO₂(LCD), CO₂ (GCD) methyl formate, trans 1,2 di-chloro-ethylene, alcohols, and others are used. Levels of up to 70 mole percent of co-blowing agent are used in certain applications to minimise the cost impact of HFC use, although there is a corresponding loss in performance compared to using higher levels of HFCs. This approach also creates the potential to offer families of products with varying levels of performance and cost, which in turn allows the end foam manufacturers more options to tailor their product offerings.

Energy efficiency versus emissions

In many applications, HFCs are selected as the blowing agent in order to provide the best available energy efficiency. This can be particularly important where limited space prevents an increase in insulation thickness. Such applications include domestic refrigerators and freezers, closed cell spray foam insulation for existing building envelopes, building panels, and insulated transport containers (e.g. reefers). In many cases the energy efficiency requirements are dictated by regulation, building codes or voluntary programmes such as the US EPA/DOE Energy Star Program, LEED, BREEAM and CASBEE.

Several analyses have been carried out on these applications that demonstrate that the Life Cycle Climate Performance (LCCP) associated with the use of HFCs is, in many cases, favourable and no worse than neutral in others compared to low GWP alternatives, even when all of the blowing agents contained in the foams are deemed to be emitted over the lifecycle. The situation is further improved when measures can be adopted to minimise emissions, particularly at end-of-life.

7.8 Hydrocarbons for small consumers

Non-Article 5 Parties' experience

In the absence of financial assistance, SMEs in non-Article 5 Parties have been unable to adopt hydrocarbon technologies to any significant extent. Most have defaulted to HFC-based technologies despite the higher system costs. Where insulation requirements are less stringent,

greater use of CO₂ (water) has also occurred. The implication of these trends is that there is little developed country experience on which to draw. The role of systems houses in optimising formulations for SMEs has been particularly important – a trend that is expected to extend to Article 5 Parties.

Need for further work

Historically, costs to implement hydrocarbon technologies were estimated at not less than US\$ 400,000 per facility. This would include a high-pressure explosion proof dispenser with pre-mixer and other auxiliaries as well as explosion proofing of the processing area. With convertible high-pressure baseline equipment this may be reduced to around US\$300,000, which would still be a very large investment for SMEs. In addition, many SMEs would not have the capacity to cope with such a technology from a technical and a safety standpoint. Options to lower these costs have not been pursued in the past because HCFCs have offered cost-effective, ready-to-use alternatives. In the context of phasing out HCFCs, however, the need for initiatives to lower HC related investment is evident if this technology is to penetrate smaller users. Cost reduction options that have been proposed and/or applied in incidental cases are:

- direct injection of HCs
- premixing at system house level
- alternative, simplified equipment for limited applications but lower costs

There may be more and, because none have been applied in an Article 5 context, all would need verification

7.8.1 Implications on costs

While no experience in the Article 5 context exists, exclusion of individual pre-mixers would save around US\$ 60,000 per facility (including the related explosion proof environment). Other simplifications may make a total cost reduction of around US\$ 100,000 possible. This implies that most likely HC technology, while more affordable, will never be able to address the requirements of very small users (i.e. consumption of less than 10 tonnes per annum)

7.9 Extruded polystyrene technology options

7.9.1 Status of transition in non-Article 5 Parties

North American XPS board producers are still on course to phase-out HCFC use by the end of 2009. The alternatives of choice are likely to rely on combinations of HFCs, CO₂, hydrocarbons and water. The significant differences in the products required to serve the North American market (thinner and wider products with different thermal resistance standards and different fire-test-response characteristics) will result in different formulations than have been adopted already in Europe and Japan for similar XPS board products. These new formulations are almost certain to rely on HFC-134a as a large component of the final blowing agent.

7.9.2 Pace of growth of XPS board manufacture in China

Equipment manufacturers have reported that approximately 350 small-scale XPS plants have been installed across China since 2001. Around 200 of these have been supplied by one manufacturer. A small number of similar plants are also being supplied to Russia. Plants were

initially based on the use of HCFC-142b (to optimise thermal performance), but switched to HCFC-22 in 2003 – primarily on the basis of price (16 RMB/kg and 12 RMB/kg respectively). Typical plant capacities are approximately 50,000m³ and process recycled polystyrene almost exclusively. Foam densities are typically 33kg/m³ with a blowing agent content of 9% w/w. On this basis, blowing agent consumption at full utilisation could exceed 50,000 tonnes of HCFC-22 with a relatively rapid emissions profile.

7.9.3 Technology options for alternative blowing agents in China

Work is being carried out by the equipment suppliers to modify existing units to introduce CO₂ into the extruder. The cost of this modification is estimated to be around 100,000 RMB. However, where bottled CO₂ cannot be used and additional storage is required, a further cost of 300,000 RMB is currently being budgeted. These modifications could allow the replacement of HCFCs by up to 30%. However, full replacement is not possible with pure CO₂.

Total HCFC phase-out will require 100% substitution, but HFC-134a and/or HFC-152a are viewed as too expensive for the Chinese market. Work is continuing with CO₂/ethanol and CO₂/hydrocarbon blends to achieve higher levels of substitution. There is some belief that a total hydrocarbon solution (n-butane) might be possible, but this would require blowing agent evacuation immediately after production to avoid major fire risks in storage and use.

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

The phase-out of CFCs in new manufacturing of refrigeration and air-conditioning systems is now nearly complete in Article 5 Parties. Some of them have started using alternatives to HCFCs in some applications for both their domestic and export markets. There has been a further significant reduction in the use of CFCs in servicing due to the adoption of good practices and the retrofitting of refrigeration and Mobile Air-Conditioning (MAC) equipment to alternative refrigerants. Technical developments are currently focused on transitioning from high GWP to non-ozone-depleting low GWP fluids and on improving the energy efficiency of systems.

8.1 Refrigerant Data

The search for new alternative refrigerants continues to be driven by concerns over the climate effects of HFC refrigerants having high GWPs. The Fluorine gas (F-gas) regulation and the MAC-directive of the European Union have given new impetus to research and development for low GWP refrigerants. Some new non-ozone-depleting low GWP refrigerants have recently been registered, which are expected to provide climatic benefits.

Research and experimentation is underway on CO₂ (R-744) and on ice slurries as refrigerants for a number of applications. These fluids have benefit of much greater heat capacities, and generally improved heat transfer coefficient associated with change of phase. Ice slurries consist of water containing ice crystals mixed with another fluid such as alcohol, a salt solution or ammonia and are used as a secondary refrigerant. Ice slurries can be very effective for distributing and preserving cold by optimising the size and total volume of ice crystals to create a uniform solution with minimum viscosity. Ice slurries can provide higher refrigerating effect at lower flow rate.

A number of standard designations for non-ODS refrigerants have been adopted or recommended as addenda to ASHRAE 34-2007 since the 2006 RTOC assessment report. They include the following:

Adopted

R-429A	R-E170/152a/600a (60.0/10.0/30.0)
R-430A	R-152a/600a (76.0/24.0)
R-431A	R-290/152a (71.0/29.0)
R-432A	R-1270/E170 (80.0/20.0)
R-433A	R-1270/290 (30.0/70.0)

Recommended

R-434A	R-125/143a/134a/600a (63.2/18.0/16.0/2.8)
R-435A	R- E170/152a (80.0/20.0)
R-436A	R-290/600a (56.0/44.0)
R-436B	R-290/600a (52.0/48.0)
R-437A	R-125/134a/600/601 (19.5/78.5/1.4/0.6)
R-510A	R-E170/600a (88.0/12.0)

Public review is currently open for the refrigerants indicated as “recommended.” ISO 817 is expected to harmonise with ASHRAE 34 on these new designations as well as the associated safety classifications. These new designations reflect commercialisation or increased commercialisation of new refrigerants. The next RTOC progress and/or 2010 assessment report will include consistent physical, safety, and environmental data for these refrigerants.

A number of new non-ozone depleting low GWP (≤ 150 for 100-yr time horizon) refrigerants are also being developed and tested for automobile air conditioning to meet the new European F-Gas regulations, some of which will have the potential for broader applications. The primary candidates to replace HFC-134a for automotive use are now carbon dioxide (R-744) and HFC-1234yf (1,1,1,2-tetrafluoropropene) in direct expansion systems, and HFC-152a (1,1-difluoroethane) in indirect systems (with a “secondary” heat transfer loop).

8.2 Domestic Refrigeration

Transition from CFC-12 to non- ODS technologies is now completed globally. HFC-134a and HC-600a continue as the dominant refrigerant options for domestic refrigerators. Hydrocarbon refrigerant usage is increasing in every market world-wide, except in North America because of the flammability concerns regarding hydrocarbons in the USA.

Refrigerator energy efficiency continues to be a highly competitive product attribute and directly affects the global warming contribution of competing technologies and products. Beyond these, no new technologies or alternatives have emerged for energy-efficient, cost-competitive application for these products. Statistics for converting new production to non-ODS alternatives have not been updated since the >95% conversion reported in the 2006 RTOC assessment report.

Future product configurations will likely see evolutionary improvements in product energy efficiency, driven by both market competition and by new energy efficiency regulations. Renewed efforts in developing non-ozone depleting low GWP alternatives to HFC-134a for automotive AC applications are expected to also produce new options for use in domestic refrigerators.

Field service conversion to non-ODS alternatives continues to significantly lag new production conversion. This is a consequence of the long product life and the absence of a good drop-in substitute for the refrigerants used in systems designed for ODSs.

8.3 Commercial refrigeration

The commercial refrigeration sector consists of three sub-sectors: stand-alone equipment, condensing units and centralised systems for supermarkets.

Stand-alone equipment consists of tightly integrated components. The transition to non-ODS refrigerants in this equipment is complete, and use of these systems is also increasing in Article 5 Parties. The dominant alternative choice is HFC-134a in the USA, including for stand-alone display cases, where the refrigerant charge exceeds 0.5 kg. Some global companies continue transitioning from high-GWP to low-GWP technologies, such as CO₂ and HC-290 (propane).

The CO₂ uptake in vending machine equipment does not show a significant increase compared to previous years due to cost-issues. The global inventory of vending machines using CO₂ in 2007 is estimated at about 90,000. An important advantage of CO₂ is its ability to produce both cold and hot temperatures in the same machine using the same thermodynamic circuit. For small

commercial freezers, isobutane is the preferred option because of its small charge, high efficiency and low GWP; it is technically and economically viable for about 80 percent of the vending machine market.

Condensing units are medium size commercial refrigeration systems, which have a refrigerant charge ranging from 1-50 kg. For new medium and low temperature equipment, a preference to use HFC-134a is apparent in non-Article 5 Parties, especially in systems with a refrigerant charge larger than one kg. R-404A and R-507A are used to replace HCFC-22, especially in low temperature applications. In some European countries condensing units using hydrocarbons are sold, but with a <5% market share. HCFC-22 is still the refrigerant of choice in Article 5 Parties, with HFC-134a and R-404A recently introduced in some applications.

R-422D has been reported as an easy retrofit for HCFC-22 in medium-temperature direct expansion refrigeration systems, with potential use also for low temperature systems. A number of case studies report successful use in commercial supermarket systems and stationary air-conditioning applications, including chilled water systems. Retrofits of HCFC-22 in medium-temperature equipment using R-422D are being done on a large scale in Europe, driven by the pending 2010 phase-out of newly produced HCFC-22 for servicing.

Centralised systems are similar to condensing units, except that one unit often includes several compressors that serve parallel sets of cooling equipment, and can produce a number of different temperature levels. They tend to be used in supermarkets, to lower energy consumption and to increase redundancy. HCFC-22 is still the most commonly used refrigerant globally.

The alternative refrigerants for centralised systems are the same as those for condensing units. However, these systems are more prone to leakage resulting in high refrigerant emission rates. Significant efforts are being made to reduce this problem by using indirect or secondary loop systems as well as distributed systems. In low temperature applications in Europe, the refrigerant CO₂ is used in secondary loops as well as in the low temperature part of cascade systems. In such systems, R-404A, R-717 (ammonia) or HC-290 can be used in the upper cascade. The primary refrigerant is confined in a shorter refrigeration circuit. This not only allows the use of flammable refrigerants but also reduces the charge of primary refrigerant. In this way the charge in these systems is reduced by 30% to 40%, which also yields lower refrigerant emissions.

Some other issues:

- Retrofit to HFCs increased in the USA during the last quarter of 2007, but still represents a relatively small percentage of the installed base.
- R-22 remains the dominant choice in Article 5 Parties for both new equipment and servicing.
- In Europe and in Japan, for new equipment the preferred refrigerants are generally HFCs.
- The European F-gas regulation stringently controls refrigerant leakage control, but outside of Northern European countries emission rates from equipment are high (estimated between 15 and 25 percent of the total charge per year). Refrigerant emissions are lowest in supermarkets and highest in hypermarkets.

8.4 Large Size Refrigeration (Industrial, Cold Storage and Food Processing)

Since the 2006 RTOC assessment report, there have been no significant changes in the industrial refrigeration sector, in which sector both ammonia and HCFC-22 are the dominant refrigerants. However, there are three emerging trends that deserve mentioning here:

- 1) There is increasing pressure on industrial users of HCFC-22 in Europe, but still no universally recognised "drop-in" alternative for large refrigeration systems with flooded evaporators. Many users are replacing older plants with new systems using ammonia or in some cases ammonia-carbon dioxide cascade systems, but the rate of conversion suggests that there will still be a significant number of users with HCFC-22 plants at the beginning of 2010, when a ban on the supply of "newly produced" HCFC-22 for servicing enters into effect;
- 2) Growth continues in the use of CO₂ in industrial systems across a very wide range of applications, including plate freezers, blast freezers, cold stores, ice rinks, chill stores, high temperature IT cooling and heat pumps;
- 3) Growth also continues in heat pump applications, in particular integrated systems that recover heat from refrigeration plants. There is no universally preferred method for doing this; ammonia systems are the most common, with currently a growing number of CO₂ systems. The uptake of this concept is still restricted by equipment availability, in particular high pressure ammonia compressors and even higher pressure CO₂ compressors.

Technical options continue to evolve quickly for low temperature applications, with CO₂ entering the market as both a heat transfer fluid and refrigerant (as was also mentioned under commercial refrigeration). CO₂ is being used in new small- and large-scale systems up to 5 MW cooling capacities in the USA, Japan and Europe. Many new CO₂ systems continue to be installed in The Netherlands due to the support by financial subsidies. The use of indirect systems is increasing as a way to reduce the quantities needed for the ammonia refrigerant charge. Research continues in the USA, Japan and Europe on CO₂ as refrigerant and on CO₂ compatible lubricants. New CO₂ compressor designs were already introduced in 2004-2006.

Retrofits are being done from HCFC-22 to CO₂ or brine systems, especially in the cold storage sector. The use of equipment with small NH₃ charges is continuously increasing, and is now expanding into industrial refrigeration systems. The use of HCFC-22 is either stable or slightly increasing in this sector in Article 5 Parties; however, some interest in non-ODP technologies is now also being reported from Article 5 Parties.

8.5 Transport Refrigeration

Transport Refrigeration includes transport of chilled or frozen products by reefer ships, refrigerated containers, refrigerated railcars and road transport including trailers, diesel trucks, and small trucks and vans. It also includes the use of refrigeration and air conditioning on merchant ships above 300 gross tonnes, and air conditioning in rail cars. This sector is gradually shifting to HFC-134a and R-404A or R-507 and more seldom to R-407C and R-410A. Use of R-410A is expected to increase in the truck and trailer business. Carbon dioxide is still only used in prototype transport systems. Hydrocarbon refrigerants might be a future option for trucks and trailers but they will not be an option for containers because these are often transported under deck. Ammonia is gaining more popularity on-board ships for refrigeration and in a few cases also for air conditioning.

New blends and new refrigerants introduced in prototype systems in car air conditioning systems have not been explored in the transport refrigeration sector. Current issues in the transport refrigeration sector are (1) refrigerant charge reduction and (2) energy efficiency. Water-cooled condensers for marine containers are now found on 85 % of all containers of the “global market leader”, substantially reducing energy consumption and the space requirement under deck. HFC-134a generally achieves higher energy efficiency than R-404A in the medium temperature range, but requires larger compressors and suction lines. R-410A also achieves better energy efficiency than R-404A while at the same time reducing the equipment size. The utilisation of waste heat in various processes in order to decrease overall carbon dioxide emissions of ships is an upcoming issue.

8.6 Unitary Air Conditioning

The refrigerant options to replace HCFC-22 in newly manufactured air-to-air air conditioning and heat pump applications has remained relatively unchanged since the publication of the 2006 RTOC assessment report. However, questions about the applicability of the current options in high temperature environments has resulted in the need to prepare a special assessment of the acceptability of the existing options for high ambient temperature climates, following Decision XIX/8 (Montreal, 2007).

In addition, a number of refrigerant blends have entered the market over the past 24 months. These blends are designed to meet the servicing requirements of HCFC-22 air conditioners and heat pumps. They generally consist of two or more HFC components combined with a small quantity of hydrocarbon refrigerant. The addition of the hydrocarbon allegedly allows these blends to work with existing compressor and lubricant systems. However, there is limited published information on the performance and reliability of air conditioning systems using these blends. More field experience is needed to determine whether these blends are suitable as service, retrofit or drop-in repair refrigerants.

8.7 Chiller Air Conditioning

HCFC-123 and HFC-134a continue to be the primary options for centrifugal chillers. Conversion of existing CFC chillers to use non-CFC refrigerants has nearly ended in non-Article 5 Parties because most good candidates for conversion have already been covered. As already reported in other sectors, two --beneficial-- trends are continuing to drive chiller development: 1) increases in energy efficiency, and 2) reduced refrigerant emissions. Improvements in energy performance are driven by concerns over global warming and by new more aggressive energy performance standards or regulations being enacted by a number of Parties. Reduced refrigerant emissions are the result of better designs and service practices. The replacement (or sometimes conversion) of CFC chillers by energy efficient HCFC-123 or HFC-134a chillers is occurring in a number of Article 5 Parties. The main reason is energy cost savings, since the current average chiller uses 35% less electricity compared to the average chiller produced 20 years ago.

New chillers employ scroll compressors in the range from 7 kW to 350 kW, and screw compressors in the range from 140 kW to about 2200 kW. These chillers generally use HFC-134a as the refrigerant, but scroll compressor systems are now starting to use R-410A.

An important development in several non-Article 5 Parties (outside Europe) is the accelerating transition away from HCFC-22 in new air-cooled and water-cooled chillers. HCFC-22 cannot be used in new chillers manufactured in many non-Article 5 Parties by January, 1, 2010, and newly

produced HCFC-22 cannot be used in servicing in Europe by that date. HCFC-22 is still used, primarily in chillers with positive-displacement compressors, which includes reciprocating, screw, and scroll compressors. Manufacturers of these chillers have redesigned their products to use HFC refrigerants. Chillers with cooling capacities up to about 350 kW are generally being redesigned to use R-410A. Chillers above this capacity generally are being redesigned to use HFC-134a.

As was mentioned under the unitary air conditioning sector, HFC refrigerant blends (containing HFCs and small amounts of hydrocarbons) are now offered for the servicing of HCFC-22 based equipment.

8.8 Water-Heating Heat Pumps

Use of these devices is high in parts of Europe, Japan, and growing in China. In Europe, comfort heating is provided by 10-30 kW heat pumps using fan coils with outside air or the ground as the heat source. Hot water temperatures are in the 45-55° C range. In the mild climate zones of China and Japan, air-source heat pump chillers are widely used for heating and cooling of residential and commercial buildings with fan coil units.

- In Japan, the market for heat pumps continues to grow. They are operated primarily at night and the hot water is stored for day-time use. Similar heat pumps have been used in Germany and Austria for a number of years.
- In Japan, CO₂ is used extensively in domestic hot water heat pumps in the residential market, a trend the Japanese government is encouraging through subsidies. However, CO₂ heat pumps are now also gaining market share in Japan, and the government is providing financial incentives for the purchasers of these units as well.
- HCFC-22 is used still in some heat pumps, but manufacturers are increasingly offering models that use HFC-134a, R-410A or CO₂. Hydrocarbons are used as refrigerants in some smaller low-charge heat pumps in Europe.
- The market for water-heating heat pumps also is expanding in Europe, especially in the more northern countries where the heat pumps can replace boilers in hydronic heating systems.
- Manufacturers are introducing new models that offer higher hot water temperatures (above 60° C) or are capable of operating at low outdoor temperatures, e.g., at -20° C.
- The market for water-heating heat pumps has now started to develop in China.

8.9 Vehicle air conditioning

HFC-134a has now fully replaced CFC-12 as the globally accepted mobile A/C (MAC) refrigerant.

The European Union has enacted legislation to limit the allowable GWP of refrigerants used in new vehicle types to 150 or less (for a 100 year time horizon) by 2011, and in all new vehicles by 2017. This eliminates the use of HFC-134a (with a GWP of about 1400) and is helping to drive research into zero ODP and low GWP refrigerants that can be used throughout the global automobile market. Refrigerants that meet the 150 GWP criteria include CO₂, HFC-152a, HFC-1234yf and hydrocarbons (mainly propane).

Since 1998, the leading potential replacement refrigerant in Europe has been CO₂. Almost all vehicle manufacturers and suppliers world-wide are working on such systems and many have already demonstrated prototype cars. Currently, technical and commercial hurdles exist, such as leakage, leak detection, materials selection, lines and fittings materials, component technology selection, and costs, all of which require resolution. The use of HFC-152a was proposed in 2001 and has been publicly demonstrated in several prototype vehicles. Although only moderately flammable, vehicle makers have not shown strong interest in pursuing HFC-152a.

Following finalisation of the EU F-gas regulation for vehicle A/C, the industry has been actively developing and testing alternative refrigerants with low GWPs. Of those prominently addressed in public, the proprietary blends once believed to be commercially promising [identified as AC-1, DP-1, Fluid H, and JDH all containing one or more unsaturated hydrofluorocarbons (olefins)] have been abandoned based on toxicity and/or other findings.

The primary candidates for automotive markets to replace HFC-134a are now

- carbon dioxide, and
- HFC-1234yf (1,1,1,2-tetrafluoropropene, an unsaturated HFC or olefin) in direct expansion systems, and
- HFC-152a (1,1-difluoroethane) in indirect systems (with a secondary heat transfer loop).

German carmakers announced in September 2007 that they have decided to use R-744 (carbon dioxide) as refrigerant in their MAC systems in order to meet the EU F-gas regulation. Companies from the United States, Japan, Korea, Italy, and France have not made a final choice and continue to investigate both HFC-1234yf as possible a alternative refrigerant and also HFC-152a in indirect systems. Final decisions on refrigerant candidates for future use are expected by the end of summer 2008.

CO₂, HFC-152a and probably also HFC-1234yf are comparable to HFC-134a in terms of cooling performance and system fuel use for the use of AC. All exhibit comparable environmental performance and qualify for use in the EU under the current regulation.

8.10 Conservation and Containment

Substitutes for ODS refrigerants have been introduced in each stationary air-conditioning and refrigeration end-use sector. Many of these alternatives are azeotropic or zeotropic blends of various HFC refrigerants, have high GWPs and operate at high pressures. These characteristics present significant challenges for containment and recycling. It is uncertain whether the current stock of refrigerant recovery and/or recycling equipment is capable of properly recovering these substitutes.

In addition, many of these blends are proprietary, making it difficult, if not impossible, to accurately “reconstitute” the blend. It may not be legal in many areas to reclaim refrigerants when the resulting formulation cannot be precisely known or controlled. Further, using incorrect blends can compromise the performance of equipment and, in some cases, present safety hazards.

These factors call into the question the potential effectiveness of future efforts to recover, recycle, and reclaim used non-ODS refrigerants. At a minimum, it would be necessary to restrict who can accept and reprocess refrigerants to organisations with proper information about formulations, special equipment and highly trained technicians.

Destruction of excess refrigerants is gaining attention, but is not yet globally viable because of high cost, energy intensity of incineration and limited destruction capacity. A similar situation exists for refrigerant separation technologies. Experience by a number of TOC experts has shown that any impediment to reclaiming used gases, whether technical or economic, provides an incentive to release gases to the atmosphere. To avoid such problems, workable plans to properly dispose of or recycle used gases and to incentivise users to do so, should be in place prior to their commercial introduction.

9 Methyl Bromide Technical Options Committee (MBTOC) Progress Report

This section updates trends in methyl bromide (MB) production and consumption, and gives progress in the development and adoption of alternatives. Preliminary information on registration, re-registration and deregistration of in-kind methyl bromide alternatives is also presented in conformity with Decisions Ex. I/4(i) and Ex. I/4(j).

9.1 MB production and consumption update

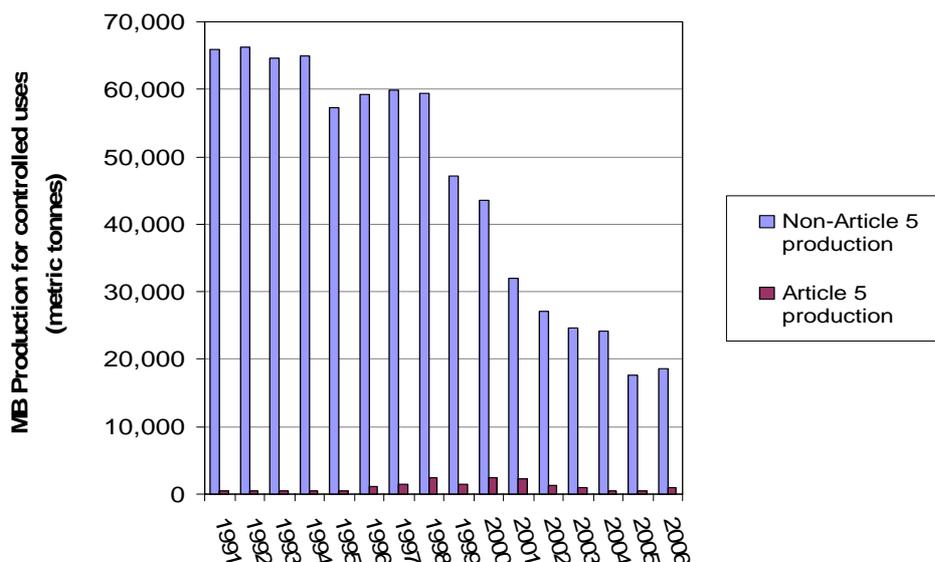
Following is an update on MB production and consumption, compiled primarily from the database on ODS consumption and production of the Ozone Secretariat available in March 2008. Under the Protocol, consumption at the national level is defined as MB production plus MB imports minus exports, minus QPS, minus feedstock; it thus represents the national supply of MB for uses controlled by the Protocol (i.e., non-QPS fumigant). Some countries have revised or corrected their historical consumption data at certain times, and in consequence official figures and baselines have changed. At the time of writing this report, the vast majority of Parties had submitted data for 2006 and the database for MB is much more complete than in the past. In the few cases where data gaps exist, data from the previous year were assumed to apply.

9.1.1 Production trends

Trends in the reported production of MB for all controlled uses (excluding QPS and feedstock) are shown in Figure 9.1. MB production for controlled uses in 2004 was about 24,635 metric tonnes, which represented 37% of the production baseline (67,376 tonnes) and 18,141 tonnes in 2005 which reduces this proportion to about 27%. However, in 2006 the global MB production for controlled uses increased to 19,635 tonnes (29% of baseline), although the consumption in both Article 5 and non-Article 5 Parties has continued to decrease each year (details can be found in section 9.2).

Figure 9-1 Historical trends in reported global MB production for all controlled uses, excluding QPS and feedstock, 1991 - 2006 (metric tonnes)

Data for 1991 and 1995-2006 were taken from the Ozone Secretariat dataset of March 2008. Data for 1992-94 were estimated from Table 3-1 of the 2002 MBTOC Assessment Report and Table 3-1 of the 2006 MBTOC Assessment Report.



Non-Article 5 Parties reduced their MB production for controlled uses from about 66,000 tonnes in 1991 (non-A5 baseline) to less than 24,100 tonnes in 2004 and 17,603 in 2005. However, non-Article 5 production for controlled uses increased to 18,666 tonnes in 2006 due to increased production in Israel. Non-Article 5 MB production in 2006 was about 28% of the baseline; this included production for export to Article 5 Parties. Article 5 Parties reduced their production for controlled uses from a peak of 2,397 tonnes in 2000 to about 536 tonnes in 2004, with an increase to 969 tonnes in 2006. MB production in Article 5 regions fell from 70% of baseline in 2003 to 39% of baseline in 2004, and increased to again 70% in 2006 (baseline 1,375 tonnes, average of 1995-98). At present, production of MB for controlled uses in Article 5 Parties takes place entirely in China and a MLF project to phase-out this activity is approved and underway.

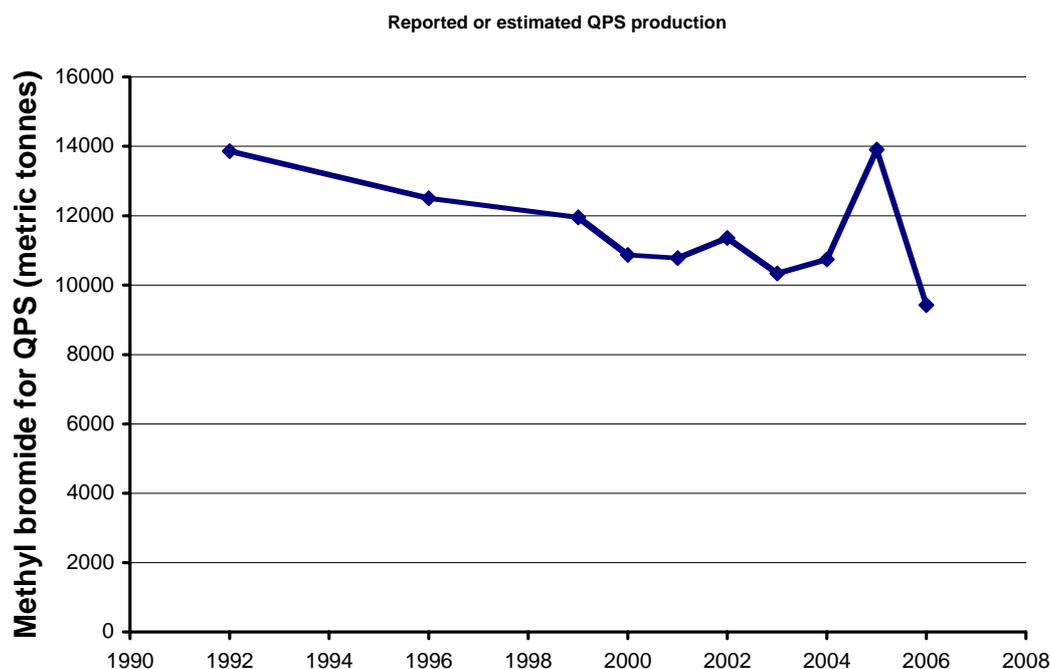
A list of known MB production facilities was published in the MBTOC Assessment of 2006 (Table 3-3). In 2006, MB was produced for controlled uses in one Article 5 Party (China) and three non-Article 5 Parties (Israel, Japan and USA).

9.1.2 Production for QPS purposes

Reported methyl bromide production for exempt QPS, as reported to the Ozone Secretariat under ** by Parties, rose substantially in 2005 over the long term and decreasing trend. Data reported for 2006 shows a return to the expected trend (Fig. 9-2). There has speculation as to the reasons for the sudden increase shown in 2005. These include stock issues, impact of adoption of ISPM 15 (**) on demand and inclusion of uses previously not considered as QPS. The latter may have

been as a result of review at time of 100% phase-out of non-exempt consumption. In the light of the 2006 data, it appears that the changes, whatever they were, were unusual and probably specific to 2005.

Fig. 9-2 Reported or estimated QPS production 1990 - 2006



9.2 Global consumption

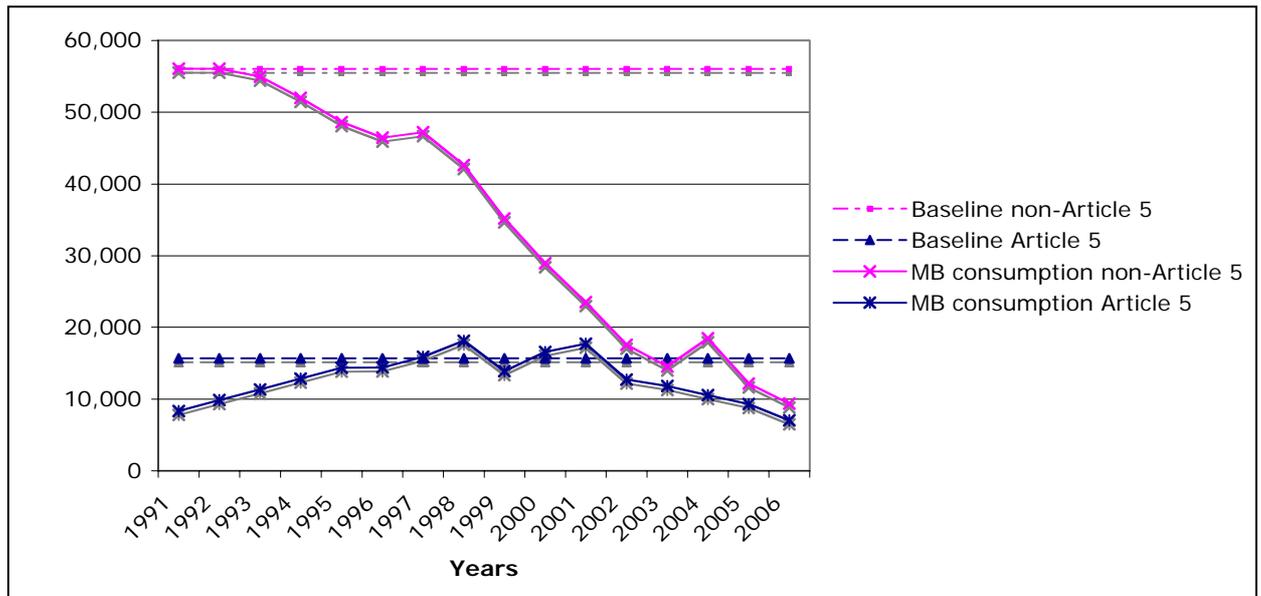
On the basis of Ozone Secretariat data, global consumption of MB for controlled uses was estimated to be about 64,420 tonnes in 1991 and remained above 60-63,000 tonnes until 1998. Global consumption was about 45,527 tonnes in 2000, falling to about 26,336 tonnes in 2003 and 16,474 tonnes in 2006 as illustrated by Fig 9-3 below.

9.2.1 Consumption trends in Non-Article 5 Parties

Figure 9-2 shows the trends in MB consumption in Non-Article 5 Parties for the period between 1991 and 2006. The official baseline for Non-Article 5 Parties was about 56,043 tonnes in 1991. By 2003, this consumption had been reduced to about 14,520 tonnes, representing 26% of the baseline. In 2004, consumption appeared to increase to 18,454 tonnes (33% of baseline), however this occurred primarily because 3,310 tonnes scheduled for export to Article 5 Parties were not shipped before 31 December of that year and this consignment was counted as part of the official national consumption of a Non-Article 5 party. Without this, the total Non-Article 5 consumption in 2004 would have been approximately 15,144 tonnes, representing 27% of baseline. In 2005 and 2006, MB consumption was reduced to 11,468 and 9,452 tonnes in Non-Article 5 Parties for critical use exemptions, accounting for 20% and 17% (respectively) of the total Non-Article 5 baseline. In 2007 the estimated consumption based on quantities approved or

licensed amounted to 8,475 tonnes or about 15% of the baseline. For 2008 about 6,966 tonnes were approved or licensed which is a further reduction to 12% of the baseline.

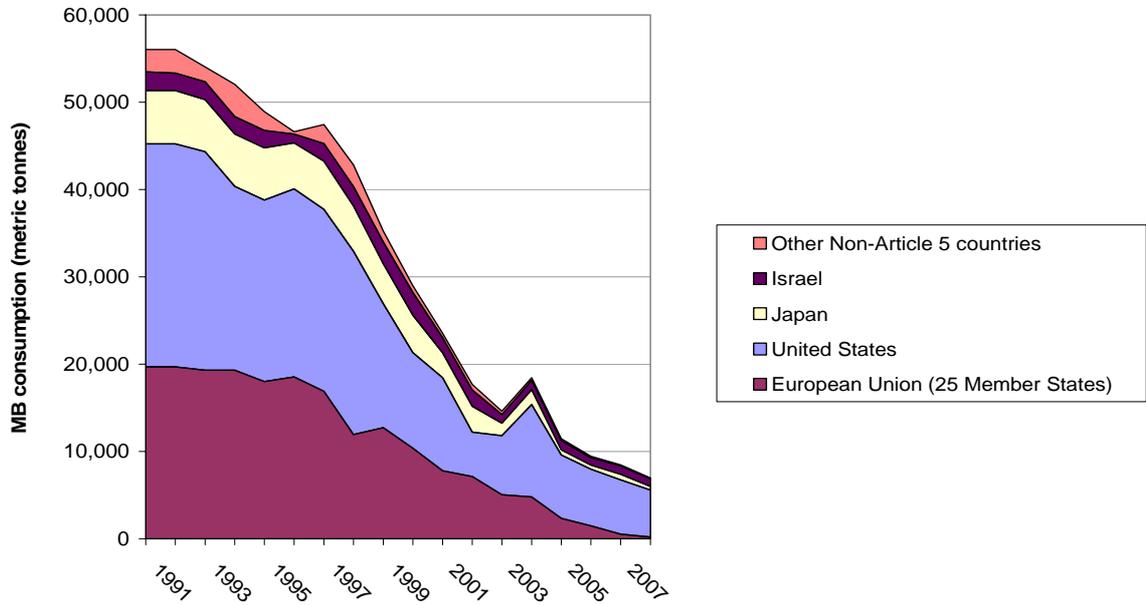
Figure 9-3 *Baselines and trends in MB consumption in Non-Article 5 and Article 5 regions, 1991 – 2006 (metric tonnes)*



Source: MBTOC estimates calculated from Ozone Secretariat data of March 2008.

Figure 9-4 shows trends in MB consumption in major Non-Article 5 regions. In 1991 the USA, European Community, Israel and Japan used 95% of the MB consumed in Non-Article 5 Parties. By 2003 these four Parties had reduced consumption to 26%, 26%, 28% and 23% of their respective national baselines. And in 2007 the authorised or licensed consumption (for CUEs) was reduced to about 24%, 3%, 27% and 10% of national baselines in the US, EC, Israel and Japan, respectively. For 2008, permitted levels amounted to 21%, 1%, 24% and 7%, in the same order.

Figure 9-4 Trends in MB consumption in the three largest non-Article 5 Parties and other non-A5 regions, 1991 – 2008 (metric tonnes)



Source: Ozone Secretariat data of March 2008; data for 2007-8 were calculated from MB consumption approved or licensed for CUEs.

MB was consumed for controlled uses by 40 out of 45 Non-Article 5 Parties in the past. The majority of these countries no longer use MB (Table 9-1). 11 countries used MB for CUEs in 2007, and this was reduced to 7 countries in 2008.

Table 9.2 summarises national MB consumption as a percentage of national baseline in countries that were granted critical use exemptions (CUEs). Several Parties have made significant reductions in CUEs. The EC, for example, reduced CUE consumption to 13% and 8% of baseline in 2005 and 2006 respectively, followed by reductions to 3% and 1% in 2007 and 2008.

Table 9-1 Summary of MB consumption in Article 5 and Non-Article 5 Parties

Status of MB use	Number of Parties		
	Non-Article 5 Parties in 2008	Article 5 Parties in 2006	Total
Parties using MB	7	44	51 (27%)
Parties that used MB in past and now have zero consumption (a, b)	33	48	81 (42%)
Parties that have not consumed MB since 1990 (b)	5	54	59 (31%)
Total	45	146	191 (100%)

(a) MB consumption reported by Ozone Secretariat. A small number of countries have not reported data for 2006 – in such cases the data for 2005 was used in this analysis..

(b) Excluding QPS

Recently, the EC announced that the EC countries will no longer use MB for critical uses from the end of 2008 (UNEP OzoNews, 15 April 2008), and informed the Ozone Secretariat and MBTOC that the EC is not submitting critical use nominations (CUNs) for 2009.

Table 9-2 MB consumption in relation to national baselines in Non-Article 5 Parties that currently use MB

Note. MB consumption data for 1991-2006 are from Ozone Secretariat dataset of March 2008. Figures for 2007-2008 are authorised or licensed CUEs from Meetings of the Parties reports and licensing data

Party	MB consumption, tonnes (percentage of national baseline)					
	1991	2003	2005	2006	2007 (a)	2008 (a)
Australia	704	182 (26%)	116 (16%)	55 (8%)	49 (7%)	50 (7%)
Canada	200	58 (29%)	62 (31%)	42 (21%)	53 (27%)	42 (21%)
European Community	19,612 (b)	5,162 (26%)	2,431 (13%)	1,487 (8%)	522 (3%)	213 (1%)
Israel	3,580	992 (28%)	1,072 (30%)	841 (23%)	967 (27%)	861 (24%)
Japan	6,107	1,430 (23%)	595 (10%)	489 (8%)	636 (10%)	444 (7%)
New Zealand	135	35 (26%)	30 (22%)	27 (20%)	18 (13%)	0 (0%)
Switzerland	43	11 (24%)	4 (9%)	4 (9%)	0 (0%)	0 (0%)
United States	25,529	6,755 (26%)	7,255 (28%)	6,475 (25%)	6,230 (24%)	5,356 (21%)

(a) Authorised or licensed CUEs (actual MB consumption has not yet been reported)

(b) Baseline of the 25 EC countries that were member states in 2005

9.2.2 Consumption trends in Article 5 and CEIT countries

Figure 9-2 shows the trend in MB consumption in Article 5 Parties in the period between 1991 and 2006. The Article 5 baseline was about 15,703 tonnes (average of 1995-98), rising to a peak consumption of more than 18,125 tonnes in 1998. Recently, total Article 5 consumption was reduced from 75% of the baseline in 2003 to 67% of baseline in 2004 (about 10,512 tonnes) and less than 45% of the baseline in 2006 (7,022 tonnes).

Most Article 5 Parties have achieved considerable MB reductions at national level, as illustrated by the following information. Further details are presented in Tables 9-1 and 9-3.

- The vast majority of Article 5 Parties achieved the national freeze level in 2002.

- By 2004, 87% of Article 5 Parties (125 out of 144) had achieved the 20% reduction step earlier than the scheduled date of 2005. In consequence, only 19 remaining Parties needed to take action to meet the 20% reduction step in 2005.
- According to latest reported consumption data (for 2005/6) only 6 Article 5 Parties (Ethiopia, Fiji, Guatemala, Honduras, Libyan Arab Jamahiriya and Saudi Arabia) were in non-compliance with the 20% reduction step of 2005. The remaining 140 Parties complied with this reduction step fully.
- 84% of Article 5 Parties (120 Parties) reduced their national MB consumption to less than 50% of national baseline in 2006 (Table 9-3).
- 81% of Article 5 Parties (117 Parties) reported MB consumption between zero and 10 ODP-tonnes in the latest reported year (2005/6).
- 70% of Parties (103 Parties) reported zero MB consumption in 2006.
- Many Article 5 Parties are implementing MLF projects to reduce or totally phase-out MB. This includes 14 of the 15 largest MB consuming 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. A project to achieve complete phase-out of MB in Mexico for controlled uses in the country (1,492 metric tonnes) by 2013 has recently been approved
- Tunisia and Algeria, together with UNIDO and Italy as implementing agencies have also submitted a project to identify alternatives for high moisture dates, which has been approved by the 54th Executive Committee Meeting. Tunisia was exempted from Montreal Protocol commitments by Decision XV/12, which deferred “*the consideration of compliance of the 20% reduction of MB consumption as established by the Protocol for Article 5 Parties in 2002 for countries using more than 80% of their consumption of methyl bromide on high-moisture dates until two years after the TEAP (through its MBTOC) formally finds alternatives for high-moisture dates*”. In 2006 Tunisia reported consumption at 64% of baseline, while Algeria reported 77% of baseline.

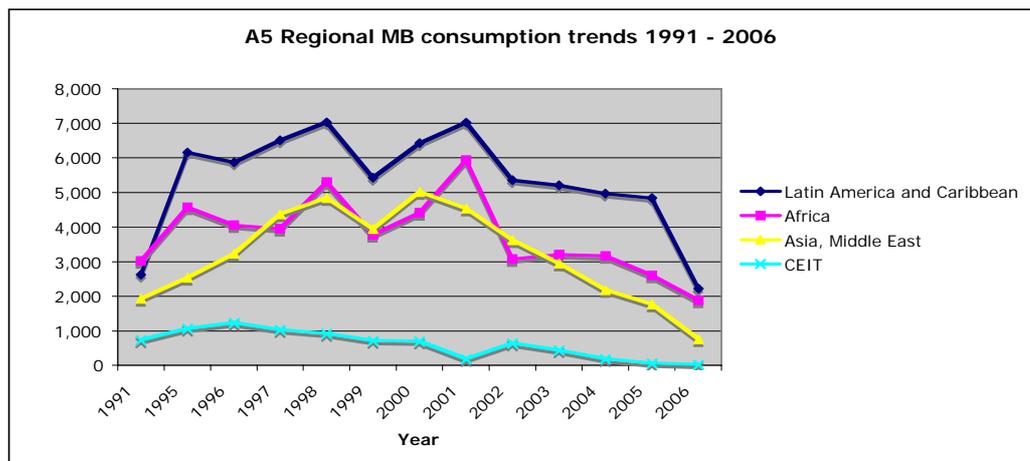
Table 9-3 National MB consumption compared to national baselines in Article 5 Parties.

Analysis of Ozone Secretariat data of March 2008

National status	Number of A5 countries		
	2003	2004	2006
MB consumption was 0% of national baseline	87	91	101
MB consumption was 0 - 50% of national baseline	106	115	120
MB consumption was 50 – 80% of national baseline	11	10	19
MB consumption was more than 80% of national baseline	25	19	4
Total	142	144	143

Regionally speaking, consumption decrease has been greatest in CEIT countries, followed by Asia and Africa, while Latin America is the region with smaller relative reductions as seen in Figure 9-5 below. Some agricultural sectors in Latin America increased use of MB in recent years: melon production in Central America, strawberry production in Chile and Argentina and cut flower production in countries such as Ecuador.

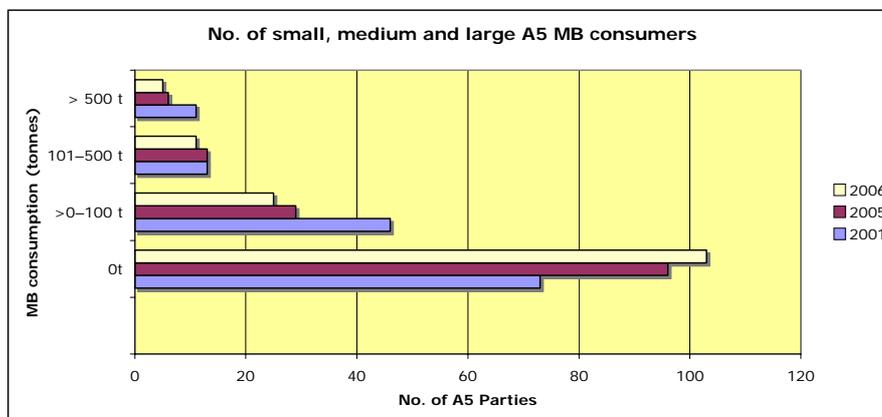
Figure 9-5 MB Consumption trends in Article 5 and CEIT countries 1991 - 2006



Source: Ozone Secretariat database, 2008

About 70% of Article 5 Parties reported zero consumption in 2006. Only 11 Parties still report consumption between 100 and 500 metric tonnes and only five countries remain in the usage category above 500 tonnes as illustrated in Figure 9-6 below.

Figure 9-6 Number of small, medium and large Article 5 MB consumers



Source: Ozone Secretariat database, March 2008

9.3 Alternatives for soil treatments

9.3.1 Key alternatives

Major chemical alternatives, 1,3-D/Pic, chloropicrin and metham sodium, used alone and/ or in combination with other alternatives are proving as effective as MB and continue to be widely adopted in many preplant soil applications (UNEP, 2005 a,b; Mann *et al.* 2005; Trout and Damodaran, 2004; CDPUR PUR data; Spotti, 2004; Carrera *et al.* 2004; Porter, 2005; MBTOC 2007). The recent registration of iodomethane has offered an option for many of the remaining uses, which are proving difficult to control with other alternatives. Various Parties previously applying for CUNs particularly in strawberry fruit, tomatoes and vegetable crops, have adopted these alternatives on a wide scale. This includes control of pathogens in the more difficult nursery and replant industries where high levels of disease control are required to meet quality standards (e.g. certification requirements).

Formulation changes and more adequate application methods continue to improve the effectiveness of several alternatives (Pic EC, 1,3-D/Pic EC) and wider adoption has occurred where these are available. 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; modification to application machinery, sometimes with economic implications have sometimes been also necessary. Some sectors that were formerly heavily reliant on methyl bromide have completely switched to other chemical alternatives and improved crop rotation practices (e.g. tomato and pepper production in Australia); other sectors have adopted more diverse types of alternatives including substrates, steam and various combinations of fumigants, other pesticides, grafted plants and resistant varieties (e.g. Spain, Italy) (Porter *et al.*, 2007). Notably, the EC has declared that its member states will no longer use MB for critical uses from the end of 2008.

Combinations of fumigant alternatives (1,3-D/Pic, Mna/Pic) with a range of herbicides have been shown to be effective for nutsedge (*Cyperus* spp), which is the key target pest for many CUN's (Gilreath *et al.*, 2004; Belcher *et al.* 2007; Clpepper, 2007).

Methods which avoid the need for methyl bromide, such as cropping in substrates, grafting plants onto resistant rootstocks and using resistant varieties, continue to expand in the ornamental and vegetable industries requesting CUNs (Cantliffe and Vansickle, 2003; Cantliffe *et al.*, 2003; Sawwas, 2003; Tognoni *et al.*, 2004; UNEP 2005 a, b).

One key transitional strategy to reduce MB usage has been the adoption of MB:Pic formulations with lower concentrations of methyl bromide (e.g. MB:Pic 50:50 or less). Their use can be achieved with application machinery that allows co-injection of methyl bromide and chloropicrin or by using premixed formulations. These formulations have proven equally effective for controlling soilborne pathogens as formulations containing higher quantities of methyl bromide (e.g. 98:2, 67:33) (e.g. Porter *et al.* 1997; Melgarejo, 2004; López-Aranda *et al.* 2004). At least one Party applying for CUNs reported that MB/Pic formulations can be modified to contain as little as 2% MB and 98% Pic, which would dramatically reduce MB dosage. This treatment would be extremely effective for pathogens, but not as suitable for weeds or nematodes.

Low permeability barrier films, LPBF, (e.g. VIF or equivalent) allow increased retention of MB and extended effective exposure periods for pests, thus controlling pathogens and weeds at reduced MB application rates compared to those used with conventional films (e.g. Gilreath *et al.*, 2003; Gilreath *et al.*, 2005a; Hamill *et al.*, 2004; Minuto *et al.*, 2003; Reuven *et al.*, 2000; Santos

et al., 2005; Wang *et al.*, 1997). These films allow for substantial reductions in dosage rates of MB compared with the minimum effective rate under polyethylene film. Reductions are typically between 25 – 50%, for both 98% methyl bromide and MB/Pic (30:70, 67:33 and 50:50). Studies are also proving their use for effective dosage reduction of alternatives, such as 1,3-D and Pic (Gilreath *et al.*, 2004; Noling, 2004; Hamill *et al.*, 2004; Fennimore *et al.*, 2004; Austerweil *et al.*, 2006; Ou *et al.*, 2007, MBTOC 2007). This is important because dosage reduction may increase areas available to be treated with specific fumigants that are limited by township caps and may lead to further reduction in MB use (Gilreath *et al.*, 2003; Fennimore *et al.*, 2004; Fennimore *et al.*, 2003; Ou *et al.*, 2007) and possibly reduce the buffer zone requirements, which limit adoption of alternatives in some countries.

At present the state of California in the US prohibits the use of certain barrier films (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)). Studies to validate emission levels of fumigants with barrier films are presently being conducted to review the regulation. Adoption of barrier films has increased substantially in other states such as Florida. 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).

9.3.2 Update on registration of alternatives

Iodomethane received registration for strawberry, peppers, tomato, ornamentals (field grown), nurseries, trees and vines in all but 7 States of the U.S. on September 27, 2007. It is presently for one year, when it will be reviewed with all other fumigants under the cluster analysis to ensure guidelines are compatible with other fumigants including MB. At this time, iodomethane has not received state registrations in key California or Florida.

A new registration for other materials such as DMDS is pending in the U.S.

In Israel, registration of metham sodium is expanding in the horticulture and ornamental sectors, allowing for substitution of MB previously used in these sectors. Registration of chloropicrin is being considered and would allow its use alone or in combinations with other fumigants and possibly for registration of 1,3-D/Pic. The registration of MB\pic formulation is not likely to take place since it all depends upon the company's registration.

9.3.3 Crop specific strategies

This section below provides an overview of the main strategies adopted in both Article 5 and on-Article 5 Parties, for those crops presently applying for CUNs.

9.3.3.1 Vegetables

9.3.3.1.1 Tomatoes

Effective alternatives adopted in the tomato sector include combinations of chemicals such as 1,3-D, chloropicrin (Mann *et al.* 2005), metham sodium and dazomet and non-chemical methods (e.g. substrates, grafting, resistant varieties, biofumigation, solarisation) (Besri, 2004, 2007a, 2007b, Runia, 2006).

MB use has been entirely phased out from all European countries as well as Australia and Israel. In northern Europe the main alternative adopted is soilless culture often in association with other

alternatives e.g. resistant cultivars and grafting. A more diverse selection of alternatives is used in Southern Europe and Mediterranean countries including grafting, alone or in combination with fumigants such as MS (Besri, 2004, 2007a, 2007b.). In Morocco, grafting is applied on a wide commercial level on 95 % of the total protected tomato producing area. In Turkey, yields in grafted tomato increased by about 35% when using grafted plants, although this proportion varied with the rootstock used. Production of grafted plants grown in soils treated with solarization (6 to 8 weeks, during the summer months) in combination with fumigants (metham sodium or 1,3-D) was very successful for avoiding damage caused by *Fusarium oxysporum*. f. sp. *lycopersici*, *F.oxysporum*. f. sp. *radicis-lycopersici* and root-knot nematodes (*Meloidogyne spp.*) (Yilmaz, 2006, 2007ab).

Tomato grafting has been reported as a feasible alternative for tomato growers in the Southeast USA (Rivard and Lows 2006, Rivard *et al.*, 2007), although at present this production system has been adopted primarily by organic producers.

In Japan, grafting is used singly or in combination with alternative chemicals (1,3-D, pic, metham sodium and fosthiazate when nematodes are present) for 60% of the regular tomatoes and 90% of the cherry tomatoes produced in the Kumamoto region where a high proportion of the country's production is concentrated (Nishi and Tateya, 2006a).

In Florida, Telone C35 was reported to be as effective as MB for controlling root-knot nematode attacking tomatoes (Dickson, 2007). Nutsedge control has been efficiently achieved in the USA with the herbicide halosulfuron. Acrolein combined with other chemicals such as Eptam=EPTC, halosulfuron or dazomet enhanced control of nutsedge and other weed species without adversely affecting yield. Yields were comparable or higher than those obtained with MB. (Belcher *et al.*, 2007).

Iodomethane applied under metalized mulch controlled nutsedge as well as MB at various dosages, with highest obtained at 252 kg/ha. Incidence of Bacterial wilt (*Ralstonia solanacearum*) was reduced when using metalized mulch as compared to the same treatment with VIF (Olson and Kreger, 2007, Bernal, 2007). Telone C35 applied with metallic mulch produced marketable yields that were statistically equivalent to those obtained with MB:Pic 65:35 (Thomas *et al.*, 2007).

9.3.3.1.2 Eggplants

Adoption of grafting continues to expand in the eggplant sector as new and more suitable rootstocks become available. In Turkey for example, yields of grafted eggplants were shown to increase by 25-30% in comparison to non-grafted plants. Fruit quality was much improved and although planting density remains largely unchanged. Growers find it possible to leave grafted plants in production for several years (Yilmaz *et al.*, 2007b)

9.3.3.1.3 Peppers

Various chemical alternatives have proved efficient for the control of soilborne pathogens and weeds. Iodomethane: Pic 50:50 with VIF, DMDS (Dimethyl sulphide) +Pic (79:21 with LDPE) and a combination of Telone II /Pic and dazomet under LDPE were tested in Georgia (USA) on bell pepper with results that were fully comparable to those obtained with MB (Culpepper *et al.*, 2007)

In Spain, biofumigation has proved successful for peppers grown in the Murcia and Castilla-La Mancha regions (Bello *et al.*, 2008). Biofumigants most commonly applied include goat, sheep and cow manure, as organic matter from rice, mushroom, olive, brassicae, and garden residues.

New varieties resistant to root knot nematodes (*Meloidogyne* sp.) are now available in Spain (Piedra Buena *et al.*, 2006, López-Pérez *et al.*, 2006) and US (Bausher *et al.*, 2007).

9.3.3.1.4 Cucurbits

Production of grafted cucurbits is expanding significantly in Mediterranean countries. When combined with other treatments, grafted plants can avoid the need for MB fumigation (De Miguel, 2004b, Beltran *et al.*, 2008). In Italy, for example, grafted plants are used with alternative fumigants (e.g. 1,3-D or Pic) instead of MB (Spotti, 2004). 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 (Blestos, 2005; De Miguel 2004 a, b, c; López-Galarza, *et al.* 2004).

In Israel, grafting is also showing promising results, particularly when this system is carefully adapted to particular growing conditions of each region (Cohen *et al.*, 2005; Koren, 2002; Koren *et al.*, 2007). Grafting is commercially adopted for crops such as tomatoes, watermelons. Melon grafting is successful for prostrate cultivars. However trellised cultivars show incompatibility and are not successful at this stage.

In the USA the main focus has been on alternative fumigants, combined with additional weed control when necessary (Culpepper *et al.*, 2007), and grafted plants have not played a significant role as MB alternatives. Iodomethane applied under metallized tarps has shown to be as efficacious as MB (Hausbeck and Cortright, 2007; Olson and Kreger, 2007), but this fumigant is not yet registered for these crops. In Florida, 1,3D /Pic (97.5:2.5) showed better control against soil borne pathogens of melon than MB/Pic formulations (Olson and Kreger, 2007).

Grafting + avermectin is an important alternative to MB for cucumber production presently in use in China (Cao, 2008, Pers. Comm.).

9.3.3.2 Ornamental crops

Non-Article 5 Parties presently requesting CUNs for this use are Israel and the United States. All other Parties previously requesting CUNs (e.g. Portugal, Greece, Belgium, France, Italy, Spain and Australia) have not reapplied for 2009 or 2010. The Australian outdoor flower industry for example, no longer uses methyl bromide and 1,3-D/Pic and metham sodium in combination with crop rotation is in widespread use. Member states of the EC once using MB have adopted substrates, and different chemical alternatives.

Floriculture is a complex industry with hundreds of flower types, production cycles and cropping systems involved. Shifting to alternatives often requires growers to change production practices substantially and implement integrated pest management programs. This may include transition to soilless systems, at times with increased investment, but often with improved quality and yields (Savvas, 2003; Graffiadelis, 2000; Grillas *et al.*, 2001; Akkaya *et al.*, 2004; Yilmaz *et al.*, 2007a).

Constraints to adoption of alternatives include regulatory issues (e.g. township caps in USA), and registration. However, alternatives that do not need registration such as steam and substrates are

used by many growers around the world particularly for flowers grown in protected environments. Effective results have also been obtained with solarisation, for example in Israel, Italy, Turkey and the state of Florida in the United States (McSorley *et al.*, 2006; Gullino and Garibaldi, 2007; Yilmaz *et al.*, 2007a).

Roses, carnations and gerberas are the flowers most commonly grown in substrates, but other flower types – particularly bulbs of many types - are also produced with this cropping system (Nucifora, 2001; Gullino *et al.*, 2003; Grillas *et al.*, 2001; Pizano, 2005; Savvas, 2003; Akkaya *et al.*, 2004; Yilmaz *et al.*, 2007a; Rea, 2008). Although the initial set up cost of a soil-less production system is comparatively expensive, growers are generally 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. (Grafiadellis *et al.* 2000; Minuto *et al.*, 2005; Akkaya *et al.* 2004; Pizano, 2004; Schnitzler and Grudde, 2002; Akkaya *et al.*, 2004; Vos and Bridge, 2006, Yilmaz *et al.*, 2007a).

Steaming, although expensive, controls soil fungi at levels that are comparable to MB when properly applied (O'Neill *et al.* 2005; Reuven *et al.* 2005; Barel, 2003). Steam is generally suited for protected flower production and for sterilising re-utilised substrates. Costs associated with steaming may be reduced through implementation of IPM strategies and by considering different types of fuels, boiler types and steaming systems (Runia 2000).

Chemical alternatives increasingly used in ornamental production include dazomet, metham sodium and 1,3 dichloropropene, the latter often combined with Pic. These have proven equally effective to MB for many kinds of flowers in Israel (Reuven *et al.* 2002; Reuven *et al.*, 2005), the USA (Schneider *et al.* 2003, Gerik, 2005 a and b, Gerik and Green, 2004, Gerik *et al.*, 2006), Spain (Peguero, 2004), Australia (Mann *et al.*, 2005; Tostovrsnik *et al.*, 2005) and other countries. Combined chemicals such as 1,3 D, Pic and metham sodium or dazomet have given good control of pests and diseases in field-grown cut flowers in the United States (Elmore *et al.* 2003; Gilreath *et al.*, 2005). Nutsedge has been successfully controlled with Pic, 1,3-D/Pic, 1,3-D alone, Chloropicrin, fufural and metham sodium (Gerik *et al.*, 2006). Recent trials show encouraging results with methyl iodide (MI) in the US (Klose *et al.*, 2007). Application of fumigants with LPB films such as VIF is allowing for reduced rates of chemicals, including MB (Klose *et al.*, 2007).

9.3.3.3 Strawberry fruit

9.3.3.3.1 Chemical alternatives in strawberry fruit sector

Recent trials in strawberry fruit comparing four key alternatives in strawberry fruit crops in Florida and Spain showed that 1,3-D/Pic, Pic alone, MI/Pic and DMDS/Pic gave yields that did not differ from MB/Pic (e.g. Santos *et al.*, 2007). Large scale validation trials with 1,3-D/Pic in conjunction with herbicides (trifluralin) confirmed that this combination is as effective as MB/Pic (67:33) for control of nutsedge and nematodes (Gilreath *et al.*, 2006). In late 2006 a review article on alternatives research in SE USA, concluded that the majority of available MB alternatives provide effective control against most soil-borne diseases and nematodes, as long as appropriate application methods and rates were used. In situations where *Cyperus* infestations are severe, alternative fumigants may be combined with herbicides to minimise weed interference (Santos and Gilreath, 2006).

Key formulations of 1,3-D/Pic, Pic alone and metham sodium combined with other fumigants have been adopted widely throughout industries applying for CUN's, and replaced at least 60% of the production area treated with methyl bromide/chloropicrin mixtures. Of the Parties previously

applying for CUN's, most have completely implemented these alternatives. Australia and France phased out in 2005, United Kingdom in 2006 and Italy, New Zealand and Spain in 2007 (EC 2007). In 2008, USA and Israel are the only non- Article 5 Parties continuing use of MB for this use. The recent registration of methyl iodide/Pic and the recent good results with dimethyl disulphide/Pic in trials in Spain and USA (López-Aranda *et al.*, 2007) offer further effective alternatives and potential for rapid phase out of methyl bromide for all strawberry fruit uses.

The combination of chloropicrin and metham sodium, 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 the EC, a range of chemical alternatives are used, including 1,3-D, MS, dazomet and Pic (EC MB alternatives database, 2006). Depending on the country, these may be applied simultaneously or sequentially but have led to successful replacement for MB. Combination of these fumigants with herbicides that are now registered has been found to be an effective way of achieving weed control sometimes not possible when these fumigants are used alone.

In China, a new formulation of 1,3-D/Pic in capsules has been developed as well as methyl iodide and methyl iodide/chloropicrin capsules. Initial results showed that there was no significant difference between 1,3-D capsule application with injection application. Avermectin is registered as a nematicide and is in wide use (Cao, 2008, Pers. Comm.).

9.3.3.3.2 Non-chemical alternatives in strawberry fruit sector

Strawberry production in substrates accounts for approximately 5% of world production. It occurs mainly in greenhouses and in 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 (Lieten, 2004; López-Medina, 2004; Nishi and Takeya, 2006). Efforts to reduce initial set up costs for substrate systems are expected to increase their adoption as a MB alternative world-wide for this crop.

9.3.3.4 *Strawberry nurseries*

MB is used for the production of strawberry runners in order to meet the stringent certification standards for virtually pest-free strawberry runner stock, which is often grown in high altitudes under cold and wet conditions. In some situations the certification standards officially issued by Parties require the application of MB, however others do not mandate MB or specify a particular fumigant. Since a single strawberry runner grown in year one can expand to several million runners by year five, the adverse impacts of pests is of particular importance.

Presently, three potential alternatives have emerged for this use: The combination of 1,3-D + Pic, where allowed and registered appears to be the most viable alternative to MB at this time (De Cal, 2004; Kabir *et al.*, 2005, Porter *et al.*, 2004). Methyl iodide, which has just been registered in parts of the USA has provided comparable results to MB/Pic in the USA, Spain and Australia (Mann *et al.*, 2005, 2007). In Australia and Spain, Ethane dinitrile, which is not yet registered, has

provided encouraging results (Mann *et al.*, 2005, García-Mendez *et al.*, 2008). In some countries large buffers restrict the use of 1,3-D + Pic (Kabir *et al.*, 2005). In some circumstances the inconsistent results using 1,3-D + Pic constrain its further adoption for runner production (De Cal *et al.*, 2005).

In Japan, a simple, economically feasible system using trays filled with substrate is proving particularly useful for the production of strawberry runners. Various materials are used as substrates (e.g. rock wool, peat moss, rice hulls, coconuts husk and bark) and can be reused after sterilising with solar heat treatment or hot water (Nishi and Tateya, 2006b).

9.3.3.5 Nurseries and propagation material for other crops

Propagation material of many types (bulbs, cuttings, seedlings, young plants, sweet potato slips, and trees) are subject to high health standards. This is critical to prevent the spread of economically important pests and pathogens from the nursery fields to the fruiting or production fields. Thus the required level of pest and pathogen control for propagation material is higher than for crops where the product is a fruit or vegetable and must be maintained through the entire crop.

For certified nursery stock, regulations might specify either a level of control that must be achieved or approved soil treatments that are accepted as meeting certification standards. For non-certified stock, the market sets the standard that must be met. In either case, lack of a clean root system could mean a 100% loss in marketable product for the grower. MB has commonly been used to meet clean propagative material standards. In some cases, sufficient data and grower experience have allowed growers to transition from the 98:2 formulations of methyl bromide that were commonly used to 67:33 or 50:50 formulations depending on the pest or pathogen to be controlled and level of severity of the infestation (US Forest Nursery CUN, 2008; US Strawberry Nursery CUN, 2008). Other research trials, indicate some materials (such as iodomethane) and some combinations (such as 1,3-dichloropropane + chloropicrin) show promise as methyl bromide alternatives for specific circumstances (Schneider *et al.*, 2003; Schneider *et al.*, 2006).

Nursery soil treatments normally require broadcast, or broadcast, application in order to ensure adequate protection against colonization by pests and pathogens in adjacent untreated soil. Strip treatment sometimes may not achieve this level of protection. The requirement for broadcast treatment has hindered adoption of LPBF in some areas where gluing of LPBF for broadcast treatment is not commercially available. However, options to overcome this problem are available in some countries such as Israel where heat sealing of VIF films is commercially practised.

An alternate approach to the use of soil treatments is the use of containerised, or soilless substrate for production systems where this approach is technically and economically feasible.

9.3.3.6 Other crops

9.3.3.6.1 Potatoes, Sweet potatoes

Nominations have been submitted for continued use of MB for the control of soilborne fungal, bacterial and nematode pests of potato, sweet potato, and ginger. Present research efforts reported in the literature focus on the control of fungi and nematodes of potato using various organic amendments (Collins *et al.*, 2006; Larkin and Griffin, 2007; Larkin and Honeycutt, 2006; Ochiai

et al., 2007; Snapp and et al., 2007) and one report for control of nematodes of sweet potato (Tateishi et al., 2007).

9.3.3.6.2 Ginger

Pythium sp. (*Pythium zingiberis*) is the major concern for ginger production. A soil borne bacteria, *Pseudomonas solanacearum*, can also attack this crop (Pegg and Moffett, 1971), resulting in heavy losses. A binucleate *Rhizoctonia* AG-R was recently recognised in China (Yang *et al.*, 2008). Several non chemical control methods are considered for the management of ginger diseases. These include improving drainage of the soil through appropriate ploughing, observing adequate watering practices and using disease free water sources. Tools and shoes should be cleaned before entering ginger fields in order to limit disease spread. Infected plants should be immediately removed. Several chemical control methods have been tested. Pre-plant fumigation with chloropicrin, metham sodium or dazomet has been considered effective in the control of root rot although longer plantback times necessary during the cold season are a drawback. Metham sodium sprayed and incorporated into the soil gave high efficacy to both root rot and weeds. Granule application of metalaxyl during the growing period of ginger plants strengthened the effects of pre-plant soil fumigants alternative to MB (Takeuchi Shigeharu *et al.*, 2000).

Cyazofamid has been recently registered for rhizome rot disease of ginger in Japan. Propamocarb is also available. These two products are applied as a soil drench around the individual ginger plants. A mixture of azoxystrobin and metalaxyl M is under registration review. Methyl iodide is not yet registered but seems to offer promising effectiveness, however while no data are still available with relation to its phytotoxicity. Phosphorous acid based compounds are also under evaluation as potential controls.

9.3.3.7 *Replant diseases*

Replant disease is a problem affecting certain orchards of perennial fruit trees and grapevines. Orchards and vineyards represent a long term investment as their production cycle can of be 10 to 40 years. The disorder thus represents a major threat and challenge to growers. Replant is poorly understood as it is often caused by undefined pathogens. A major factor contributing to this problem is the persistence of old, well developed and established deep seated roots of the previous crop, which can act as a reservoir and inoculum source of disease for the new trees/vines. Fumigation or other methods are thus not only needed against the undefined pathogen complex but also to kill the old roots.

A number of alternatives to MB are presently in use in many countries, particularly where specific pathogens are known to contribute to the problem and/or methods that are effective in removing or killing old roots. These include agronomic practices such as rotation where possible, resistant rootstocks, organic soil amendments, partially replacing old soil with fresh soil and others, singly or in combination. The most appropriate chemical alternatives include 1,3-D used singly or with Pic, Metham sodium and Dazomet (Browne *et al.*, 2003; Tostovrnisk *et. al* 2005). Widespread commercial use of these mixtures occurred in Australia for example, before phase out of methyl bromide (Tostovrnisk *et. al* 2005; VDPI 2003, 2004).

Constraints to adoption of alternatives exist in the US and are mainly of regulatory nature. In California, for example, although 1,3-D is effective in killing old roots and used in light sandy soils, the dosage needed for the heavy soils exceeds the maximum allowed under California

regulations (Schneider *et al.*, 2005). Metham sodium and dazomet are inconsistent at the depths required although the development of improved application technologies and effective moisture control in the heavy soils are ongoing (Schneider 2002a, b). Promising results were obtained with grapevines by killing the old roots with herbicides, starving the old soil ecosystem and replanting with a different rootstock (McKenry *et al.*, 2007). Further studies are also being conducted on almonds and other stone fruit with alternative fumigants at reduced rates in California with promising results (Browne *et al.*, 2007). Similar trials are underway with walnut but no results are available as yet (Kluepfel *et al.*, 2007). Site specific fumigation entailing the accurate placement of the fumigant based on global positioning can reduce the amount of fumigant needed whether alternative or MB to up to 78% (Coates *et al.*, 2007).

9.3.3.8 Weeds

9.3.3.8.1 Boomrape

Broomrapes are obligate root holoparasites of the genus *Orobanche*. These parasites lack chlorophyll and depend entirely on their hosts for their supply of carbon, nitrogen and inorganic solutes. *Orobanche* species parasitize a wide range of economically important hosts such as tomato (in greenhouses and in the open field), sunflower, chickpeas, groundnuts, potato, crucifers, carrots, fresh and processing herbs from the Umbelliferae family such as parsley; melon and watermelon. Broomrape appears in the nomination of Israel for eradication purposes in heavily infested field of which crop production is no longer feasible. A scientific research in the countries of which this pest is considered a major pest is carried out with regard to the biology, physiology and host-weed interaction. However the literature in the last two years lacks any new progress with regard to new or improved ways to control this parasitic weed, especially to reduce the huge seed bank, which is generated each year in the soil. The main challenge with broomrape is reducing the seed bank in heavily infested soil, which are no longer in production such as processing tomato fields in Israel.

Recently, Abanga *et. al* (2007) have described a community-based integrated management approach for controlling broomrape in seven countries in the Near East and North Africa (NENA) where this weed causes serious problems. The paper reviews conventional *Orobanche* research and development approaches, and highlights their weaknesses as opposed to participatory approaches.

9.3.3.8.2 Nutsedge

Yellow and Purple Nutsedge, *Cyperus spp* are stubborn pests that have been identified as the limiting factor preventing the elimination of methyl bromide in many Critical Use Nominations. In the past year, trials involving combinations of herbicides and combinations of fumigants as well as strategies involving both herbicides and fumigants have been reported.

In an Alabama field trial, yellow nutsedge control was provided by the aquatic herbicide acrolein in combination with other herbicides and with metham sodium. The successful combinations included acrolein + Eptam, acrolein + halosulfuron and acrolein + metam sodium. Tomato yields were not affected in these trials (Belcher, *et al*, 2007).

In a Florida study, DMDS, under VIF and metalized film, controlled yellow nutsedge as well as MB/Pic in a tomato field trial (Olson and Kreger, 2007).

In Georgia trials, MB/Pic (57/33), iodomethane/Pic (50/50) and a three fumigant system of 1,3-D followed by chloropicrin, followed by metam sodium were evaluated on peppers. Nutsedge was controlled similarly with MB/Pic, iodomethane/Pic and the 1,3-D/chloropicrin/metam combinations. DMDS did not perform as well and at harvest there were 2.9 to 3.2 more nutsedge with DMDS compare to MB/Pic (Culpepper, 2007).

9.3.3.9 Virus diseases of cucurbits and peppers

Cucumber green mottle mosaic virus (CGMMV), Kyuri green mottle mosaic virus (KGMMV), Melon necrotic spot virus (MNSV) and Pepper mild mottle virus (PMMoV) are important pathogens of watermelon, melon, cucumber (CGMMV, KGMMV, MNSV) and on peppers (PMMoV) world-wide. Seeds, grafted seedlings, soil, plant sap and cuscuta (*Cuscuta subinclusa*, *C. lupuliformis*, *C. campestris*) are the main means of dissemination for these viruses. However, the only country using MB to control them is Japan.

Except for 1,3-D/Pic, which is registered to control MNSV in Japanese melons no other chemical alternatives can be used. However these viruses can be controlled with an IPM program that includes seed treatment with heat (Nagai 1981), sanitation practices such as removing residues from the previous crop before transplant and immediate removal of infected plants. Soilless culture and treatment of soil with hot water or steam are also recommended control practices.

Pepper varieties that are resistant to the P₁₂₃ strain of PMMoV have been developed (Tsuda *et al.*, 1997), however another strain of PMMoV which overcomes resistance has been reported (Genda *et al.*, 2007).

9.3.4 Economic aspects of methyl bromide alternatives

In the Assessment Report of 2007, MBTOC showed that the existing peer-reviewed literature on the economics of the impact of the methyl bromide phase-out could be divided into three categories:

- Articles that report only the changed (increased) costs of using MB alternatives;
- Articles that use partial budgeting techniques to assess the impact of MB alternatives on the revenues and costs of a particular application;
- Articles that report the impact of MB alternatives on the sector (e.g. California strawberries, cut flowers in Spain) as a whole.

The review showed that much work needs to be done to increase understanding of the impacts of the methyl bromide phase-out. The existing literature is narrow in the sense that more work needs to be done on countries outside of the USA (especially in Article 5 Parties) and on a wider range of methyl bromide uses.

To this end, a further six articles have been traced, all of which fall within the category of partial budgeting identified above. One of these addresses economic aspects of structures in the USA (Adam, 2007), four address economic aspects of soils use in the USA (Byrd *et al.*, 2006; Sydorovych, *et al.*, 2006; Subbarao, 2007; Taylor, *et al.*, 2006), and one economic aspects of soils use in Turkey (Engindeniz, 2007).

9.4 MBTOC QSC Progress Report and Report on Article 5(1) Issues

9.4.1 Update on Registration of Alternatives

Lack of full registration and approval of alternative chemically-based technologies continues to delay or restrict uptake of technologies identified as effective for post harvest and quarantine uses.

9.4.1.1 Structural uses

One of the key alternatives for disinfestations of structures, heat treatment, does not generally require registration, although other authorities, such as local fire prevention or health and safety authorities or insurance providers may become involved in the approval of treatment plans. Furthermore, the effective use of spot heat treatment may require combination with other measures, including insecticidal barriers around treated areas to kill escaping pests. These methods may or may not require registration.

Sulfuryl fluoride has emerged as a major alternative to methyl bromide for some structural treatments, particularly of flour mills and some other food-processing facilities. Registration of sulfuryl fluoride usually proceeds in a two phase process. First, its use in empty mills or food-processing facilities is registered. Then, as trials and adoption progress, the need to set maximum residue levels (MRLs) and/or approve food contact registration for the foods, which may be present in those facilities, becomes apparent and registration is then sought for them. The latter registration typically avoids the need to totally clear out the treated mills of foodstuffs.

Currently, of the countries that submit critical use nominations for mills and food processing structures, Canada and the United States have registered sulfuryl fluoride, although differently. Sulfuryl fluoride is not registered in Israel. In Canada, sulfuryl fluoride is registered for empty facilities, and there has been no maximum residue level set for food contact. As a result, in Canada, there is no incidental fumigation of flour or food allowed and a mill must be completely emptied before fumigation. This presents difficulties for the adoption and use of this fumigant in some circumstances. In the United States, mills and food processing facilities and numerous different food commodities have been approved for treatment by SF. However, many of the ingredients found in, or food commodities produced by, mills and food processing facilities are not registered for contact with SF and/or no MRLs have been established. At the moment, this situation is delaying or preventing adoption of SF for some mills and food processing facilities in Canada and the United States.

Meanwhile, in the European Union, registration for the use of sulfuryl fluoride in empty mills and processing facilities, combined with quickly expanding approvals of commodities has contributed strongly to pest control without the use of methyl bromide. The European Commission submitted a survey of 12 EU member countries and over 137 flour mills as a contribution to the MBTOC flour milling review published in the 2008 Spring Progress report. That report notes that many mills in the EU have adopted sulfuryl fluoride now that all EU mills have moved away from MB use.

9.4.1.2 Commodities

At this time in the US, many processed foods or food mixtures are not approved for treatment with sulfuryl fluoride, because of lack of appropriate residue tolerances. On the other hand, there are many single commodities registered and tests of the technical efficacy of pest control in those commodities are progressing. Very significantly, reductions in allowable bromide residues in food (EU 149/2008, in force Sept 2008), combined with registration of sulfuryl fluoride as a plant protection fumigant in the European Union, together with the upcoming publication of MRLs for fluorine, are expected to have a significant effect on the ability to use methyl bromide and sulfuryl fluoride on various commodities. At this time, MBTOC has not been able to fully assess the impact of these changes, but they may be expected to impact critical use nominations for some US produced commodities since the EU is a major market.

9.4.2 Adoption of alternatives for treatment of commodities and structures

In the Philippines, MB will not be used for non-QPS purposes after 2008. The Party is currently using about 7 tonnes of non-QPS MB. The National Methyl Bromide Phase-Out Strategy supported by the Multilateral Fund commenced 3 years ago. Fumigators and flour mill operators have been trained on IPM. Only one flour mill still uses MB. The Philippines Fertiliser and Pesticide Authority has changed the label so that MB will only be allowed for QPS only. Philippines also has a reliable system for tracking MB use. Cylinderised phosphine and ethyl formate formulations are registered and available as methyl bromide alternatives. SF will not be registered in Philippines due to the lack of commercial interest from registrants.

There has been significant progress in the adoption of controlled atmosphere treatment for commodities, replacing methyl bromide treatments in some cases. For example, controlled atmosphere facilities have been established in Bangalore, India (45,000 tonne capacity for treatment of sesame seed for export to Germany), Bolivia for sesame seed, Greece (for processed packaged rice on pallets), India, for some durable foodstuffs under exports, Netherlands (35,000 tonne facility for cocoa beans in Amsterdam and a Rotterdam facility 12 rooms each holding a 20 foot container for QPS treatment) and Thailand (for processed packaged rice).

MBTOC does not know of a technically effective alternative for MB treatment of infested traditional cured ham in storage in Southern US and this use is the subject of a CUN. The United States has begun a multi-disciplinary research program to resolve this issue. In the interest of collaborating in research ideas, MBTOC has gathered some information about control of pests in cured pork in other countries, while recognising that these traditional products and their processing varies by country. In Spain, dipping in hot oil and lard is used early during the manufacture process for both preventive and curative reasons. The high temperature kills mites that could be already present on the surface of the ham and lard fills crevices preventing the colonisation of mites deep into the ham (this is the most important reason). Also, lard has another very important advantage not related to mite control, as it slows the drying process. During processing, temperature and relative humidity determine the behaviour of mites. Controlling both parameters contribute to the prevention of infestation by this pest. In Spain, hams are maintained at low ambient RH conditions (50 – 60%) mainly during the last period of storage. This prevents the development of surviving mites to the hot oil treatment and the re-invasion from outside the store. The Spanish traditional ham industry considers it essential to maintain high hygiene standards inside the rooms and in and around the entire facility, and to empty, clean and spray facilities and frames before new hams are introduced. Additionally, USG may wish to investigate

the potential for controlled or modified atmosphere storage for cured pork. Specifically, a low O₂ environment, which does not elevate the CO₂ level, might be effective.

9.4.3 Quarantine and Pre-Shipment MB Issues

The third meeting of the Commission on Phytosanitary Measures (3CPM) approved a policy document relating to the reduction of methyl bromide use in phytosanitary measures. These are essentially Quarantine measures as defined under Decision VII/5, particularly applied to plants and plant-derived products in trade. This document (IPPC 2007) recommends IPPC members to seek to put in place alternatives for methyl bromide where possible for QPS treatments covered by IPPC.

There continues to be only limited information available on the exact uses to which QPS-exempted methyl bromide is put. Three surveys on QPS uses of methyl bromide have recently been completed – one of Australian uses (Banks, 2008) and one of uses in the Asia Pacific region (UNEP ROAP, 2007). The Australian survey identified the treatment of timber and wooden materials, both import and exports as the major QPS use, followed by treatment of export hay and grains. In the Asia Pacific region, the predominant treatment by volume was for logs and wooden materials, both for imports and exports, followed by export and import grains, particularly rice. In both surveys a diverse range of low volume uses were identified.

Most exporting countries have now adopted procedures to meet ISPM 15 requirements to treat wood packaging materials for prevention of spread and importation of harmful pests of standing timber. Croatia implemented ISPM 15 as of Jan 1, 2008 with the result that Croatia now expects imported packaging materials to meet this standard. Some alternatives to the two specified procedures under the current version of the standard (methyl bromide or heat treatment) are under consideration by the IPPC. The recent meeting of the Commission on Phytosanitary Measures called for further data on these candidate alternatives and did not approve them as alternatives to meet ISPM15. Canada and Taiwan have now discontinued any methyl bromide use to meet ISPM 15 and rely only on heat treatments. Heat treatment facilities to treat wooden pallets (new or used) to ISPM 15 have been set up in many countries including Australia, Bangladesh, China, Jamaica, Malaysia, Singapore and Thailand. These use a variety of heat sources, including hot water systems, electricity, and natural or liquefied petroleum gas. A project in Fiji to develop a solar-assisted treatment system to treat pallets to ISPM 15 is ongoing.

Commercial scale fumigation tests for timber under tarps were conducted in Japan in March 2008 using sulfuryl fluoride/methyl isothiocyanate mixture and also methyl iodide to confirm each fumigant's efficacy, the gas concentration obtained under commercial conditions and safety hazards that they present.

These tests were carried out to generate data to allow amendment of the Japan plant quarantine regulations to authorise treatment with either fumigants for imported timber. These successful tests gave complete mortality of added test insects, including longhorn beetles, bark beetles and wood borers (Ambrosia beetles). Both the sulfuryl fluoride/methyl isothiocyanate mixture and also methyl iodide have been registered as agrochemicals in Japan. After the completion of public hearings, it is expected that both fumigants will be introduced into the Japan quarantine treatment schedules.

The export of forestry products from New Zealand requires fumigation to control quarantine pests. New Zealand's QPS MB use continues to increase (14% in one year) with the growth of trade in forest produce to China, India and Malaysia. Forest produce fumigation is 74% of the

177.3 tonnes QPS MB used in 2006. Some 200 tonnes annual demand of MB have been replaced with the phosphine fumigation of logs in transit to China; negotiations are underway with India to use the same process.

As an additional approach to reducing MB quarantine use in New Zealand, following an international symposium on MB alternatives held in March 2008. A stakeholders group has been formed and is collecting a voluntary levy of \$1/kg of MB, which will be used for research and development of QPS alternatives. A strategy to reduce and replace MB for QPS uses is being developed. The priority will be for timber treatments with further validation of phosphine, tests with methyl iodide and sulfuryl fluoride (not yet registered) in particular. New Zealand requires collaboration with other Parties to test phosphine against wood insects to progress approval as an internationally acceptable treatment to meet ISPM 15.

New Zealand is implementing a program to ensure only clean empty shipping containers leave ports in the Pacific Islands. This has been successful in reducing the high frequency of MB fumigations due to hitchhiking pests. The program also includes assistance with all treatments such as ISPM 15 and high temperature forced air treatment of fresh fruit and vegetables to reduce the number of MB fumigations on arrival in New Zealand.

The Australian Fumigation Accreditation Scheme (AFAS) seeks to assist fumigators involved in quarantine fumigations to maintain a high standard of fumigation performance. AFAS is a bilateral agreement between Australia and some four countries in Asia, with negotiations continuing to expand the scheme to other countries in the region. By promoting best practice, it reduces the need for repeat fumigations with methyl bromide, thus reducing methyl bromide use for quarantine purposes and utilising the gas well where it is used. The scheme includes training programs to improve methods and decrease the incidence of inadequate fumigation and injury to dock workers when opening imported containers.

In Japan, imported vegetables are fumigated with MB if quarantine pests are found at inspection. The quarantine MB dosage for vegetables is fixed at 48.5 g/m³ despite variation of susceptibility of pest species. Last year, mortality tests with frequently-detected pests on vegetables were performed to establish a MB-saving fumigation standard, taking into account susceptibility of pest species. The results indicated that the newly established MB dosage could reduce MB use down to as much as 50% while retaining sufficient fumigation efficacy against pests.

Used vehicles arriving in New Zealand require a pest control treatment. A stand-alone, mobile, heat treatment unit capable of treating large vehicles and 40ft containers is operating at New Zealand's largest port. This unit has replaced the fumigation of used vehicles imported with a savings of nearly 2 tonnes of methyl bromide per year. The heat treatment unit is diesel operated at 8L diesel per hour.

9.4.3.1 *Irradiation quarantine update*

Recent regulatory approvals expanding the use of irradiation as a quarantine treatment have resulted in increased adoption of the process and indications that irradiation is being accepted by consumers.

USDA-APHIS published a rule in 2007 providing generic irradiation quarantine treatments. The rule approved irradiation doses of 150 Gy for any tephritid fruit fly and 400 Gy for all other insects except the pupa and adult stages of Lepidoptera. The generic irradiation treatments apply to all fresh horticultural commodities. Hawaii has used generic doses to export tropical fruit since

2000. In May 2007, India began exporting mangoes to the U.S using irradiation, becoming the first country to use the newly approved generic doses. Thailand was recently approved to export six tropical fruits using the new generic doses and export of irradiated mangosteen to the US has begun.

New Zealand has recently begun importing irradiated Australian mango and papaya. While the irradiation of mangoes in export trade does not replace a methyl bromide treatment (some likely pests are not reachable by methyl bromide), it does indicate the utility of the treatment with some other fresh fruit that are currently MB treated.

9.4.4 Recapture of methyl bromide

Decisions to install methyl bromide recapture systems continue to be driven by local pollution control concerns and regulations, not solely protection of the ozone layer. There has been substantial increase in adoption of methyl bromide recapture systems in a few regions during 2007/08, as urged under Decisions VII/5(c) and XI/13(7). However, in the absence of approved systems under XV/9, there is no benefit received under the Montreal Protocol production and consumption framework for the effort and expense of recapture.

There has been adoption of recapture in Belgium, driven by the regulations that came into force on 1 June 2007 requiring fitting of recapture to all methyl bromide fumigations there. Typically, these systems are fitted to standard freight containers when under fumigation.

A Belgian company, Desclean, has 7 units operational in Belgium with capacity to service 15,000 containers a year in total. The Desclean units also use carbon for methyl bromide capture, but the sorbed methyl bromide can be released for reuse by controlled heating. Desclean estimates 50-60% of methyl bromide used is reused.

An environmental court in one region in New Zealand has ruled that recapture is to be used on all fumigations using more than 3 kg of MB within the local port, this ruling results in the requirement for recapture equipment that is bigger in capacity than any currently available commercially.

Nordiko, an Australian supplier of fumigant recapture equipment, report their methyl bromide capture units are now operating in several countries. These are based on MB absorption on charcoal, followed by regeneration of the carbon or disposal of the used material. The 4 units operating in Belgium can service up to 60,000 containers a year. Systems are operational in Australia (10 systems), Malaysia (2 systems), India (1 system) and USA (1 system).

The registration status of methyl bromide recovered from recapture systems is not clear in many countries.

9.4.5 MBTOC QSC Article 5 Issues

Two issues pertaining to problems of quarantine, structure and commodity treatments in Article 5 Parties have been brought to the notice of MBTOC.

The first is a trade issue, which has been reported to be negatively affecting trade in goods shipped on MB treated packaging materials from Sub-Saharan African Parties.

These countries report a serious problem resulting from their use of MB to treat wood packaging materials to meet ISPM 15 (IPPC 2006) for international trade. Some large EU companies are refusing to accept product that has been placed on MB treated wooden packing materials. ISPM 15 requires that treated wooden pallets and crates be labelled with type of treatment. Heat treatment of pallets and crates is allowed as an alternative to methyl bromide under ISPM 15, but its use is problematic in many Sub-Saharan countries due to lack of reliable energy sources and the high cost of providing the energy. The major products affected by the action of the EU companies are tea, bananas, flowers and other fruits, even though these commodities are not themselves treated with MB.

The second issue is the need for technology transfer of alternatives to methyl bromide in fumigation of flour mills, grain storage structures, processed and stored products in Article 5 Parties.

Tropical ecology with relatively high temperatures and humidity, prevalent in developing countries, exacerbate pest infestations resulting in the need for specialised control strategies for grain storage, flour milling and other food processing uses. These environmental conditions also mean that techniques used in developing countries may have different functionality. Although fumigants and techniques have been extensively trialled in developed countries, it is not clear whether these methods will work the same way in developing country environmental conditions and circumstances.

Phosphine is widely used in the developing countries as an alternative to MB for control of pests in the flour mills, grain storing structures, and stored products. However, due to emergence of resistance of pests to phosphine, coupled with its corrosive nature to equipment, and long treatment time, flour mills, processed and stored product industries continue to favour using MB in some situations.

Developed countries are making good progress in replacing methyl bromide with pest control techniques for flour milling and food processing that include heat treatments (full site or spot heat with additional pest barrier methods), and with the fumigant sulfuryl fluoride (SF).

From experience, flour milling and food processing sectors have learned that effective accomplishment of full-site heat treatment methods can be unexpectedly complex and potentially considerably more expensive, depending on the mill or processing situation and local environmental conditions. On the other hand, techniques for spot heat treatment of mill and processing equipment can be simpler, once appropriate equipment and monitoring techniques have been established and tested.

However neither heat technique has been trialled and adapted to the needs of developing countries located in tropical zones where high humidities can affect treatment efficacy.

Although developed countries are making good progress adopting sulfuryl fluoride, in flour milling and for food processing facilities, the efficacy of SF has not yet been demonstrated in most developing countries. One country, Mauritius, has trialled the use of sulfuryl fluoride in its only flour mill, with good results. As with all trials, there is a learning curve and continued experience tends to lead to improvements in fumigation results.

Currently, regulatory barriers do not significantly constitute a major constraint to the use of SF in a number of the developing countries. For example, the use of SF in Eastern Africa (Ethiopia, Kenya, Malawi, Tanzania and Uganda) and in Southern Africa would readily be registered for use

once documents are submitted to show that SF is registered by USA-EPA for use in fumigation of the flour mills, grain storage structures, and stored products.

The main constraint holding back the use of SF in the developing countries is the lack of technology transfer as regards the fumigant and lack of interest by commercial suppliers of the material.

The phase out of MB use in flour mills, grain storage structures, and stored products in the developing countries would augment global efforts to save the ozone layer. Phosphine has widely been used to replace MB in grain storage, but heat treatments and SF, the techniques most commonly used in the milling and processing sectors, have not yet been adopted by the developing countries.

Whereas heat treatment and SF are currently promoted and encouraged for widespread use to replace MB in the developed countries, no similar efforts have made to explore or demonstrate the efficacy of heat treatment or SF in developing countries, China excepted. For these reasons, MBTOC QSC encourages financial and technical assistance for Article 5 Parties to acquire appropriate technologies, skills, and expertise that would lead to efficient, and cost-effective use of heat treatment techniques and/or the use of SF, under IPM strategy, in Article 5 Parties. These technology transfer projects could assist developing countries to accelerate MB phase out used in flour mills, grain storage structures, processed and stored products.

9.5 References

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10 Current Status of Technical Efficacy, Costs and Adoption of Methyl Bromide Alternatives in Flour Mills

10.1 Introduction

In its presentation to the Meeting of the Parties in Montreal 2007, MBTOC Quarantine, Structures and Commodities (QSC) indicated it would focus on the use of MB and adoption of alternatives in the flour milling sector. As we indicated, adoption of alternatives in this sector seemed inexplicably slow, in the face of alternatives already registered and in effective use by some companies.

In 2007 and 2008, three Parties, Canada, Israel and the United States, nominated flour mills for continued critical use of methyl bromide. Although amounts of methyl bromide requested for flour milling use have declined each year, the decrease was slower than for other post-harvest sectors. At the same time, we note that some flour sector members express continuing concern about the technical efficacy and cost of alternatives.

MBTOC developed a summary paper reviewing effectiveness, costs and adoption of alternatives in the milling sector, in countries where there are CUNs, would be useful to Parties. In January 2008, MBTOC QSC sent letters requesting information about the current status of adoption of alternatives in the flour milling sector to Parties, industry associations and suppliers of alternatives. In response, Canada (7, 11, 18, 19, 21, 29) and the United States (2,3,4,5) sent several reports and industry correspondence; the European Commission surveyed 12 countries and provided an extensive report (16); the UK response was received in the form of several letters from fumigators and millers (17, 42, 43, 4, 45) and two large reports summarising recent flour mill research (6, 9); Israel arranged a meeting for MBTOC with Israeli fumigators (23). Additionally, MBTOC members supplied information from their reference data bases, national libraries, research and commercial contacts.

Effectiveness and adoption of alternatives in the milling sector is not often a subject of research; the information is more likely to be found in commercial experience. Therefore we could not limit our search for information to the research literature. Unfortunately, commercial experience and views of sector members do not often arrive in a citable format. To ensure fairness and transparency, all cited references and viewpoints used will be made available upon request by any Party. We established evidence rules requiring any document to be either in the public domain, or submitted to MBTOC as signed and citable.

Information included in the CUNs also contributed to MBTOC's evaluation. We can not, however, supply CUNs to Parties. The US CUNs are public documents found on the website of the US Environmental Protection Agency. Canada's CUNs are not public documents and are protected commercial confidential. MBTOC is not certain of the confidentiality status of Israel's CUNs.

The reference list forms an important part of this report: summaries of all references were written and included in the reference list. Cited references are available to Parties on request to UNEP Ozone Secretariat (contact: meg.seki@unep.org)

10.2 Executive Summary

Achieving reliable pest control without using methyl bromide requires more intensive sanitation and the use of integrated pest management (IPM) as a prerequisite to the alternative full site treatments that are necessary for pest control (7, 9, 11, 16, 40, 44). Sanitation standards and repercussions for pest presence vary by country but this report did not assess these country to country differences.

Determination is required to resolve the difficulties that are commonly experienced in the first trials of a new fumigant or technique (10, 17, 42). Reliable methods and parameters have been established for each alternative, but these must be fine-tuned through experience at each mill to maximise effectiveness. Mills must be evaluated to see which alternative will work best in each situation (6, 11, 34). The majority of fumigators who submitted reports noted that as they gained experience in treating a particular mill, technical efficacy of the alternative improved. All alternatives require extensive planning and experience before success is achieved (7, 9, 11, 13, 16, 17, 42, 43, 45).

The most likely and most often used alternatives are, heat treatment either as a full site treatment or as spot heat (combined with the use of a further pest barrier method) and sulfuryl fluoride (SF), either alone or with the addition of supplemental heat in a combination treatment.

In the US, while approved, tested and deemed successful by some millers, the phosphine combination treatment is not in widespread use because of concerns over the damage to electronic equipment. It has been eclipsed by the use of heat treatment and/or SF. However Phosphine could be used to treat infested food commodities removed from mills if SF is being used for the structure.

Millers in Canada and the United States report real problems in adopting SF because of the lack of regulatory approval for food contact (22, 32). In Canada there is no MRL established for SF food contact (11). In the US, many foods which can be contacted by MB can not be contacted by SF (3, 22). Mills which produce bakery mixes are the most affected (3, 4). Domestic regulatory authorities are working to resolve these problems (4).

Furthermore, millers and some researchers consistently express concerns about the ineffectiveness of SF in killing eggs at low or ambient temperatures, discouraging its adoption (1, 7, 8, 21, 33). As with MB, which also did not always kill all life stages present (40), other pest management methods could be deployed to keep the mill pest free. Egg kill can be obtained by increasing SF dosage rates, but the expense of doing so concerns millers. Raising dosage rates may also not be the wisest choice from a total environmental perspective. Egg kill can, however, be achieved by combining SF and temperatures $>27^{\circ}\text{C}$ (80°F) (5, 14, 17, 30, 36, 37, 45).

The emerging information does not clearly establish the comparative costs of heat, MB, SF, and other treatments. Many reports indicated the alternatives cost more than methyl bromide treatment (1, 5, 8, 11, 17, 21, 28) but some reports indicate that alternatives cost about the same as methyl bromide, once tailored to site-specific conditions (12, 20, 26, 27, 37). To these costs must be added the additional costs for improved IPM systems since improved IPM systems are a necessary prerequisite to the full treatments needed (35). Two fumigators indicated that the use of alternatives plus IPM improvements has reduced costs for some mills (20, 27).

The relevant cost consideration should be the total cost of a “pest control system”, which would include costs for improved IPM, plant modifications, sealing, protecting sensitive items from

damage, removing or isolating food products and ingredients if necessary, and downtime. At the same time, there may be savings resulting from reduced frequency of fumigation, reduced downtime due to faster airing and other factors (15, 20). All these factors have to be balanced against performance (efficacy) of the system.

All pest control measures have environmental impacts. Methyl bromide is ozone depleting, but it seems that SF and heat alternatives have higher global warming potentials (4 25, 29). All fumigants are toxic by nature and must be used responsibly both from the point of view of their eventual airing to the outside environment and to avoid possible development of pest resistance resulting from sub lethal treatments. Therefore it is important to achieve the best pest efficacy possible in exchange for the environmental cost.

Flour mill industry concerns that the alternatives are not as effective as MB, and are more expensive, are delaying adoption of the alternatives. Lack of efficacy is associated with the need to re-fumigate or re-treat the mill, which significantly increases expense. Although concerns were reported with the use of each alternative, there were no reports indicating that any particular mill structure, type or conformation completely lacked a *technically effective* alternative treatment (11, 16). In the countries with CUNs for flour milling, there were, however, regulatory barriers to the use of effective alternatives, and cost concerns or cost barriers.

To resolve the flour mill industry concerns about lack pest efficacy with the alternatives, while achieving the best possible pest kill efficacy for the environmental impact, MBTOC recommends that for any full site treatment (fumigation or heat treatment) in flour milling, the aim should be to kill all life stages of pests present.

For sulfuryl fluoride treatments this recommendation means that SF fumigations should be conducted jointly with heat to a temperature of 27°C (80°F) to achieve satisfactory egg kill. In many cases, supplemental heat will be required to achieve the necessary temperature (42).

For heat treatments this means that very careful consideration and planning attention be given to ensuring adequate heat sources and to use additional pest protection barriers such as heated mats, diatomaceous earth (DE) (and/or insecticidal spraying or oil treatment where allowed by regulation) on basement floors, in floor-wall joints, cracks, crevices and wall voids (6, 7, 9, 11, 18, 19, 24). Spot heat as part of a progressive pest control program is considered effective in some circumstances where temperature monitoring is done carefully and where additional pest barrier techniques are also used (7, 23).

Adherence to MBTOC's recommendations will likely result in additional costs for the alternatives but will result in greater pest kill efficacy and may reduce frequency of full site treatments, a major contributor to overall pest control costs (20, 43).

Through reduced dosage rates, fumigation frequency with MB and/or adoption of alternatives, plus other factors, CUNs for flour mills in Canada, Israel and the USA combined have decreased approximately 170 tonnes or about 51% between 2005 and 2010 (based on MBTOC's interim recommendations).

10.3 Technical Efficacy

Achieving successful pest control, without the ability to repeatedly fumigate with MB, requires much greater attention to mill sanitation and IPM approaches to pest control (7, 9, 11, 16, 40, 44).

A determination to work to find an alternative and make it effective in a particular situation was an essential part of the eventual successes reported (10, 17, 42). Technical efficacy with MB alternatives is achieved through repeat experience. Virtually all the fumigator and research reports indicate some difficulties in achieving the desired level of efficacy in initial fumigations or treatments. However, these first experiences also identified the problems, for example mill sealing inadequacies, which caused low gas concentrations, or inadequate electrical capacity to generate the heat required in heat treatments. At the same time, virtually all the fumigator and research reports indicate that subsequent fumigations were much more successful (9, 10, 11, 15, 17, 30, 34, 37).

At this time in North America, full site fumigations are usually only conducted once or twice per year during normal holiday shutdowns. They may be carried out as a precautionary measure, in the absence of demonstrated need, to avoid risk of costly unscheduled shutdowns or public problems if pest populations reach unacceptable levels. In Israel, spot phosphine or spot heat are used as part of a program of rotating pest management treatments.

Mills are large commercial concerns; and mills are often very different in structure from each other. Mill managers are required to be technical skilled and intuitive to respond to changes in raw materials, environmental factors and how these factors affect the mill and its output. The real measure of success is the satisfaction of the mill management with the alternative treatment at that particular mill.

Aside from the satisfaction of mill management, success in mill fumigation can be demonstrated by the immediate, or delayed, death of insects in test cages (40). Other measurement methods include recording pest rebound in the mill structure or equipment (10, 11, 14, 15). But since mills constantly bring in grains and raw materials, and are often located near significant environmental sources of pests, it is difficult to clearly correlate pest rebound with fumigation efficacy (37). Rebound due to pest survival will be likely to occur sooner with methyl bromide treatments than, for example, sulfuryl fluoride treatments. With methyl bromide, older, pre-adult stages are much more tolerant than eggs, while for sulfuryl fluoride the reverse is true and hence survivors will take longer to develop through to the adult stage.

Some management plans for the use of SF have been designed at dosage levels which will allow some egg survival. This causes concern to millers who believe such a treatment is different than MB, and because a pest control treatment that is designed to allow survival may not meet inspection standards (1, 7, 11, 33). Concern about pest egg survival has delayed acceptance of SF, yet this review indicates that egg survival can be avoided (5, 14, 17, 30, 36, 37, 45). Sulfuryl fluoride treatments that result in egg survival have not been evaluated for the development of pest resistance. There is no resistance evidence at this time, but it is an eventual concern when pests survive a treatment (33).

To resolve the flour mill industry concerns about lack pest efficacy with the alternatives, while achieving the best possible pest kill efficacy for the environmental impact, MBTOC recommends that for any full site treatment (fumigation or heat treatment) in flour milling, the aim should be to kill all life stages of pests present.

According to the researchers who conduct insect assays, the fumigation companies who work for mill managers, and reports of satisfaction from mill managers, heat, sulfuryl fluoride and phosphine (combination treatment) can each achieve technically successful pest control in flour mills (6,7,9,10, 12,14,15,16,17,18,19, 20,24, 26,27,28, 30, 31, 36, 37, 39, 40, 42, 45). Some alternatives may work better in some mills than in other mills. Of these three most likely mill

treatments, heat (with additional pest barrier techniques) and sulfuryl fluoride with heat (a combination as described below), seem most likely to succeed in the current commercial context.

Although the parameters for a successful full-site heat treatment are clear, there is an unexpected degree of complexity to achieve success (6, 7, 11, 18, 21, 33, 34, 35, 38, 43). Structural heat treatment commonly involves raising the building temperature to 50-60°C, and to manage risk of building damage, at a rate of 5°C per hour (and cooling at a rate of 5-10°C) (6,7,9,18, 38). Sufficient heaters to ensure that 50°C is reached within 6-8 hours are required.

The use of air movers or fans is essential to ensure uniform heating (a cost factor). Using insulated and heated floor mats was found necessary in the UK to raise basement floor and floor-wall joints to temperature (6, 9). The use of diatomaceous earth (DE), insecticide sprays or other pest barrier methods are also reported as necessary to assist efficacy of heat treatment (6, 9, 23).

Although stored products pests die in <1 hr at these temperatures, structural heat treatment requires that these temperatures be maintained for 24-36 hours to ensure uniform heat distribution in all portions of the building (6,7,9,18). There are heat calculation models available from US university researchers and others to assist mill managers and fumigators to calculate the required BTUs for a successful heat treatment (37). Different portions of, or equipment in, the building will heat at different rates. Under some circumstances, some parts of the structure, notably walls or floors in basements of concrete construction, may prove difficult or impossible to heat to the required level because they act as heat sinks. For this reason the use of insulated floor mats, DE and/or insecticidal spraying is needed on these harder-to-heat surfaces (7, 9). In portions of the building where the temperature is <50°C, insect survival can be expected (38).

Spot heat treatments are also used by some companies as part of a progressively applied pest control program (7, 23). In this instance, a piece of equipment, or a zone of a processing facility, is heated with hot air moved by fans or forced hot air (creating a high pressure zone) until the area is heated to above 50°C for the required time. In Israel the spot heat treatment for mill equipment is 52°C for 30 minutes. (23) Key to the use of spot heat is the additional use of a barrier method to kill pests which will crawl from the heated area in search of cool refuge. Diatomaceous earth, insecticide sprays or food-grade mineral oil applied in a thick drip line can be placed on the floor across routes of escape to kill or trap escaping pests. Spot heat is one alternative available for those processing facilities or situations where a full site treatment is not practicable.

The parameters for successful treatment with sulfuryl fluoride are clear, but have not been fully agreed by the users and fumigator suppliers. The current supplier of SF to North American mills is Dow AgroSciences. They also supply a fumigant management system called the Fumiguide™, which forms part of the registration package in many countries. The Fumiguide calculates dosages and fumigation management targets to achieve the level of pest control desired based on mill and environmental parameters input by fumigators. It advises necessary dosage rates for different temperatures and depending if egg kill is targeted (15, 30, 31, 32).

Egg kill can be achieved by increasing dosage or by increasing temperature during the SF fumigation. Based on fumigation and pest kill data submitted for this report, in virtually all cases where sulfuryl fluoride was deemed to be most successful, mill temperature was also recorded as $\geq 80^{\circ}\text{F}$ ($\sim \geq 27^{\circ}\text{C}$) (17, 30, 36, 37, 42, 43). In many instances this will require additional work, and cost, to raise the mill temperature. This might be achievable through the use of comfort heating equipment or may require the use of additional heaters (depending on the local environmental conditions and mill equipment).

Although some mills have obtained successful SF fumigations without the use of additional heat, weighing the full realm of technical, cost, regulatory and environmental issues, leads MBTOC to conclude that the best way to use SF for mill treatment is to use a heat plus SF combination and to target all life stages of pests.

In the US, while approved, tested and deemed successful by some millers, the phosphine combination treatment is not in widespread use because of concerns over the damage to electronic equipment caused by phosphine gas. It has been eclipsed by the use of heat treatment and/or SF. However phosphine could be used to treat infested food commodities removed from mills if SF is being used for the structure.

Although concerns were reported with the use of each alternative, there were no reports that indicated any particular mill structure, type or conformation completely lacked a technically effective alternative treatment. In the countries with CUNs for flour milling, there were, however, regulatory barriers to the use of effective alternatives, and cost concerns or cost barriers.

10.4 Regulatory Issues Affecting Alternative Adoption

Heat treatment does not usually require approval by pest management regulatory authorities, but insurance companies may become involved. There are additional pest barrier methods recommended for use in heat treatments, and these may require regulatory approval. The use of DE seems to have widespread regulatory approval, but it is slower acting and ineffective in damp areas. The use of insecticidal spraying in a mill is subject to regulation. The use of food-grade mineral oil resolves many of these issues.

Fire protection and occupational health authorities have and may continue to express concerns and demand hazard management plans and methods that can contribute to costs and delays in adopting heat treatments (7, 11). Many mills have successfully adopted heat treatments. But, some facilities can not adopt heat due to the design of their sprinkler system, their inadequate electrical capacity and/or the unavailability of adequate footprint for external heater and electrical systems (11).

The real regulatory issues affecting adoption of alternatives have and will continue to pertain to the chemical fumigants. Recent years have seen the approval of the use of sulfuryl fluoride at national and state levels, followed by the very widespread training of licensed fumigators. However, regulatory approval of sulfuryl fluoride has not been complete enough to satisfy mill management.

Millers in Canada and the United States report real problems in adopting SF because of lack of regulatory approval for food contact (3, 4, 5, 11).

For example, in Canada, no maximum residue levels (MRL) have been set for contact with food (any food or raw agricultural ingredient) (11). As a result, the mill has to be either completely emptied of any grain or finished product or those items have to be completely sealed off. These actions are not always possible, and if possible, have an as-yet-undetermined cost. Millers believe when the MRL is effectively zero, then they could be liable if fluoride residue is found in small amounts of flour left behind when equipment is fumigated.

In the United States, MRLs have been established for grains and processed flour, but not for the other commodities used in bakery mixes and consumer flour mixes (4, 22). One estimate is that over 40% of US flour mills also produce these items and would have them present in large

quantities in the mill. The products would have to be removed or completely sealed off before a SF fumigation, which may not be possible, or may be impractical, or too costly. Furthermore, it is unknown if sealing off the commodities would satisfy the regulations which prohibit food contact by sulfuryl fluoride. Regulatory authorities in Canada and the US are working to resolve these issues, but currently these issues remain barriers to greater or lesser extents.

Phosphine, CO₂ and heat combination treatment requires approval of regulatory authorities in Canada, but appears to not require separate approval in the US. (Note that the use of phosphine alone is already approved in both countries.) The combination treatment of phosphine, heat, and CO₂ has not yet been approved in Canada (11).

MBTOC also reviews critical use nomination for flour mills in Israel. Israel does not require regulatory approval to use heat, and indeed it is used in Israel's flour mill sector as spot treatment. But, sulfuryl fluoride is not approved and no application has been received for its use. Phosphine is allowed to be used, and is used for spot treatments in the majority of Israel's mills. As with any treatment that allows some pest survival, MBTOC is concerned that such spot treatments may give rise to continued pest presence. For that reason, MBTOC recommends the use of barrier methods to ensure pests seeking cool refuge from the spot heat treatment are killed. In Israel a thick drip line of food grade mineral oil placed on the floor around the heat-treated equipment has been shown to kill any escaping insects (23).

10.5 Costs of Alternatives

The emerging information does not clearly establish the comparative costs of heat, MB, SF, and other treatments. Many reports indicated the alternatives cost more than methyl bromide treatment (1, 5, 8, 11, 17, 21, 28), but some reports indicate that alternatives cost about the same as methyl bromide, once tailored to site-specific conditions (12, 20, 26, 27, 37). In more temperate environments such as in Canada and the UK, reports generally agree that heat treatment costs more than MB (6, 11, 42, 43).

To these costs must be added the additional costs for improved IPM systems since improved IPM systems are a necessary prerequisite to the full treatments needed (35). But, two fumigators indicated that the use of alternatives plus IPM improvements has reduced costs for some mills (20, 27).

The relevant cost consideration should be the total cost of a "pest control system" which would include costs for improved IPM, plant modifications, sealing, protecting sensitive items from damage, removing or isolating food products and ingredients if necessary, and downtime. At the same time, there may be savings resulting from reduced frequency of fumigation, reduced downtime due to faster airing and other factors (15, 20). All these factors have to be balanced against performance (efficacy) of the system.

There is inadequate information on the comparative costs of alternatives in the milling sector. Furthermore, there is not ever likely to be adequate information on a sectoral basis. Mills vary so much in structure, design, conformation and other factors that the only valid comparison would be on a mill-specific basis. While that information likely exists, it is likely proprietary between the mill management and its fumigators and will not likely be reported to MBTOC or Parties (21).

Where partial costs have been reported, such as in Canada's heat trials, or in the reports by Adams and Bartlett cited here (1, 6, 11) or in the numerous reports from fumigators included here, costs of alternatives seem to either higher (1, 5, 8, 11, 17, 21, 28) or sometimes, roughly

equivalent (12, 20, 26 27, 37). We can assume that if millers found an effective alternative that cost them a lot less they would immediately switch to it. Perhaps the millers who have switched to alternatives found an alternative that cost less in their specific circumstance.

10.6 Environmental, Health and Safety Issues

From a policy perspective, the likely increased costs of alternatives should also be viewed in a total environmental perspective. That perspective would evaluate the environmental impacts of continued MB use (and ozone depletion), evaluated next to other environmental issues such as the GWP of alternatives. However, business finances are driven by actual costs and revenues; environmental costs do not appear on profit and loss statements. Nevertheless, some corporate environmental policies have resulted in a more determined effort to switch to alternatives that are not ozone depleting and/or not contributing to global warming (4).

Governments take environmental, health and safety issues into consideration during registration processes. MBTOC does not take these matters into consideration for that reason. MBTOC does not consider an alternative to be available unless it is registered for use in that region and for that circumstance. Environmental, health and safety issues with the alternatives are responsible for many of the regulatory barriers to the adoption of alternatives. Currently, a US court challenge about the safety of fluoride residues arising from the use of SF has the potential to result in greater controls being placed on SF use in flour milling in the US.

MBTOC has not evaluated the global warming effects of the use of alternatives for flour milling. However, MB has been reported to have a GWP of 5 (100 yr), (25) and SF has 100-yr GWP of 278-47 (29). It should also be noted that considerably more SF is used in a mill fumigation than is needed for MB in the same mill (1, 5,). Heat treatments would also have an as-yet-unmeasured and potentially high environmental impact.

Since all pest control measures have environmental impacts, it will be sensible to work to achieve the best pest control possible in exchange for the environmental cost.

10.7 Adoption of Alternatives

In 2003 and 2004 when Parties began to submit critical use nominations, MBTOC received CUNs for flour milling from: Belgium, Canada, France, Germany, Greece, Ireland, United Kingdom and United States. The European Commission reported to MBTOC that MB had been used in mills in 17 of the EC-27 countries at some time in past years. Now, however, all EU mills are using alternatives to MB and are not using MB. Mills in the EU are using a wide range of alternatives, in combination with IPM (16).

Each of the three Parties with flour milling CUNs has decreased MB use. The graphs and tables below show the CUNs for flour milling for Canada, Israel and the United States. It is important to note that the amount of MB actually used for flour milling in the US could be different from the CUE amounts because the sector has had access to MB stocks available for purchase.

There are several reasons for decreased MB flour milling use in Canada, Israel and the US since 2003 when the CUN process started. First, mills took several steps to reduce the frequency of fumigation. They began by adopting or improving IPM systems and improving mill sanitation to reduce pest presence. A need to decrease flour dust presence in mills for health and safety reasons also drove the use of improved IPM. Reductions in frequency of fumigation could account for 30 – 50% of the decrease in MB use. In some cases the adoption of MBTOC's standard dosage rate

for MB for structures also resulted in a decrease in MB use. As fumigators began new training programs for sulfuryl fluoride they realised that additional sealing and other structural improvements would also reduce MB use, a move which was also driven by increasing costs of MB. In recent years many flour millers, perhaps as many as half, have tested one or more alternative treatments, and many flour mills have adopted alternatives, at least for some of the fumigations needed for the mill (2, 11, 14, 24, 30, 31, 41). In this sector, a trial of an alternative can replace a methyl bromide fumigation. Finally, there were some early adopters of alternatives, especially heat treatment and some mills are now not treated with MB.

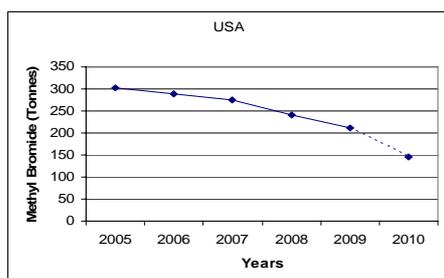
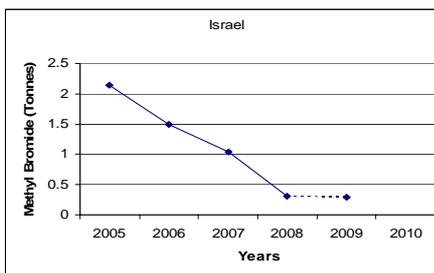
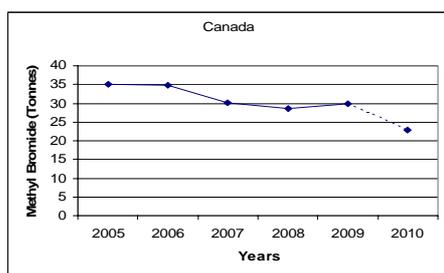
Elsewhere in the TEAP Spring report, MBTOC has published its interim recommendations for the 2008 round of critical use nominations, including those for flour milling. As these are interim recommendations, Parties may request changes and provide information to support changes in these recommendations.

Currently, mills in Canada seem to be conducting an average of 1-2 fumigations per year with MB (the CUN was unclear and MBTOC has requested further information). MBTOC has commented that no more than one annual fumigation with MB, (and hopefully fewer) can be likely be justified at this time. MBTOC believes that Canadian environmental conditions would result in less pest pressure in Canadian mills (compared mills in hotter more humid regions).

Israel is only using MB for spot treatments in a few of its mills. The other mills use spot phosphine or spot heat. Spot heat equipment has recently been imported to Israel and successfully tested. Israeli fumigators have developed techniques to kill pests which try to escape the treatment. More heat equipment is on order for import and MBTOC has made an interim recommendation that Israel should finish its MB use in this sector by 2010.

In the US, mills average 2.5 fumigations per year. MBTOC has made an interim recommendation that the 58% of mills which do not have bakery mixes should be able to transition to no more than (and hopefully fewer than) 2 MB fumigations per year by 2010.

CUN MB in flour milling in Canada, Israel and the United States – Dotted line indicates MBTOC interim recommendation for 2008 round



Flour Milling CUE and CUN MB Amounts Canada, Israel and US

	2005	2006	2007	2008	2009	2010
Canada	35	34.774	30.167	28.65	29.913	22.878 ¹
Israel	2.14	1.49	1.04	0.312	0.3 ²	
USA	302.704	289.39	274.65	240.765	212.352	144.789 ³

1. This is the CUN for Canada mills for 2010. MBTOC has been unable to assess this nomination pending the receipt of further information.
2. This is the CUN for Israel mills for 2009. MBTOC has recommended this amount as a final transition to alternatives.
3. This is the amount recommended for US flour milling for 2010. The US nominated 163.790 tonnes for flour mills for 2010

Notes:

The Canadian CUN for 2005 was for 47.2 but it included both mills and pasta. It seems the flour mill amount was probably around 35 tonnes in 2005.

The US flour milling amounts for 2005 and 2006 were estimated from CUNs that included other food processing structures. In later years, US submitted disaggregated CUNs that indicated separate amounts for flour mills.

10.8 Reference List and Summaries of References Used

Copies of cited references are available from: Meg Seki, UNEP Senior Scientific Affairs Officer (meg.seki@unep.org)

1. Adam. B. 2008. Cost comparison of methyl bromide and ProFume for fumigating a food processing facility. A report to National Pest Management Association and Dow AgroSciences. Economic Consulting LLC.

This economic analysis covers both food processing and cocoa bean SF economics. The summary here only includes the food processing issues. Specifically, the author examined fumigation costs for a food processing facility of size 1 Million ft³. The analytical approach used by the authors provides cost estimates for typical firms under alternative scenarios and not firm-specific scenarios. The author only examined the use of Fumiguide 'high dose' recommendations, since the fumigators interviewed said the 'low dose' would allow for egg survival and would result in dissatisfied customers. All fumigations were assumed to be 24 hours (plus set up and aeration times). Data for this study was gathered from interviews with six fumigation companies having experience with both SF and MB, from fumigant distributors, from Dow AgroSciences and from literature reviews. Most likely price of SF was US\$0.50 less than price of MB but SF use rate was 2.5lb/K ft³ and the MB use rate was 1.5 lb/K ft³. Adams reported the cost of MB was US\$7.00/lb and the cost of SF was US\$5.00 – 7.00/lb. An analysis of chemical costs relative to insect species

and temperature showed that SF costs more than MB for all species. Equipment costs assumed the fumigator conducted 50 fumigations per year and equipment costs for SF were lower. Labour costs for SF were also lower mainly because of faster aeration time. The author presented tables which showed the impact on total fumigation costs when use rate and fumigant costs varied. Numerous cost scenarios resulted, but if we assume that a use rate of SF of 2.5 lb/1000 ft³ is technically comparable to MB at 1.5 lb/1000 ft³, then an SF fumigation of a 1 Million CuFt food processing facility costs 12, 29 or 45% more depending if the cost of SF is US\$5, \$6 or \$7 per lb respectively.

2. Bair, J. 2008. North American Millers Association. Email to Michelle Marcotte concerning the number of flour mills in the United States.

Bair reports that the number of flour mills in the US is slightly fewer than 200, spread across 38 states.

3. Bair J. 2008. North American Millers Association. Email to Michelle Marcotte. March 12.

Provided clarification that obtaining data on SF use in mills was difficult because the mill reports belong to the fumigators. Also clarified that mill companies not belonging to NAMA may use SF more frequently because they can not have CUE MB. Also outlined a label problem that SF users are trying to understand and gain clarification from EPA and Dow. The problem concerns the use of the words 'incidental' and 'impractical' on the label. This is not only an EPA problem but also a problem of enforcement which is done by the State Departments.

4. Bair J. 2008. North American Millers Association. Notes of conversation with Michelle Marcotte. March 12

Conversation was held to clarify label and other problems with use of SF by millers and US stored product industry. Marcotte took notes. Bair outlined three problems. First is that the label includes the use of SF on raw grain, although that use is unlikely because there are other cheaper, easier methods to disinfest raw grain (phosphine, aeration etc). However as a result, the raw grain potential use contributed to the EPA risk assessment and the whole fluorine residue issue for which there is a lawsuit pending. This lawsuit is a great concern. Second is that the label (see Dow SF label page 10) lists foods which may be fumigated and says that if a food is not listed it may not be fumigated (standard pesticide regulatory language). However the label also later says allows 'incidental' fumigation of unlisted foods if removing them would be 'impractical'. The problem is understanding 'incidental' and 'impractical'. Pet Food Industry received a letter from EPA clarifying that incidental should be defined as 'negligible amounts of commodity due to their presence in a different targeted use site' (see letter from Hazen of EPA to Payne of Pet Food Institute). This problem impacts millers whose flour goes into bakery mixes since they have other kinds of foods on their premises (dried eggs, shortening etc). These foods are allowed to be fumigated with MB but not SF. Dow disagrees with the Pet Food – EPA letter and says the millers could allow the fumigation of those unlisted foods as long as those foods are not the actual target of fumigation. Millers are concerned about that interpretation because EPA, or the State Dept., which does the enforcement, may decide the use was illegal (after it was used or food distributed). There are very large legal and market repercussions arising from the illegal use of pesticides on foods (US mill sector can point to some actual examples with resulting very large costs and jail time for person held responsible). The third problem worrying the millers is that many mill companies, or their parent corporations, have made commitments to reduce their carbon footprint to reduce global warming. SF has been found to have a relatively high GWP compared to CO₂ (see Canadian Pest Management Regulatory Assessment section 5.2). Bair then

described the increase in SF required to be used at various fumigation temperatures, but to provide more detail, later sent an SF Fumiguide printout to illustrate.

5. Bair J. 2008. North American Millers Association. Email to Michelle Marcotte and attached sample SF Fumiguide printout showing dosages at various temperatures. March 12.

NAMA submitted four more documents for this study (all of which were reviewed, summarized and included as references): EPA letter from Hazen to Payne, Dow AgroSciences SF label, Canadian Pest Management Regulatory Agency SF assessment (specifically responding to GWP of SF), and, a ProFume Fumiguide printout showing the need to use considerably more SF than is required for MB. As noted by other papers reviewed here, MB dosage is usually 1 – 2 lbs/1000 cu ft, or 1000 – 2000 lbs per facility of 1 M cu ft. In the SF scenarios presented, with a 12 hr half loss time, and 24 hr exposure, SF requirements ranged from 6648 lbs at 70°C to 2701 lbs at 90°C. At 80°F, the temperature that seems necessary for pest control efficacy, 4564 lbs of SF would be required.

6. Bartlett, D., Conyers, S.T., Bell, C.H. and Watson, C.R. (2005). Further development of heat-based methods for disinfesting flour mills.

HGCA Project Report No. 378, Home-Grown Cereals Authority, London, 62pp.

This report summarizes a year-long project in heat treatment in UK mills. It provides details of studies at two mills, one 3078m³ and one 6600m³ and discussed heat treatment methods. The report recommends that a temperature of 50°C be achieved and that the total heating period be 50 hours; about half that time will be required for the facility to reach the target temperature. Heating larger mills will take longer and the scaling up of heat requirements may introduce other problems making heat treatment impractical. It was difficult to achieve adequate temperatures in floor-wall joints, outside walls and windowsills indicating that additional methods such as insecticidal spraying and the use of diatomaceous earth would be required as an adjunct to the heat treatment. Mills with roller mills situated on basement floors will experience difficulty in achieving a kill temperature within and beneath the machines. The cost of treatment is likely to exceed those currently incurred with MB fumigation. For example, heat treatment in one mill cost twice that for a MB treatment at the same mill the previous year. The report concluded that the use of DE is recommended for ground floors and wall joints. The report also concluded that it will never be practical or economic to heat concrete ground floors to a level that will ensure 100% kill (which resulted in the recommendation to use DE when heat treating floors).

7. Beckett, S.J., Fields, P.G. and Bh. Subramanyam. 2007. Disinfestation of stored products and associated structures by heat. In: Heat treatments for postharvest pest control: Theory and Practice. Eds: Tang, J., Mitcham, E., Wang S., and S. Lurie. Pp 182-237. CAB International. UK.

This paper reviews the need for, and history of, pest control for stored products and the facilities that store and/or process the commodities. Further it reviews pest control methods but places more extensive emphasis on heat treatment. Most Western countries have zero tolerance for insects in finished food products such as flours or baked goods, and that insect parts in processed foods are also restricted. For example, in the USA, wheat flour with 75 insect fragments/ 50 g of flour can not be sold. Additionally, buyers of grain and processed food have the right to reject entire shipments based on the presence of insects or insect fragments. Further, buyers may also impose major penalties for insect infestation. Structural heat treatment involves raising the building temperature to 50-60°C at a rate of 5°C per hour (and cooling at a rate of 5-10°C).

Sufficient heaters to ensure that 50°C is reached within 6-8 hours are required. (MBTOC bases its heat treatment recommendation on this research paper.) Use of air movers or fans is essential to ensure uniform heating (a cost factor) Although stored products pests die in <1 hr at these temperatures, structural heat treatment requires that these temperatures be maintained for 24-36 hours to ensure uniform heat distribution in all portions of the building. Different portions of or equipment in the building will heat at different rates. In portions of the building where the temperature is <50°C, insect survival can be expected. The paper provides extensive heat tolerance data for numerous stored product pests and life stages. The authors note that better targeted treatments and predictive models may result in new treatment practices in the future. Thorough cleaning of the facility and equipment is needed prior to a heat treatment, because insects will find cooler refuge in even small amounts of flour or debris. (Cleaning is also necessary prior to any fumigation so this is not an additional cost factor for heat.) Heat susceptible materials and packaging materials have to be removed from the facility. If food products in the facility are infested, they have to be removed and treated with phosphine or another fumigant. (In these ways, heat or SF treatments differ from MB treatment which results in additional labour costs.) Spot heat treatments versus full site treatments were compared; in flour mills for example, spot heat treatment could be considered if roll stands were infested. However, the open floor plans and multi-story design of North American flour mills would favour insect escape from spot heat treatments and therefore full site treatment is favoured. (MBTOC notes that additional pest barrier methods would assist to resolve this problem.) This report identifies potential problems such as difficulties in calculating the amount of heat (and heating equipment) required for a treatment, unknown effects on mill equipment and structures, and notes some preparatory requirements such as ensuring sprinklers and mill equipment is rated to withstand 95°C. (MBTOC notes that this setting may cause concern to fire prevention officials since the usual sprinkler setting is 165°F or 76°C.) Nevertheless the authors expect greater use of heat treatment as pressure to eliminate chemical fumigations increases.

8. Bell, C. 2008. *Stored Product Consultant. Problems with alternatives to MB. Email to Marcotte April 4.*

The author cautions that costs of alternatives may be underestimated. Current introductory pricing of SF may be giving a false impression of its costs and heat treatments if done ineffectively (but inexpensively), may result in the need for multiple heat treatments in a year, which increases costs annually. Author reiterates concerns about deliberately aiming an SF treatment to a dosage rate that is not likely to kill all eggs present. (Note: Author Bell is a MBTOC member.)

9. Bell, C. H., Bartlett, D., Conyers, S. T., Cook, D. A., Savvidou, N. and Wontner-Smith, T. J. (2004) *Alternatives to methyl bromide for pest control in flour mills. HGCA Project Report No. 329, Home-Grown Cereals Authority, London, 113pp.*

This report covers 39 months of work in UK flour mills, largely to investigate methods to achieve effective heat treatments, sometimes in combination with diatomaceous earth (DE) and controlled atmospheres. Numerous common stored product pests were included in the studies. Heat plus DE very much improved treatment efficacy. (Earlier MBTOC Assessment reports also showed considerable benefit from using DE in heat treatments, and particularly for crack and crevice treatments in heat treatments and as a residual between treatments.) Heat treatment parameters included: limited air delivery of heaters to 65-70°C to avoid activating sprinklers and limit thermal expansion and cracking; and maximum air speeds of 5m/s to avoid dust explosions and avoid blowing away applied DE. Many practical arrangements for heater and heated floor mats were discussed. Considerable attention was paid to the problem of achieving adequate temperature on cement floors, floor-wall joints and other difficult to heat surfaces. The use of

heaters, fans and heated floor mats were all observed and measured for efficacy. Several mill heat treatments were observed in the UK and Germany, but some had inadequate heat sources. The authors concluded that: shaped heating mats should be used on basement floors and wall joints, especially in the corners to avoid offering a cool area for pest to escape to; use enough heaters to raise the temperature to 65°C within 6-8 hours; an 18 kW heater for every 300 – 700m³ of space depending on mill size and temperature will be needed. On upper floors, perforated polyethylene ducts can be used to target hot air on floor-wall joints; begin doing so when air temperatures reach 50°C. Effective cleaning and spraying of ground floors will minimize survival. Keep the building closed to prevent exchange of outside air. Use infra-red hand held thermometers to check on heat distribution. (MBTOC based some of its recommendation on heat treatment techniques on this research paper.) (Note: Author Bell is a MBTOC member.)

10. Bradley, R. 2006. *Quality Assurance Manager, Brighton Mills. Letter to Dow AgroSciences.*

This company expressed their satisfaction with the level of stored product pest control resulting from two years experience with ProFume fumigations of their mill. They noted that the first fumigation did not give the results they wanted, but they believed this could have been because of other variables. They reported working with their fumigator to improve conditions in the mill to make further fumigations more successful, and since then they have been pleased with the results. They formerly measured the success of methyl bromide fumigations when there were at least 90 days between fumigation and insect infestation. With ProFume they report no insect emergence until four months after fumigation. As a result, the company has switched to using ProFume instead of methyl bromide.

11. Canadian National Millers Association. 2007. *Comparative evaluation of integrated pest management, heat treatments and fumigations as alternatives to methyl bromide for control of stored product pests in Canadian flour mills. pp 48. March. (Also submitted in French with the title: Évaluation comparative de la gestion intensive des parasites, des traitements thermiques et des fumigants comme solutions de rechange au bromure de méthyl pour le contrôle antiparasitaire des produits en réserve dans les minoteries canadiennes. Association canadienne des minoteries de farine de ble.) Ottawa Canada.*

This report summarizes a joint project of the Canadian National Millers Association, Agriculture and Agri-Food Canada (AAFC), and fumigation companies who conducted tests at several mill facilities in Canada. Science aspects were managed by Paul Fields, AAFC Cereal Research Centre scientist located in Winnipeg Manitoba; his reports are appended to the CNMA report. This report also includes an update of CNMA's 2004 report comparing heat treatment to MB. The report details extensive practical learnings and technical efficacy data resulting from: five heat trials (in three mills); four SF trials (four mills); one benchmark MB trial; and one phosphine, CO₂ and heat combination trial (one mill). Some of the trials were conducted prior to pesticide registration under agreement of the Pest Management Regulatory Agency (to generate needed efficacy data). The report's detailed investigation of pest management and IPM in Canadian mills is not summarized here. This summary focuses on adoption, technical efficacy and economic issues. Millers require alternatives for all mill sizes and configurations, that effectively reach and kill all pest life stages, with treatments that can be completed in 72 hours, do not require the removal of unmilled and milled grain, with either no pesticide residues or pesticide residues established in MRLs that can be met in the commercial context, and affordable as measured within Canada's traditional cost structure and in comparison with US costs (since Canadian and US mills compete within the North American free trade environment). Millers and fumigators have trialled phosphine (combination method), sulfuryl fluoride and heat. The low dose of

phosphine needed to avoid equipment damage requires that the temperature be raised in the mill; this combination treatment requires regulatory approval that has not yet been received. Sulfuryl fluoride approval does not allow contact with any milled or unmilled grain, flour enrichments or additives; request to approve still pending. A mill has to be completely emptied of all grain and finished product, or with bins sealed off. The lack of MRLs for fluoride residues has made adoption of this alternative difficult. Three suppliers of heat equipment are present in Canada and trials have been conducted on all equipment types (as reported in the 2004 report). The main difficulties in using heat include lack of boiler capacity (resulting in the need for either purchased or rented heaters), inadequate electrical capacity for the heat equipment, and fire protection systems that are incompatible with the heat treatments. All treatments tested killed Red Flour beetle adults. In one heat method (propane heaters) egg mortality was 94%. With SF, egg mortality varied between 35-99.6%. Pest rebound, while significantly influenced by factors other than fumigation efficacy, is nevertheless an important factor for millers judging the efficacy of fumigation. In these trials, phosphine and SF showed a similar range of delay of pests to that of MB, but heat treatment gave the best delay of pest rebound. With the exception of costs for some of the heat treatment factors, treatment costs were not reported for these trials. In any case, given the wide variety of mills, sizes, structures etc, knowing the treatment costs might not be too helpful. The costs of heat equipment rental, propane or natural gas input costs ranged from CDN\$400 – \$6,600. Fields, summarizing the research determined that SF, heat, phosphine (combination treatment), can control insect populations in flour mills for over 18 weeks. He also noted some factors that contributed to difficulty in achieving good fumigation results in Canadian mills. Mill sealing, a very significant factor in fumigation efficacy needs to be improved; US mills have half loss times that are double those seen in the Canadian mills in this study. Higher temperatures could be utilized to improve fumigant pest kill efficacy. The increase in temperature could be achieved by utilizing the comfort heat furnaces for summer fumigations and/or by using additional heaters during fall fumigations.

12. Coleman, J. 2005. Research Fumigation Company LLC. Letter.

This fumigation company reported having conducted many successful fumigations with SF, in terms of pest control efficacy and because the fumigation management software assists the fumigator to improve fumigation management and use less fumigant. This company has managed to maintain the same fumigation costs to the customer by reducing unnecessary fumigations, improving facilities (often needed to improve SF fumigation efficacy), and offering comprehensive pest management plans.

13. Cryer, S. 2007. Predicted gas loss of sulfuryl fluoride and methyl bromide during structural fumigations. Journal of Stored Product Research. 44 (1-10).

Gas loss from a mill during fumigation affects both fumigant efficacy in killing pests and the economic efficacy because excessive gas loss increases fumigation costs. Gas loss results from leaks through cracks, crevices and other building structural factors and the loss can be compounded by environmental facts such as wind. Computational analysis based on two commercial grain mills was used to predict gas loss under various wind scenarios and as a function of building structure in conditions of calm wind. In conditions of calm wind, sulfuryl fluoride was found to have increased leakage rate (~5.4%0.). In wind conditions, leakage rates for sulfuryl fluoride and methyl bromide were statistically indistinguishable. Wind conditions in California and Texas, the location of the commercial grain mills were found to be rarely calm, but wind conditions vary regionally making knowledge of local wind conditions an important factor in planning gas loss prevention.

14. Dow AgroSciences. 2006. Comments of Dow AgroSciences LLC on protection of stratospheric ozone” The 2008 critical use exemption from the phase out of methyl bromide. (RIN 2060 – A030: Docket No.: OAR-2006-1016). Excerpt submitted to MBTOC by Prabhakaran, Dow AgroSciences.

This letter explains the position of this supplier of sulfuryl fluoride (trade name ProFume) vis a vis the US government position on domestic allocation of methyl bromide. It makes several interesting points. In 2006, Dow says that 60% of the grain milling market had demonstrated success using ProFume (page 5). Of the 140 locations fumigated with ProFume, 90 have been fumigated multiple times (up to 7 consecutive ProFume fumigations) (page 5). Dow notes that typical commercial use rate for MB is 1.5 lbs/1000 f³, whereas the commercial use rate for SF is 2 lbs/1000 ft³. Since gas fumigant contributes only 30% to total fumigation costs, the use of SF should contribute a <10% increase in fumigation cost. Over 100 wheat mills and warehouses in 52 locations have been successfully fumigated with ProFume since registration (page 17). On the question of increased temperature required for increased efficacy, Dow points out that increased temperature increases the efficacy of all fumigants and that SF fumigations have been conducted all year round in various US regions. They indicate that milling equipment operation results in increased temperatures in the equipment and in the mill. Dow does not agree with statements that a 5-yr transition to alternatives is required for this sector because the same fumigation companies who have been conducting SF fumigations for other flour milling companies are available to assist the not-adopting companies (pages 7-8).

15. Dow AgroSciences. Undated (likely 2004). Optimizing Operations: Six year study at rice facility demonstrates value of precision fumigation practices. Dow AgroSciences brochure.

This paper discusses the knowledge gained from six years of fumigation experience at one rice mill and the experience of conducting a fumigation during a severe storm with high winds. Since high winds are a key factor in fumigation failure, this paper provides an unusual observation point. The rice mill was formerly fumigated with methyl bromide twice a year. Beginning in 1998, and for six years, this mill has only fumigated once a year with ProFume, assisted by improved pest control practices. The paper reviewed the improvements made to sealing and to reduce fumigant concentration variability throughout the facility. Since sulfuryl fluoride aerates faster than methyl bromide did, fumigation downtime has been reduced from a minimum of 36 hours with methyl bromide to 28 hours with ProFume. Millers consider production downtime to be the most important cost factor in a fumigation. During one fumigation, a severe storm set in with 50 mph winds for several hours and the loss of electrical power. This event could have resulted in the failure of the fumigation with the associated costs. However, Dow reported that the sealing methods previously tested, the ability of their fumigant management software to identify areas of low concentration and calculate needed gas additions, plus some quick moves from the fumigation company to keep the monitoring lines running in a power outage, were able to ensure a successful fumigation under adverse circumstances.

16. European Commission. 2008. Information on the use of methyl bromide and alternatives in mills in the EC. Information provided by the EC to MBTOC-QSC. April. 26pp.

In response to the request for information from MBTOC, the EC surveyed countries on methyl bromide and alternative use in flour mills, providing a very extensive report. The report covers responses from 12 countries and more than 137 flour mills. The report includes information on: pests; mill size; mill regions; current and past MB use by country and mill; alternative use by country; current pest control practices; industry standards and guidelines; regulatory requirements; and data sources. In addition, an annex to this report includes the actual survey

responses, which will be attached to this reference for requestors. Of the 137 mills, only about 3 never used MB. But, none use MB now, following withdrawal of MB licenses for mills in the EC. Pest control techniques include: IPM; HACCP; sulfuryl fluoride (sometimes with supplemental heat); phosphine (sometimes with supplemental heat); phosphine heat and CO₂ (in combination); hydrogen cyanide; insecticides; heat; cold (in form of dry ice); and mechanical treatment of finished products. Mills were asked to report their pest control treatment results and if they received consumer complaints. Although many mills did not report their treatment results or consumer complaints, almost the same number of mills noted that pest control was the same or nearly the same now that MB is not used. Several reported that pest control was better now. For the most part, consumer complaints had not increased. MBTOC notes that some of the alternatives registered for use in the EC are not registered for use in the countries for which CUNs have been requested.

17. Falvey, G. 2008. Senior Milling Executive Bread Bakeries Division, Premier Foods. Letter to Banks and Marcotte.

Rank Hovis is the flour milling business of Premier Foods and the largest milling company in the United Kingdom. They have been using sulfuryl fluoride (ProFume supplied by Dow AgroSciences), for several years. As a result of early research conducted with Igrox (a UK based fumigation company), and Central Science Laboratory (a UK government stored products research laboratory); they determined that the efficacy of the fumigant could be improved by heating to 30°C for the duration of the treatment. They now use ProFume on a regular annual basis at 4 of their largest flour mills. As a result of this experience, they noted increasing efficacy can be attributed to: greater experience in using the fumigant, improved preparation for fumigation including greater attention to sealing and building improvements to prevent leaks, scheduling the treatment in the summer months to improve chances of more benign climate conditions, and acknowledging that fumigation is part of an overall pest management plan. ProFume does cost more than methyl bromide, at 300% the cost of MB.

18. Fields P.G. 2006. Alternatives to chemical control of stored-product insects in temperate regions. In: Proceedings of the Ninth International Working Conference on Stored Product Protection. Campinas Brazil. Pp 653-662. pfields@agr.gc.ca

Reviews and describes effectiveness of cold, heat, low moisture, inert dusts, hermetic storage, impact and varietal resistance as methods to control or kill insects in grains and other stored products. Time-temperature death curves are described by species. Describing heat treatment of structures as requiring 50°C for 24-36 hours with a rate of heating or cooling of not more than 5°C per hour (to prevent structural damage). Although insects die in a few minutes at 50°C, at least 24 hours is needed to insure all locations in the facility receive adequate heat. Sprinkler heads should be rated for at least 85°C. Some electronic equipment may have to be removed or enclosed with cool air. Some plastics may warp with the heat. Fire extinguishers should be removed before the heat treatment. As with fumigation, the structure and equipment should be cleaned of food residues to allow good penetration of the heat.

19. Fields, P. 2008. Scientist, Agriculture and Agri-Food Canada. Temperature conditions for heat treatments. Email to Marcotte April 4.

The author was asked by MBTOC to further the understanding of the parameters of a heat treatment, specifically, could heat treatments be conducted if the mill temp was <10°C and how to conduct heat treatments is cold weather conditions. The author responded that even in Central Ontario in November with outside temperatures as low as 0°C, temperatures in an operating mill

are still above 20°C. In cold conditions the difficulties with a heat treatment include extra time and extra costs to reach sufficient temps, especially on outside walls. One solution is to preheat the facility to 25°C, while the facility is operating and then close the facility for the normal time for the heat treatment. One problem with reports of lack of efficacy for heat treatments is that there was insufficient heat capacity, so the treatment took too long and was stopped early because the facility needed to resume operations. To learn how to do a heat treatment, start small, have adequate heater and fan capacity, to allow time for correct temperature to be reached with adequate cool down time. Learn from experienced people.

20. Garrett, J. 2005. Fume Tech Inc. Letter to Marta Montoro, USEPA E-Docket No. OAR 2005-0122.

This company conducts fumigations of structures and commodities and this letter reports experience with adoption of sulfuryl fluoride in rice mills, commodities and warehouses between 2003 and November 2005. The author reported that his customers have switched from methyl bromide to sulfuryl fluoride and customers are satisfied with the efficacy. Costs to the customers of sulfuryl fluoride were similar; six commercial fumigation bid sheets submitted show decreased costs for sulfuryl fluoride. Fumigation down time (the biggest cost concern to mill operators) is the same with SF as with MB. Furthermore, SF fumigations can be manipulated to meet the requirements of the mill operator (in other words a faster fumigation can be achieved, if needed, by using more gas). From the viewpoint of the fumigation company, costs to seal the mill are higher, but this company maintains these higher costs are offset by the decreased time required for achieve gas equilibrium and aerate the mill after fumigation. This fumigator also notes the fumigation management program required by the SF supplier results in more precise fumigation, which maximises fumigation efficacy while minimising the amount of pesticide used.

21. Harrison, G. 2008. President Canadian National Millers Association. Costs of Alternatives. Email to Marcotte, March 19.

The author provided further information on costs of alternatives in Canadian milling, while explaining that it is illegal for a Canadian industry association to gather information on costs of goods and services. As part of research studies companies were required to submit invoices and so some costs are known and these were reported in the Canadian National Millers Association reports summarized above. Costs remain a consideration. It can take significantly greater volume of SF to achieve 100% or virtually 100% kill of all life stages including eggs. If heating is required to improve efficacy that introduces an additional cost factor, especially in October-November fumigations done in those mills that traditionally conduct two fumigations per year. The author says an SF fumigation requires a higher volume of gas required, at a higher price plus the added cost of adding supplemental heat to the structure. The author says that it is decidedly more expensive to pursue a satisfactory level of stored product pest control in Canadian flour mills using any heat treatment (portable external propane or gas), SF or intensive IPM alone or in combination with others. Additionally, at a later date, costs will also be reported resulting from studies currently being conducted in Canadian pasta facilities.

22. Hazen, S.B. 2006. Principal Deputy Assistant Administrator, USEPA, Office of Prevention, Pesticides and Toxic Substances. Letter to Stephen Payne, Vice President Pet Food Institute. November 8.

Clarifies that pet foods are not listed among the foods that can be treated with SF, however pet foods sites can be fumigated. Also says that, "For the purposes of the ProFume label, EAP uses the phrase 'incidental fumigation' to mean the fumigation of negligible amounts of a commodity

11.3.7 Evaluations of CUNs – 2008 round for 2009 and 2010 exemptions

MBTOC S and MBTOC QSC subcommittees met concurrently April 14-18, 2008 in Tel Aviv, Israel. This meeting was held as required by the time schedule for considerations of CUNs given in Annex I referred to in Decision XVI/4. If required, further meetings to consider further input from nominating Parties on their various CUNs will be held prior to publication of a final report in October 2008. Consensus decisions were made in subcommittees. Outcomes from deliberations by the two MBTOC subcommittees were discussed and vetted in plenary.

CUNs in this report relate to CUEs sought for 2009 and 2010. No nominations in this particular round were submitted for longer periods.

Five Parties (Australia, Canada, Israel, Japan, USA) submitted nominations for either 2009 or 2010. These Parties have submitted nominations in previous CUN rounds. Israel submitted a nomination for seed production, which had not been applied for in the 2006 and 2007, but was in 2003 and 2004. The total number of nominations has been reduced from about 58 nominations submitted by seven countries in the last round. The EC has submitted no nominations in this round for 2009. Japan indicated in correspondence that it plans to phase out all soils uses by 2013. Some CUNs were for increased acreages of crop, new areas or increased harvested commodity under methyl bromide treatment.

MBTOC Soils assessed 31 nominations, which included 12 nominations for 2009 and 19 nominations for 2010. These totalled 697.084 and 4042.582 metric tonnes respectively. In its interim assessment, MBTOC has been able to recommend a total of 608.454 for 2009 and 3167.335 tonnes for 2010.

MBTOC QSC assessed two new or additional critical use nominations for 2009 and seven nominations for 2010, totalling 7.719 and 313.341 metric tonnes respectively. At this time for these nominations, MBTOC has been able to recommend 4.4 tonnes for 2009 and 235.177 tonnes for 2010.

Two Parties met with MBTOC during the Tel Aviv meeting for discussions with regard to their CUNs, in accordance with paragraph 8 of Annex 1 referred to in Decision XVI/4.

MBTOC has sometimes recommended quantities of MB for 2009 or 2010, which are different from those nominated. Grounds used for these recommendations are given in detail after the relevant CUNs in Table 11-6. The adjustments follow the presumptions given in Table 11-5.

Two nominations assessed by MBTOC-QSC were placed in the 'unable to assess' category because information was insufficient to make an evaluation, as required under paragraph 10 of Annex 1 of the final report of 16 MOP.

In paragraph 20 of Annex 1 referred to in Decision XVI/4, Parties, among other things, specifically requested that MBTOC explicitly state the specific basis for the Party's economic statement relating to CUNs. Table 2 provides this information for each CUN. This information was prepared by MBTOC economists.

In general, CUNs resulted mainly from the following issues: regulatory restrictions on alternatives, scale-up of alternatives, economic issues and, to a much smaller degree, the technical unavailability of alternatives. This was as in the previous two years of CUNs. For the most part, technical alternatives exist. Additionally, MBTOC notes that some Parties continue to struggle with the

ability to adapt previously identified alternatives to their circumstances, within their definition of economic feasibility.

11.3.8 Critical Use Nominations Review

In considering the CUNs submitted in 2008, as previously, both MBTOC subcommittees applied the standards contained in Annex I of the final report of 16MOP, and, where relevant, the standard presumptions given below (Table 11-5). In particular MBTOC sought to provide consistent treatment of CUNs within and between Parties while at the same time taking local circumstances into consideration, and also to provide transparency in its processes and conclusions.

In evaluating the CUNs for soil treatments, MBTOC assumed that a technically feasible alternative to MB would need to provide sufficient pest and/or weed control for continued production of that crop to existing market standards.

MBTOC evaluation of CUNs relating to production of strawberries, tomatoes and some other crops was assisted by information provided by a large number of published studies on MB alternatives and by a meta-analysis (Porter *et al.*, 2006). The published studies assisted in providing additional transparency to MBTOC evaluations, as requested by the Parties in Decision XV/4.

For commodity and structural applications, it was assumed that technically and economically feasible alternatives 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, while ensuring the costs were economically feasible in the context of that nomination, to the extent that could be determined.

Technically feasible alternatives do not necessarily provide superior pest control results than are achieved in practice by MB; economically feasible alternatives do not necessarily cost the same as MB.

Unless otherwise indicated, the most recent CUE approved by the Parties for a particular CUN was used as baseline for consideration of continuing nominations. In some instances, this quantity differed from that used as a baseline by the nominating Party. Assessments were independent of the size of the nominated quantity. Specific circumstances of each nomination were taken into account.

The standard presumptions, used by MBTOC to assess nominations, are given in the sections below.

11.3.9 Disclosure of Interest

All MBTOC members have prepared disclosure of interest forms relating specifically to their level of national, regional or enterprise involvement for the 2008 CUN process, according to a standardised format developed by TEAP. The Disclosure of Interest declarations are found in Annex V. As in previous rounds, some members withdrew from a particular CUN assessment or only provided technical advice on request for those nominations, where a potential conflict of interest was declared.

11.3.10 Consideration of alternatives

As in previous years, MBTOC used the guidance given in the Annex I referred to in Decision XVI/4 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; and ‘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 nominated 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 similar region. For example for preplant soil uses of MB, 1,3-dichloropropene/chloropicrin (1,3-D/Pic), metham sodium alone or in combination with Pic, dazomet, substrates and the use of resistant varieties and grafted plants (for solanaceous crops, melons and other cucurbits) have been adopted to replace MB for a range of crops in industries applying for CUNs and in many regions where MB was once used.

MBTOC evaluation of CUNs relating to production of strawberries, tomatoes and some other crops was assisted by information provided by a large number of published studies on MB alternatives and by a meta-analysis (Porter *et al.*, 2006). The published studies provided additional transparency to MBTOC evaluations, as requested by the Parties in Decision XV/4.

Rate of change in commercial adoption, partly as a result of rapidly changing regulation, challenges MBTOC’s ability to make diligent recommendations in the use of alternatives for post-harvest applications, especially when recommendations are considered for one or two years in the future. In post-harvest applications, where research is minimal, but commercial adoption trials are more common, MBTOC needs Parties and the affected industries to release the results of commercial trials, using group reporting methods when data is judged to be proprietary.

For commodity and structural applications, it was assumed that technically and economically feasible alternatives 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, while ensuring the costs were economically feasible in the context of that nomination, to the extent that could be determined.

Technically feasible alternatives do not necessarily provide superior pest control results than are achieved in practice by MB; economically feasible alternatives do not necessarily cost the same as MB.

MBTOC has to be knowledgeable about regulatory advances, but in post-harvest applications domestic, import and export regulations all play a role that complicates adoption of alternatives. Several post-harvest CUNs indicate that if importing Parties were to set maximum residue levels for fluoride in foods, then the use of alternatives, for both food and structural applications by exporting countries, would improve. This year, as MBTOC was making its final recommendations, some Parties published maximum residue levels for fluoride in several foods, or only in imported foods as in the case of Canada. Given the newness of these announcements, the impact of these publications on actual MB use for 2007 and 2008 was difficult to predict.

11.3.11 Sustainable Alternatives

In a large proportion of CUNs, the most currently appropriate alternatives are chemical fumigant alternatives, which themselves, like MB, have issues related to their long term suitability for use. In both the EC and US, MB and most other fumigants are involved in rigorous reviews that could affect future regulations over their use for preplant soil fumigation. MBTOC has been informed that the US government has received a petition to stay (i.e. remove regulatory approval) the pesticide tolerances for SF. Sulfuryl fluoride is a recently approved, important, methyl bromide alternative for several post-harvest applications. A stay or other action that removes the pesticide tolerance for SF would increase significantly pressure to revert to MB in structural and commodity fumigation. For preplant soil uses of MB, the regulatory restrictions on 1,3-dichloropropene and chloropicrin are preventing further adoption of these products and putting pressure on industries to retain MB.

MBTOC urges Parties to consider the long term sustainability of treatments adopted as alternatives to MB, to continue to adopt environmentally sustainable and safe chemical and non-chemical alternatives for the short to medium term and to develop sustainable IPM or non-chemical approaches for the longer term.

Decision IX/6 1(a)(ii) refers to alternatives that are 'acceptable from the standpoint of environment and health'. MBTOC has consistently interpreted this to mean alternatives that are registered or allowed by the relevant regulatory authorities in individual CUN regions, without reference to sustainability.

11.3.12 Frequency of allowed MB use

In the CUN round for 2008, reductions in MB for both preplant soil and post harvest uses could be achieved in some nominations, where effective alternatives were identified, by reducing the frequency of MB fumigations. Instead of annual fumigation, some growers continue to experiment with fumigating every 2nd or 3rd year. In some production systems, methyl bromide is already used only every 3rd or 4th year as a result of multiple crop rotation.

Noting this effort, MBTOC will not automatically conclude that episodes when MB is not used mean a fully successful adoption of alternatives. There is no instruction from Parties as to how to consider renewed CUNs in the future that result from a potential need for methyl bromide in the years where a reduced frequency fumigation is to take place.

11.3.13 Use of disposable canisters of MB

One non-Article 5 Party is still using small disposable canisters (i.e. 500 to 750g canisters) for application of MB for preplant soil use under plastic films under strict worker health guidelines. Canister applications have been eliminated in all remaining non-Article 5 Parties as this application is considered to be less efficient for the control of soil-borne pathogens than other methods. The treatment is considered more dangerous to workers than injection methods, because and generally treatment does not involve use of trained contractors. This practice is not considered as effective for pathogen control as use of MB/Pic mixtures and also can lead to high emissions of methyl bromide as the MB gas is released immediately beneath the plastic sheets. According to the Party, canisters are used because they provide small-scale farmers with an easy application method and the ability to apply targeted amounts of MB to small areas where injection machinery may be difficult to use. In this case, farmers are reported to use strict controls.

11.4 Interim CUN Report – Issues Specific to MBTOC Quarantine, Structures and Commodities

11.4.1 Standard presumptions used in assessment of nominated quantities

Table 11-5 below states the standard presumptions applied by MBTOC QSC in assessing this round of CUNs where continued methyl bromide use is sought. These have not changed since presentation to the Parties at 17th MOP.

Table 11-5 Standard presumptions used in assessment of CUNs – Structures and Commodities

	Comment	CUN Adjustment	Exception
Dosage rate - structural	20 gm ⁻³	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 for bulk commodities 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

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.

11.4.2 Adjustments for standard dosage rates

No adjustments were made to nominated quantities for 2009 or 2010 for excessive dosage rates in postharvest applications. All CUNs considered used dosage rates close to or below the standard presumptions.

11.4.3 Details of evaluations

Fifteen members of MBTOC QSC met in Tel Aviv to review the CUNs. Members were present from: Argentina, Australia, Canada, Belize, Croatia, France, Japan, Kenya, Netherlands, New Zealand, Philippines (2), Spain, United Kingdom and United States. There were 6 Article 5(1) members present.

Parties submitted nine CUNs for the use of MB in structures and commodities in 2008.

Three nominations were for 2009 for a total MB amount of 8.467 tonnes and seven were for 2010 for a total MB amount of 313.341 tonnes. One Party adjusted its nominated quantity downwards during correspondence subsequent to submission of the CUN, resulting in a total nomination for 2009 of 7.719 tonnes.

Of nominations for 2009, MBTOC recommended 4.4 tonnes in 2009 and for 2010 237.117 tonnes. MBTOC did not recommend 23.484 tonnes for 2010.

Table 11-6 provides the MBTOC QSC interim recommendations for the CUNs submitted in 2008.

Table 11-6 Interim evaluations of CUNs for commodity or structural treatments, submitted in 2008 for 2009 or 2010

Industry	Quantity approved for 2005 (ExMOP1 and MOP16)	Quantity approved for 2006 (MOP 16 +ExMOP2+MOP17)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
Australia Rice	6.150	6.150	9.205	9.200	7.820	None	-	7.820	NR
<p>Not recommended – MBTOC does not recommend the Party's nomination of 7.820 tonnes for packaged rice. The Party has not adopted alternatives and according to the CUN does not plan to adopt any alternatives until after having had 3 years of high harvests. The CUN indicates the rice milling industry is unlikely to begin adopting alternatives until possibly 2013. MBTOC recognises that drought has resulted in severe economic hardship for the applicant, however, alternatives for this MB use include phosphine and controlled atmospheres; they are registered and commercially available for this application. Alternatives to MB are technically and economically feasible and in use in many other countries for this product. Phosphine treatment could be completed under tarps or in containers in the yard without the construction of new silos. Controlled atmosphere is used for packaged rice in Greece and Thailand. These facilities are available on a lease basis. MBTOC observes that the MB used is recaptured.</p>									
<p>MBTOC comments on economics: CUN states drought has made it impossible to undertake investment in phosphine facilities. Estimated costs for up to 100 silos would be \$Aus47 million. CUN states it would involve three years of transition, potentially complete in 2013. However, CUN does not provide annual cost of this capital expenditure. Even if borrowing or raising external capital is not feasible, the calculations of the annual cost have to be based on the amortised capital cost over the economic life of the investment</p> <p>CUN describes trials of alternatives, two of which, namely cold disinfestation and 'packaging alteration with oxygen scavenging' are regarded as economically infeasible. In the former case, party expects costs to exceed \$Aus100 million plus an unknown cost for electricity. In the latter case, party argues that operating costs increase from \$Aus34 per tonne to over \$Aus119 per ton.</p>									
Canada Mills	47 (included mills and pasta)	34.774	30.167 (included mills only)	28.650	26.913	None	-	22.878	U
<p>MBTOC is unable to assess the nomination of 22.878 tonnes for treatment of particular flour mills in Canada in 2010. The amount requested in 2010 represents a 15.3% decrease over the amount granted by the Parties for 2009, but in this sector, trials of alternatives can replace a methyl bromide treatment. Sulfuryl fluoride as an alternative fumigant to methyl bromide has only recently become available for use in mills in Canada, and it is subject to ongoing trials. Its use is constrained by lack of tolerances for residues in foodstuffs that may be present in mills, and not easily removed. Heat systems continue to be used and tested, both as whole-site treatments and as part of IPM systems. In order to allow an assessment, additional data are requested on number of mills involved in this nomination and the frequency of fumigations with MB in them. MBTOC will reassess this nomination and requests the Party to provide an MB volume adjusted to permit frequency for MB fumigation not exceeding once per year and demonstrating adoption of available alternatives. Only one MB fumigation per year should be necessary in Canada where pest pressure from sources external to the mills is expected to be less than that experienced in regions with longer periods of warmth and humidity conducive to pest activity. Infestation is managed, both in Canada and elsewhere, by other approaches so as to avoid the need for additional treatments.</p>									

Industry	Quantity approved for 2005 (ExMOP1 and MOP16)	Quantity approved for 2006 (MOP 16 +ExMOP2+MOP17)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
<p>MBTOC comments on economics 2008: CUN states the use of alternatives and associated building modifications would add 2 to 4 percent to manufacturing costs that would be passed to Canadian consumers whose use accounts for 80% of annual shipments of milled grain products. Also stated that there is no program for government financial assistance to millers. MBTOC notes that lack of government financial assistance programs has not been a consideration in assessments of economic feasibility. CUN did not provide detailed data on estimation of the 2%-4% cost increase. Regardless of exact amount, the CUN suggests milled grain product market relationships are such that added costs would be borne in large part by consumers. In turn, this suggests that if technical and regulatory barriers to adoption of alternatives can be overcome, the Party will have no basis to then assert economic infeasibility.</p>									
Canada Pasta	(see Canada mills)	10.457	6.757	6.067	None	5.319	2		
<p>MBTOC recommends a reduced CUE of 2.0 tonnes for pasta mills in Canada for 2009. This provision is to allow treatment of any one of the three pasta mills in this CUN with methyl bromide, as part of orderly transition to alternatives. This volume of methyl bromide is recommended for use, if it should happen that an alternative treatment failed, or if MB is required for food storage areas if no other alternative is suitable or available. Interim reports submitted concerning SF trials done late in 2007 have demonstrated some effectiveness in these facilities. It is clear that additional experience with this fumigant is required in these premises to optimise efficacy. It may be that moderate supplemental heating will be required to improve effectiveness of the SF treatments against the egg stage of pests. Further SF trials are scheduled in 2008. In this sector, trials of alternatives can replace a MB treatment. Use of sulfuryl fluoride is only permitted in areas that do not contain raw commodity or foodstuffs, as there is currently no residue tolerance in Canada for fluorine in these materials arising from SF treatments. In this recommendation, it is assumed that pest control in parts of the premises containing product and raw materials (e.g. finished product stores) can be carried out to an appropriate standard without resort to fumigation and the areas can be isolated from the SF fumigation of the main processing areas. Heat treatments, either as full site or spot heat treatments may also be considered for these facilities as part of their IPM program. Heat has proven technically feasible in pasta facilities elsewhere (e.g. Italy) (Nomisma 2006).</p> <p>(Nomisma. 2006 plus executive summary which is undated but covers work done in 2005. Pest Control in the Italian food industry: Selected case studies.) Summarized in the flour milling report of the 2008 MBTOC/TEAP Spring Progress Report. The Party is referred to the flour milling review report published in the 2008 MBTOC/TEAP Spring Progress Report for technical information on the conduct of spot heat treatments and recommendations to improve technical efficacy of SF treatments.</p>									
<p>MBTOC comments on economics 2008: The Economic feasibility section is marked N/A. Elsewhere it is asserted that heat is roughly twice the cost of MB.</p>									

Industry	Quantity approved for 2005 (ExMOP1 and MOP16)	Quantity approved for 2006 (MOP 16 +ExMOP2+MOP17)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
Israel Dates	3.444	2.755	2.200	1.800	None	2.100	2.100		
<p>MBTOC recommends a CUE of 2.1 tonnes for dates in 2009 associated with rapid treatment of fresh dates at time of harvest. This represents an increase of 0.3 tonnes over the amount of MB granted by the Parties for 2008. The increase in methyl bromide is due to projected increase in harvest of date varieties for which heat or other treatments have not yet been developed. Israel continues an active research programme to resolve technical, logistical and economic difficulties and adapt heat treatment for the non-Medjool varieties. If upcoming research on either heat or ethyl formate and carbon dioxide result in effective methods, Israel may consider reducing the amount granted in domestic allocation process.</p>									
<p>MBTOC comments on economics: CUN argues that heat treatment is economically feasible for Medjool dates, but that in depth feasibility studies still have to be carried out to determine the efficacy of thermal treatment on other varieties. No economic data is provided.</p>									
Israel Flour mills	2.140	1.490	1.040	0.312	None	0.300	0.300		
<p>MBTOC recommends a CUE of 0.3 tonnes for flour mills in 2009 as a one year transition to spot heat treatment or expanded use of phosphine. This represents a decrease of 0.012 tonnes over the amount of MB granted by the Parties for 2008. Mills in Israel are not considered suitable for full site treatments due to age and condition. Spot heat treatment has been determined to be effective for older mills in Israel. Techniques have been developed to assure its efficacy. Portable heat equipment has been purchased by a pest control operator and is in commercial use in the circumstances of this nomination. More equipment has already been ordered for import. For this reason MBTOC sees a need for one year to transition to heat. Additionally, phosphine is in use in most mills and its use could be expanded. Improvements in IPM and sanitation would improve pest control in Israel mills. MBTOC sees no reason for continued MB use in Israel flour mills after the transition to heat or phosphine is made by 2010. The Party is referred to the flour milling review report published in the 2008 MBTOC/TEAP Spring Progress Report for technical information on the conduct of spot heat treatments and recommendations to improve technical efficacy of alternatives.</p>									
<p>MBTOC comments on economics: CUN argues that the alternative used in North America and Northern Europe of heating the entire mills is not economically feasible in Israel because most of the mills are more than 20 years old, with poor structural upkeep of the mills and so thermal insulation is not possible. Furthermore, heating equipment is not available because of the small size of the market. However, the CUN argues that new spot heat techniques have become available from Canada, and that these are economically feasible. No economic data is provided.</p>									

Industry	Quantity approved for 2005 (ExMOP1 and MOP16)	Quantity approved for 2006 (MOP 16 +ExMOP2+MOP17)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
Japan Chestnuts	7.100	6.800	6.500	6.300	5.800	None	-	5.400	5.400
<p>MBTOC recommends a CUE of 5.4 tonnes, the amount nominated for fresh chestnuts for 2010. This represents a 0.4 tonne decrease in MB nomination over the amount granted by the Parties for 2009. An extensive research program has resulted in the finding that methyl iodide treatment is technically effective for this use, and registration has been applied for. The registration process is progressing appropriately. Japan has set an acceptable daily intake of methyl iodide of 0.0034 mg/kg body weight. Progress has been made in improving the logistics of treatment to ensure the use of MB is minimised while awaiting registration results. MBTOC knows of no other effective alternative treatment for fresh chestnuts.</p>									
<p>MBTOC comments on economics: The CUN states that, for economic feasibility evaluation, it is prerequisite for economic evaluation that a technically feasible alternative exists. In fact there is no technically feasible alternative, and accordingly economic evaluation has not been carried out.</p>									
United States Commodities	89.166	87.719	78.983	58.921	45.623	None	-	43.007	1.984, U,U,NR
<p>MBTOC is unable to assess this nomination in total for treatment of dry commodities, but can give recommendations for some parts of it. The Party nominated 43.007 tonnes for the four subsectors included in this CUN. At this time, MBTOC recommends a CUE of 1.984 tonnes for 2010 for the component of this nomination relating to pest control treatment of (1) dried beans directly after harvest. It is unable to assess the components concerned with rapid treatment of (2) walnuts and (3) dry dates at harvest. MBTOC does not recommend the component relating to postharvest protection of (4) dried plums (prunes). (1) Concerning beans, there are no alternatives immediately available for rapid disinfestation of dried beans under the circumstances of the nomination, specifically the current treatment logistics. Fumigation with phosphine, while registered and effective, requires a treatment time that is too long to meet current shipping and handling schedules; and sulfuryl fluoride lacks appropriate registration. There appears to be scope for further reduction in this component of the nomination through adoption of phosphine fumigation under revised logistics which MBTOC recommends be incorporated in any future CUN. (2) Methyl bromide is used for rapid disinfestation of in-shell walnuts immediately post-harvest to meet timing requirements of particular export markets in advance of holiday sales periods. However, sulfuryl fluoride can provide treatment in the same length of time. As a result of recent EU decisions, (EU 149/2008 as of September 2008) reducing bromide tolerances and adding fluorine tolerances, there are uncertainties that prevent a firm recommendation on the CUN at this time. The EU is a major market for in-shell walnuts. It is likely that the reduced residue tolerances for bromide in the main walnut export market may prevent effective use of methyl bromide for walnuts prior to 2010 and the increased fluoride tolerance may favour the use of sulfuryl fluoride. The Party is asked to assess the impact of this EU regulatory change, possibly providing a revised nomination for walnuts. (3) Further information is sought on the need for methyl bromide for rapid disinfestation of dry dates at time of harvest and the applicability of phosphine and sulphuryl fluoride fumigation, and other pest management options, under the circumstances of this nomination. The CUN indicates SF trials were conducted in April 2008. These trials may have demonstrated the applicability of SF as a rapid disinfestant for dry dates. Furthermore, part of the crop may be treatable with phosphine at time of harvest. In a reassessment, MBTOC expects to recommend only that portion of the nomination that is involved in rapid treatment immediately after harvest, and that is not replaceable by SF, controlled atmospheres or other processes. (4) In the case of dried plum treatments, the initial processing (drying) involves exposure to temperatures (>60°C) sufficient to achieve disinfestation. The product may become infested subsequently during storage and handling. In the absence of need for very rapid disinfestations, this reinfestation (mainly of moths) can be managed by currently available systems, particularly phosphine fumigation. Phosphine fumigation is the main technology used in the dried vine fruit industry with similar circumstances to the dried plum industry involved in this nomination. Controlled atmosphere storage and treatment is used by many EU countries for the same commodities included in this CUN.</p>									

Industry	Quantity approved for 2005 (ExMOP1 and MOP16)	Quantity approved for 2006 (MOP 16 +ExMOP2+MOP17)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
<p>MBTOC comments on economics 2008: CUN provides economic data on alternatives for walnuts and dried fruit other than dates. Phosphine fumigation costs more because it takes longer to accomplish, leading to increased labor costs, it corrodes equipment and its use means sellers do not meet December holiday export market window. CUN states walnuts and dried fruit all require substantial additional treatment time and subsequent lost revenues if phosphine is used. Net revenues for alternatives are negative. CUN states that profit margin decreases from 13.3% to -7.5% for walnuts and from 5% to -16.8% for dried fruits. An economic analysis was not done for dates. In the case of dried beans, response to MBTOC question states that cost of an additional facility would be \$1.2m per unit, but annual costs were not provided.</p>									
United States NPMA food processing structures (cocoa beans removed)	83.344	69.118	82.771	69.208	54.606	None	-	37.778	37.778
<p>MBTOC recommends a CUE of 37.778 tonnes, the amount nominated for food processing facilities in 2010. This nomination represents a 30.82% decrease (excluding cocoa beans) over the amount granted by the Parties for 2009. The CUN now includes three sectors, after cocoa bean sector fully transitioned to alternatives in 2009. (1) MBTOC recommends 1.812 tonnes, the nominated amount, for cheese in storage. Cheese stores are only fumigated if USDA inspectors find mites in the cheese. If cheese stores were held at 7°C instead of 10°C, mites would not develop, but it is unknown what effect lowering storage temperature would have on cheese maturation and quality. MBTOC knows of no effective chemical alternative for this use, but we note that USG is conducting research on the effect of sulfuryl fluoride on mites in cheese. (2) MBTOC recommends 2.439 tonnes, the nominated amount for herb and spice processing facilities. According to the CUN, 2010 is the final year of a four year transition in herb and spice processing sector. Spot heat treatment of processing machinery with additional use of barrier methods to prevent pest escape would seem to be a good alternative for this sector. (3) MBTOC recommends 33.527 tonnes, the amount nominated for the processed food sector. This nomination represents a 45% reduction over the amount granted by the Parties for 2009. According to the CUN 2010 is the last year of a 4 year transition to alternatives in processed foods sector. This sector is expecting a registration of methoprene for use in packaging materials which will assist in achieving post-processing pest control.</p>									
<p>MBTOC comments on economics 2008: An economic analysis was not conducted because the CUN reports the sector did not have an alternative registered. For food-processing facilities listed in the NPMA CUN, economic feasibility of such alternatives was not assessed due to the lack of revenue information, which is necessary to quantify the economic impacts to food-processing facilities. There is a major change to this 2010 nomination from NPMA. An economic study found that sulfuryl fluoride is economically feasible for cocoa beans (Adam 2007). Therefore NPMA has not requested methyl bromide for use on cocoa beans for 2010. Sulfuryl fluoride is not always economically feasible in all food processing facilities (Adam 2007), therefore that portion of NPMA's request remains. Adam (2007) conducted a cost comparison of methyl bromide and sulfuryl fluoride in the fumigation of cocoa beans. It is an economic-engineering approach, which estimates of costs that "typical" firms would face under different scenarios (Adam 2007). Adam (2007) found that with regards to cocoa beans, if the methyl bromide and sulfuryl fluoride are the same price per pound, then a sulfuryl fluoride fumigation costs 1% less than a methyl bromide. Sulfuryl fluoride is more economical than methyl bromide for cocoa beans, primarily because less sulfuryl fluoride is needed (Adam 2007). Sulfuryl fluoride is highly dependent upon temperature, so should a facility need fumigation during cooler temperatures, it may not be the product of choice because of increased heating costs. Also sulfuryl fluoride requires higher dosages for egg kill, and in many facilities killing eggs is paramount; this also may lead to higher costs. Cheese does not have a technically and economically feasible alternative to methyl bromide at this time.</p>									

Industry	Quantity approved for 2005 (ExMOP1 and MOP16)	Quantity approved for 2006 (MOP 16 +ExMOP2+MOP17)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
United States Mills and processors	483.000	461.758	401.889	348.237	291.418	None	-	191.993	187.534
<p>MBTOC recommends a CUE of 187.534 tonnes in total for use in US food processing structures (rice mills, dry pet food producers and flour mills) 2010. The CUN nominated 191.993 tonnes for the three sectors. The CUN represented a 35.6% decrease in MB requested over the amount granted by the Parties for 2009. In part this large percent decrease resulted from the bakery sector (formerly included in this category), which will complete its transition to alternatives in 2009 and did not request MB for 2010. Bakery sector is commended for its work to adopt alternatives. In addition, rice mill sector also decreased 70% in one year, for which it is also commended. (1) For rice mills, MBTOC recommends the nominated amount of 14.511 tonnes. The remaining MB use is for rice mills that contain food mixes for which contact with SF, the alternative largely adopted by this sector, is not registered. (2) For pet food facilities, MBTOC recommends 13.722 tonnes, the nominated amount. The sector has decreased its MB nomination 37.5% over 2009 levels. Since the registration for SF treatment of pet food facilities does not include pet food commodity and ingredients, there is a registration barrier to the use of SF in some circumstances. Pet food facilities could, however, expand use of full site or spot heat treatment, utilising appropriate pest barrier methods to prevent pest escape from spot heat treatments. (3) For flour mills, MBTOC recommends a reduced CUE of 144.789 tonnes. The sector nominated a 23% decrease, as part of its orderly transition to alternatives. MBTOC further decreased the nomination because the CUN included an average of 2.5 MB fumigations per mill, including those 58% of mills that USG believes can transition to alternatives, because they do not produce food mixes. MBTOC believes the frequency of fumigation can be reduced. The registration for SF treatment of flour mills does not include treatment of some food mixes and ingredients that may be held inside the treated structure. Consequently, there is a registration barrier to the use of SF in 42% of mills according to the CUN. During this time when such processed foods are not registered for SF treatment, mills could increase their adoption of heat treatment. MBTOC notes that US researchers have considerable information available to assist millers to accomplish successful heat and IPM treatments. The quantity recommended for this sector, 144.790 tonnes, was calculated assuming 42% of the nomination (68.79 tonnes) was unable to transition at this time and needed the nominated frequency of treatment, while the 58% of treatments that could transition could reduce their treatment frequency with MB from 2.5 to 2x a year (95.0*2/2.5 tonnes). The three sectors included in this CUN are expected to work to improve treatment logistics that improve product segregation so that more adoption of alternatives can be accomplished even if regulatory barriers to the use of SF persist. When conducting SF fumigations where food mixes are present, the applicant could test covering the food with a tarp under positive pressure or removing food ingredients and mixes to non-fumigated areas or sealing off stored product warehouses to allow SF treatment of facility while ensuring that food is not exposed. The Party is referred to the flour milling review report published in the 2008 MBTOC/TEAP Spring Progress Report for technical information on the conduct of heat treatments and recommendations to improve technical efficacy of SF treatments.</p> <p>MBTOC comments on economics: 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. Where sulfuryl fluoride is technically feasible it results in loss of net revenue of 57% (rice millers), but only 4% (bakeries) and 2% (pet food manufacturers and North American Millers Association). Profit margins were added to the economic assessment. Sulfuryl fluoride is highly dependent upon temperature, so should a facility need fumigation during cold temperatures, it may not be the product of choice because of the increase in costs. Also sulfuryl fluoride requires higher dosages for egg kill, but in some facilities killing eggs is paramount, again contributing to higher costs. The CUN cites a new study that compares methyl bromide structural fumigation to an alternative. This paper uses an economic-engineering approach to estimate costs that "typical" firms would incur under alternative scenarios, as opposed to specific firms and situations (Adam 2007).</p>									

Industry	Quantity approved for 2005 (ExMOP1 and MOP16)	Quantity approved for 2006 (MOP 16 +ExMOP2+MOP17)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
United States Cured pork	67.907	40.854	18.998	19.669	18.998	None	-	4.465	4.465
<p>MBTOC recommends a CUE of 4.465 tonnes for specific cured (air-dried) pork products in 2010. This CUN has decreased by 14.533 tonnes over the amount granted by the Parties for 2009. The USG is in the second of a three year multi-disciplinary research program to try to find non-MB methods to control mites in this traditional cured pork product and associated storage houses. No chemical alternatives are registered for pest control in these products. Although MBTOC does not know of methods that have been published as effective for this situation. In the interest of contributing to research ideas, we can suggest: low oxygen controlled atmosphere; or dipping the hams in oil and lard at 90°C as practised in Spain with a similar product.</p>									
<p>MBTOC comments on economics: No economic data given. This is a minor use and there is little economic incentive to develop alternatives.</p>									

11.5 Interim CUN 2008 Evaluation Report – Issues Specific to MBTOC Soils

11.5.1 Summary of outcomes

In the 2008 round, 31 CUNs were submitted for soil uses, 12 for 2009 and 19 for 2010. Interim recommendations were made on all nominations for 2009 and 2010. MBTOC Soils has recommended a total of 608.454 tonnes for 2009 and 3167.335 tonnes for 2010. An amount of 89.000 tonnes was not recommended for 2009, and 875.247 tonnes not recommended for 2010.

Table 11-7 Summary of MBTOC Soils recommendations for 2009 and 2010 by country for CUNs received in 2008 for preplant soil use of methyl bromide (tonnes)

Country	CUE approved at MOP 19		Requests for 2009 and 2010		MBTOC-S Interim Recommendation	
	2008	2009	2009	2010	2009	2010
Australia		29.	790	29.790		29.790
Canada		7.462		7.462		7.462
EC	244.146					
Israel	858.96		697.048		608.454	
Japan		299.580		283.100		214.570
USA		3854.666		3722.230		2915.513
Total		4191.498	697.048	4042.582	608.454	3167.335

(a) Unable to assess 848.795 tonnes for 2009 of the Israeli CUNs pending further information.

11.5.2 Issues related to CUN Assessment for Preplant Soil Use

Technical alternatives exist for almost all uses requesting CUNs, but uptake of alternatives varies between countries, crops and the pest pressure. In general, CUNs for preplant soil use of MB resulted mainly from the following issues: regulatory restrictions on one or two specific alternatives, adoption times to implement alternatives, and economic infeasibility of some key technical alternatives, such as the use of methods which avoid the need for MB, i.e. use of grafted plants.

Key issues which assisted MB reductions and also affected the need for CUNs in the 2008 round were i) a new registration of iodomethane (methyl iodide, MI) in the US, ii) regulations on key alternatives, particularly 1,3-D township caps and buffer zones on 1,3-D, metham and Pic used alone or in mixtures (iii) restrictions on use of high rates of Pic (greater than 200 kg/ha (20 g/m²)) in some counties of California, iv) lack of effective controls for nutsedge, and v) lack of studies in specific sectors i.e. nursery industries and some of the replant uses, such as walnuts, almond, stone fruit.

Unusually large buffer zone restrictions on fumigant alternatives, particularly limit their adoption, especially in Israel. MBTOC urges Parties to consider review of these regulations in view of the ability of barrier films to reduce dose rates of MB and alternatives and associated emissions. As in the previous round, Parties have found alternatives for propagation materials such as strawberry runners and nurseries more difficult to adopt, however the lack of research studies provided with CUNs has also led to difficulties in assessment as these CUNs as they are considered not to fully satisfy the requirements of Decision IX/6. Current reviews of VOC emissions in California may also have a major impact on MB use and the use of alternatives in California in future nominations. The registration of a key alternative, 1,3-D/Pic is uncertain in Israel, however a recent alternative fungicide, fludioxonil has been registered. In addition to registration of iodomethane in the US, recent permits for methyl iodide use for trials in Australia look promising for commercial registration.

MBTOC also notes that a large proportion of MB has been nominated for uses where regulations or legislation prevent reductions of MB dosage, e.g. the mandatory use of MB at a specified dosage for certified propagation material or bans are imposed on the use of barrier films, which can reduce MB dosage. Also regulations on alternatives are preventing their uptake for a substantial proportion of the remaining CUNs for preplant soil use. MBTOC urges the Parties to align their local policies and regulations with internationally accepted methodologies and MB alternatives that lie within the Montreal Protocol's goals.

In this round, MBTOC has sometimes suggested quantities of MB for 2009 or 2010 different from those nominated. Grounds used for these changes are given in detail after the relevant CUNs in Table 11-8. The adjustments follow the standard presumptions given in Tables 11-6 and 11-7, unless indicated otherwise.

11.5.3 Standard presumptions used in assessment of nominated quantities.

Tables 11-8 and 11-9 below provide the standard presumptions applied by MBTOC Soils for this round of CUNs. These standard presumptions were first proposed in the MBTOC report of October 2005 and were presented to the Parties at 17th MOP. They were revised for some sectors after acceptance by the Parties at the 19th MOP. The rates and practices adopted by MBTOC as standard presumptions are based on maximum rates considered acceptable by published literature and actual commercial practice. A copy of the actual dosage rate of MB in MB/Pic formulations is shown in Table 11-9 below.

As in the evaluations in previous years, MBTOC considered reductions to quantities of MB in particular nominations to a standard rate per treated area where technical evidence supported its use (see Appendix VI and V). MBTOC considered the maximum MB application rate for 98% MB to be either 250 or 350 kg/ha (25 to 35 g/m²), in conjunction with low barrier permeability films (e.g., VIF or equivalent), combined with extended exposure periods. Several Parties indicated that 250 kg/ha (25g/m²) of 98:2 were effectively used in standard commercial application, especially on sandy soils.

In cases where use of high chloropicrin-containing mixtures (approximately MB:Pic 67:33 or 50:50 or lower) is considered feasible, maximum dosage rates of either 150 or 175 kg MB/ha (15.0 - 17.5 g/m²) where nutgrass is the key pest and 125 or 150 kg/ha (12.5 - 15 g/m²) for pathogens were used as the maximum standard presumptions unless there was a regulatory or technical reason indicated otherwise by the Party (see Table 11-11).

As a special case, MBTOC accepted a maximum rate of 200 kg/ ha (20 g/m²) for certified nursery production. However, several Parties indicated that rates of 200 kg/ha (20g/m²) or less (Appendix IV) of MB: Pic 50:50 were effective with barrier films for production of ‘certified’ nursery material.

The indicative rates used by MBTOC were maximum guideline 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.

Table 11-8 Standard presumptions used in assessment of CUNs for the 2007 round – soil treatments.

	Comment	CUN adjustment	Exceptions
1. Dosage rates	Maximum guideline rates for MB:Pic 98:2 25 to 35 g/m ² with barrier films (VIF or equivalent); for mixtures of MB/Pic 12.5 to 17.5 g MB/m ² for pathogens and nutsedge respectively, under barrier films depending on the sector. 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.
2. Barrier films	All treatments to be carried out under low permeability barrier film (e.g. VIF)	Nomination reduced proportionately to conform to barrier film use.	Where barrier film prohibited or restricted by legislative or regulatory reasons
3. MB/Pic Formulation: Pathogen control	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 (Pic) is not registered
4. MB/Pic Formulation: Weeds/nutgrass control	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
5. Strip vs. Broadacre	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, emission regulations on MB, or open field production of high health propagative material

Table 11-9 Maximum dosage rates for preplant soil use of MB by sector used in the 2008 round.

Film Type	Maximum MB Dosage Rate (g/m ²) in MB/Pic mixtures considered effective for:			
	Strawberries and Vegetables	Nurseries*	Orchard Replant	Ornamentals
Barrier films -Pathogens	12.5	15	15	15
Barrier films -Nutsedge	15.0	17.5	17.5	17.5
No Barrier films – Pathogens	20	20	20	20
No Barrier films - Nut sedge	26	26	26	26

* Maximum rate unless certification specifies otherwise

Table 11-10 Actual dosage rates applied during preplant fumigation when different rates and formulations of methyl bromide/chloropicrin mixtures are applied with and without barrier films. Rates of application reflect standard commercial applications rates.

Commercial application rates of formulation	MB/Pic formulation (dose of MB in g/m ²)			
	98:2	67:33	50:50	30:70
<i>A. With Standard Polyethylene Films</i>				
400	39.2	26.8	20.0	12.0
350	34.3	23.5	17.5	10.5
300	29.4	20.1	15.0	9.0
<i>B. With Low Permeability Barrier Films (LPBF)</i>				
250	24.5	16.8	12.5	7.5
200	19.6	13.4	10.0*	6.0
175	17.2	11.8	8.8	5.3

* Note: Trials from 1996 to 2007 (Appendix VI) show that a dosage of 10g/m² (e.g. MB/Pic 50:50 at 200kg/ha with LP Barrier Films) is technically feasible for many situations and equivalent to the standard dosage of >20g/m² using standard films

11.5.4 Meta-analysis update

In response to Decision XVI/5, which provided financial support to MBTOC for expert assistance with the assessment of the critical-use nominations, a statistical analysis or metaanalysis study was conducted to analyse methyl bromide alternatives for pre-plant fumigation (Porter *et al*, 2006).

This report provides the Parties with a technical overview of results from current published research. It provides the statistical best estimate of the relative effectiveness of the major chemical alternatives to methyl bromide as determined by analysis of information across a large number of studies in different regions and under different pathogen pressures. Effectiveness was assessed by comparing relative yield of the alternative to the respective methyl bromide/chloropicrin (MB/Pic) treatment. The study takes account of both registered and unregistered products and concentrates on two major crops, strawberry fruit and tomatoes. Comparisons are made to peppers, melons and other cucurbits and eggplants where possible; much of the information for tomatoes (i.e. effect on target pathogens and weeds) is relevant to the outcomes for these other crops. The meta-analysis

also includes a detailed assessment of the effect of alternatives for nutsedge under different pressures and the influence of low permeability barrier films across a range of regions and crops.

Analyses from strawberry fruit trials showed that a large number of alternatives used alone or in various combinations had mean estimated yields, which were within 5% of the estimated yield of the standard methyl bromide treatment (MB/Pic 67:33). Of these, a number of alternatives and MB/Pic formulations (50:50, 30:70) led to results that were similar to MB/Pic 67:33. These included PicEC (chloropicrin), TC35EC (1,3-dichloropropene/ chloropicrin), TC35 and TC35ECMNa (TC35 EC combined with metham sodium) and MI60 (methyl iodide/chloropicrin), which is undergoing review for registration in several countries.

Analyses from tomato trials showed that a range of alternative treatments used alone or in various combinations had mean estimated yields, which were within 5% of the estimated yield of the standard methyl bromide treatment (MB/Pic 67:33). While some of these treatments contained pebulate, a herbicide which is not commercially available anymore, most treatments did not contain this particular product. Several treatments, PicMNa (chloropicrin combined with metham sodium), 1,3D/Pic in combination with a range of herbicides and MI60 (methyl iodide/chloropicrin) (not registered), provided results similar to MB/Pic 67:33.

Decision XIX/9 reads “*To note the importance of transparency in the critical-use exemption process and to request the TEAP to provide to the Open-ended Working Group at its next meeting a written explanation of its methodology for using its meta-analysis in its work and to disclose to the Parties in a written explanation any significant changes or deviations it intends to make to that methodology before it undertakes any such change or deviation*”. MBTOC uses the meta-analysis report as a guide to the relative effectiveness of many alternatives, together with many others obtained from scientific journals, conference proceedings, published reports and others, to substantiate and support its recommendations. No change to this approach has been made in this round.

11.5.5 Use/Emission reduction technologies - Low permeability barrier films and dosage reduction

Decision IX/6 states in part 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*’. Decision Ex.II/1 also mentions emission minimization techniques, requesting Parties “*...to ensure, wherever methyl bromide is authorized for critical-use exemptions, the use of emission minimization techniques such as virtually impermeable films, barrier film technologies, deep shank injection and/or other techniques that promote environmental protection, whenever technically and economically feasible.*”

As in past rounds, MBTOC assessed CUNs where possible for reductions in MB application rates and deployment of MB emission reduction technologies, such as use of LPBF, including VIF, or other appropriate sealing and emission control techniques including deep injection of MB, use of formulations with a lower proportion of MB and/ or reduced frequency of application.

The use of low permeability barrier films (VIF or equivalent) is compulsory in the 25 member countries of the European Union (EC Regulation 2037/2000). In other regions LPBF films are considered technically feasible and large adoption has occurred, e.g. Israel and SE USA. In Florida, the use of barrier films in vegetable crops expanded to over 30,000 acres in 06/07 and continued expansion has been reported throughout SE USA since then. An exception to the use of barrier films is the State of California in the US where a regulation currently prevents use of VIF with MB (California Code of Regulations Title 3 Section 6450(e) but not the alternatives. This regulation

has been set over concerns of possible worker exposure to MB when the film is removed or when seedlings are planted due to altered flux rates of MB.

11.5.6 Adjustments for standard dosage rates using MB/Pic formulations

One key transitional strategy to reduce MB dosage 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) (e. g. Porter *et al.*, 1997; Melgarejo *et al.*, 2000; López-Aranda *et al.*, 2003; Santos *et al.*, 2007). Formulations containing high proportions of chloropicrin in mixtures with methyl bromide have been adopted widely by non-Article 5 Parties to meet Montreal Protocol restrictions where such formulations are registered or otherwise permitted. Their use can be achieved with similar application machinery, which allows co-injection of methyl bromide and chloropicrin or by use of premixed formulations. Consistent performance has been demonstrated with both barrier and non barrier films. Parties are urged to consider lower dosage rates, i.e. as low as 75 kg/ha (7.5 g/m²) of 30:70 or 100 kg/ha (10 g/m²) of 50:50 MB/Pic in conjunction with barrier films as these have shown similar effectiveness of higher rates of 67:33 MB /Pic and much higher rates of 335 to 800 kg/ha (33.5 to 80 g/m²) of MB 98% using standard polyethylene.

Table 11-11 Final evaluations of CUNs for preplant soil use submitted in 2007 for 2008 or 2009

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
Australia	Strawberry runners	35.750	37.500	35.750	35.750	29.790	None	-	29.790	29.790
		<p>MBTOC comments 2008: MBTOC recommends 29.790 tonnes for this use in 2010. The key pests affecting strawberry runner production are fungi (<i>Phytophthora</i>, <i>Pythium</i>, <i>Rhizoctonia</i>, <i>Vorticillium</i>) and weeds (<i>S. arvensis</i>, <i>Agrostis tenuis</i>, <i>Raphanus</i> spp, <i>Poa annua</i>, <i>Cyperus</i> spp). The CUN states that MB/Pic 50:50 at a MB dose of 25 g/m² is required to meet certification standards. The Party's request exceeds MBTOC's standard presumption of 20 g/m² but this rate is not currently registered. The Party is conducting field scale testing to confirm earlier small scale plot trials, which demonstrated no reduction in efficacy at a MB rate of 12.5 g/m². If successful, adoption could occur in 2010. The Party states that the most promising alternative, methyl iodide/chloropicrin has been demonstrated in small scale trials to compare with the efficacy to MB/Pic. Commercial scale-up trials are in progress and could lead to registration in 2009/2010. MBTOC encourages the Party to (1) expedite the registration and use of the MB/Pic 50:50 formulation with a MB rate of 12.5 g/m² with barrier films and (2) to expedite the registration of the iodomethane/Pic (MI/Pic), and (3) to continue the pilot testing of soilless production of the foundation generation of runners with commercial adoption possible in 2011.</p>								
		<p>MBTOC comments on economics 2008: The nomination was not based on economic arguments. Economic statements provided in CUN. CUN states that the Victoria Strawberry Industry Certification Authority is developing a two-year research program to investigate the feasibility of moving to soilless production of foundation generation runners, but notes that, while this may be feasible for the tens of thousands of runners for the foundation generation, it will not be feasible for the scaled up production of millions of certified runners required for the industry as a whole. Research on alternatives in this latter respect is continuing. No economic arguments or data are provided.</p>								
Canada	Strawberry runners (PEI)	6.840	6.840	7.995	7.462	7.462	None	-	7.462	7.462
		<p>MBTOC comments 2008: MBTOC recommends a CUE of 7.462 tonnes for 2010. The nomination states that MB/Pic 67:33 at a dose of 500 kg/ha (50 g/m²) is required to meet the certification standards for strawberry runners, which exceeds MBTOC's standard presumption of 200 kg/ha (20 g/m²); however the lower rate is not currently registered. PMRA requires data that demonstrates that the reduced rate is efficacious with LPBF before registering the lower rate. MBTOC notes that no progress has been made in more than three years on testing with LPBF and expects that future nominations will show reports of trials in order to satisfy the criteria of Decision IX/6. The Party has attempted to replace MB with 1,3-D, but 1,3-D was banned in January 2003 due to groundwater contamination. The permit for Chloropicrin 100 is still pending approval at PEI, even though Canada registered Pic in 2007. No studies on other potential alternative fumigants, such as Pic, DMDS, MI/Pic have taken place. MBTOC expects that future nominations will also demonstrate significant progress with key alternatives. MBTOC encourages the Party (1) to finalize the permits necessary for use of chloropicrin and dazomet, (2) implement the use of LPBF, which are currently used worldwide and (3) in the absence of an effective alternative becoming available, conduct the necessary trials to support a lower application rate of MB to conform with MBTOC's standard presumption, (4) provide assessment on the suitability of soilless cultures for at least part of the production cycle.</p>								
		<p>MBTOC comments on economics 2008: No economic arguments or data provided</p>								

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
Israel	Broomrape	None	None	250.000	250.000	None	125.000	125.000		
<p>MBTOC comments 2008: MBTOC recommends 125 tonnes for 2009, which represents 50% of the requested amount . The Party has informed MBTOC, that the project for 2010 has been reduced by 50% (from 1000 ha to 500 ha). The Party reports that results of field trials with 1,3-D in sequence with metham sodium are promising and that registration is expected in 2009. If 1,3-D is registered, MBTOC anticipates that there will be uptake of this alternative and appropriate reduction in the use of MB. The nomination is eradication of broomrape and land rehabilitation of 500 ha in the Golan Heights. The recommended CUE is based on a dose of 250 kg/ha (25 g/m²) of MB:Pic 98:2 using LPBF. MB will be used only once in this region and the treatment is expected to bring the weed population below the disease threshold allowing for adoption of other alternatives. The Party has identified some alternatives for controlling low infestations of <i>Orobanche</i> (e.g. solarization) but they are considered not adequate for controlling severe infestations of <i>O. aegyptiaca</i>. In 2007, five field trials were carried out with sulfosulfuron, imazapic, and imazomox. MBTOC acknowledges that a registration for chloropicrin is being considered in Israel and that this would possibly allow for lower dosages of MB to be used for Orobanche in the absence of other effective alternatives.</p> <p>MBTOC comments on economics 2008: The nomination was not based on economic arguments. Economic statements provided in CUN: CUN argues that broomrape infestation is being aggravated by the phase out of MB, as all crop-specific registered MB alternatives have a narrower range of activity and lower crop-specific efficacy than MB. This is also true for agrotechnical means and long-term fallow cropping which in practice and in economic terms do not cope with the long-term vitality of broomrape seeds and their gradual germination mechanism. CUN also states that biological control of broomrape with either the aid of a parasitic fly or with Fusaria do not provide economic answers for the problem. No economic data are provided.</p>										
Israel	Cut flowers- bulbs- protected	303.000	240.000	220.185	114.450	None	113.821	85.431		
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 85.431 tonnes for this use in 2009. The nomination is for a variety of cut flowers produced under cover, which are mainly affected by weeds (<i>Cyperus</i> in particular), nematodes (root-knot but also ectoparasites such as <i>Longidorus</i>) and fungi. MBTOC does not consider MB essential for the control of ectoparasitic nematodes. MBTOC does not recommend the use of 1.64 t for fumigating substrates used in rose production as alternatives such as steam are efficient for this use. Overall, there is very little change from nominations submitted in previous years, particularly in 2007. Phase-out efforts are still based on transitional measures - LPBF barrier films with reduced rates. In spite of this, registration of certain alternatives, such as metham sodium and 1,3-D, has now expanded to include additional flower types. More expansion of registration is expected this year. Substrate production protocols are now available for many of the flowers presently treated with MB (Bar-Yosef <i>et al</i>, 2001; Gullino <i>et al</i>, 2003; Savvas and Passan, 2002; Urrestarazu, 2004; Urrestarazu, 2005). The recommended amount is based on a 25% transition rate applied for adoption of chemical alternatives in those species where the nomination states these are now registered. In keeping with the 2007 recommendation a further 25% transition rate has been applied to those flowers where substrate production is possible (lilium, calla lilies, gerberas and carnations outside the Ghaza area). Additionally, MBTOC has adjusted MB dosages used for carnations grown in Ghaza (from the requested 50 g/m² to the standard presumption of 35 g/m²). MBTOC is aware that carnation cultivars resistant to fusarium wilt are available, commercially used and accepted by international markets (Gullino and Garibaldi, 2007)).</p>										

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
	MBTOC comments on economics 2008: CUN argues that nutsedge causes heavy economic losses not only under outdoor conditions but in greenhouses as well, despite the fact that shade reduces its activity. No economic data are provided.									
Israel	Cut flowers- open field	77.000	67.000	74.540	44.750	None	42.777	34.698		
	<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 34.698 tonnes for this use in 2009. Overall, there is very little change from nominations submitted in previous years, particularly in 2007. Phase-out efforts are still based on transitional measures - barrier films with reduced rates of fumigants. The nomination is for open field production of cut flowers, which are mainly affected by weeds (<i>Cyperus</i> spp in particular) and nematodes (root-knot but also ectoparasites such as Longidorus) and fungi. MBTOC does not consider MB necessary for controlling ectoparasitic nematodes. Lack of registration of key alternatives on flowers such as 1,3-D+Pic, dazomet and metham sodium, continue to be the major constraints affecting substitution of MB at this time. MB formulations with higher chloropicrin content are also not registered. In spite of this, registration of metham sodium and 1,3-D has expanded and now includes additional flower types. More expansion of registration is expected this year. In keeping with the 2007 recommendation, a 25% transition rate has been applied to the nominated amount to allow for adoption of alternatives, including chemicals and solarization, which is being adopted successfully. The reduction has not been applied to the 10.462 t requested for nurseries of geophytes where high health plant material needs to be produced, although no certification issues are involved.</p> <p>MBTOC comments on economics 2008: CUN states that nutsedge is a major problem of the flower industry on outdoor crops and on geophytes, specifically. It causes heavy economic losses under outdoor conditions. CUN also argues that MB substitution and phase out brought about the appearance of new and minor pests e.g. the free-living nematode Longidorus spp. became a major economic problem of Aster, Solidago and Lilly. No economic data are provided.</p>									

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Israel	Melon - protected and field	125.650	99.400	105.000	87.500	None	87.500	87.500		
<p>MBTOC comments 2008: MBTOC recommends 87.5 tonnes for this use in 2009. <i>Monosporascus cannonballus</i> is the key pathogen in the Arava Valley. The requested amount at a rate of 250 kg/ha (25 g/m²) of 98:2 MB under barrier films (LDPF) complies with MBTOC's standard presumptions. However, MBTOC notes that 70:30 MB/PIC mixtures are registered for strawberry, potatoes, cucumber, eggplant, peppers, tomatoes, gerbera, gladiola, roses, and avocado, but not for melon. MBTOC understands that formulations with more chloropicrin (MB/Pic 67:33, 50:50) could be as effective as the currently used and urges the Party to make the necessary efforts to assess this situation under the criteria of Dec.IX/6.</p> <p>MBTOC notes that alternatives are already used for 100% of the fall melons grown in the Arava valley including Telodrip, metham sodium, dazomet, solarization, Formaldehyde+MS, Telopic (only in the southern Arava). The CUN is solely for the spring crop as the alternatives seem not feasible because the plant back time is short (2-4 weeks). MBTOC visited the area and was shown experiments testing a strategy based on fumigation and solarization in the summer before the fall crop, followed by sanitation with MS at the end of fall crop. The third component is repeated application of the fungicide, azoxystrobin (still not registered) as a soil drench during the spring crop. Results are promising so far. Another material tested to prevent possible accelerated degradation in soil is the application of the fungicide prochloras. The Party is requested to submit information regarding progress in future nominations.</p> <p>MBTOC notes that Pic and MB/Pic mixtures and the fungicide, fludioxonil, are effectively used for <i>Monosporascus</i> in other countries under similar conditions (e.g. Stanghelini <i>et al.</i> 2003; Martyn 2002).</p> <p>MBTOC comments on economics 2008: CUN concludes that presently Basamid is not feasible economically because the price of Basamid has increased, and because of waiting period constraints. Economic data provided show that the price of Basamid is lower than that of MB, but that the gross margin with Basamid 300kg and Basamid 1200 kg is negative, while for Basamid 600 kg it is significantly lower.</p> <p>CUN also points out that a new approach for inoculum reduction of <i>Monosporascus</i> was developed in the area. It consists of MS applied at lower rates at crop-end to kill off the roots of the harvested fall melons and subsequently the resting structures of <i>Monosporascus</i>. This practice is effective at infestation levels of up to 20% and became a routine practice applied on the harvested fall crop prior to the spring crop. It is cost effective since the rate is low (150l/ha) and the return high.</p>										

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Israel	Potato	239.000	165.000	137.500	93.750	None	75.000	75.000		
<p>MBTOC comments 2008: MBTOC recommends a CUE for 75 tonnes for this use in 2009. Potatoes are produced in a small cultivable area of the Sharon and in the Negev regions. The nomination is only in the Sharon (10% of total cultivated area) where tuber yield and quality are impacted by <i>Rhizocotnia solani</i>, <i>Verticillium dahliae</i>, <i>Streptomyces scabies</i> (common scab), <i>Spongospora subterranea</i> (powdery scab), <i>Orobanche</i> spp. (broomrape), <i>Cyperus rotundus</i> (purple nutsedge), and volunteer plants that carry viral diseases (PVY). The Party has made a 20% reduction with respect to the amount approved by the MOP for 2008. The dosage rate of 250 kg/ha (25 g/m²) of MB 98:2 is in accordance with the standard presumptions for hot gas under barrier films in sandy soil. The Party identified that 300 of 15,000 ha are located in highly populated areas where winter production occurs and pathogens are high and regulatory constraints are in place for feasible alternatives such as 1,3-D + Pic (61:35), which as a result of buffer zones prohibit their use. The Party indicates that effective control alternatives are in development for the pest complexes and that they are transitioning to these. The CUN indicates that development of new injection machine is underway in the Sharon. MBTOC notes that there are effective alternatives but that their use is affected by buffer zones, which are larger than in other countries. MBTOC urges that Party to consider review of these buffers in the light of use with barrier films.</p> <p>MBTOC comments on economics 2008: CUN argues that, because the registered alternatives do not cover the broad spectrum activity of MB, thus given the high pathogen populations of the area, their application would require the addition of complementary compounds, with self-explanatory environmental and economic implications. No economic data are provided</p>										
Israel	Seed Production	56.000	28.000	None	None	None	22.400	NR		
<p>MBTOC comments 2008: MBTOC does not recommend any MB for this use in 2009. The application is similar to the nominations presented in 2004 and 2005 for 2005 and 2006 use: same area, same constraints and almost the same requested quantity in 2009 (22.4t) as the approved quantity in 2006 (28t). No progress has been made during these last 4 years. The same experiments and results are presented. In the 2004 nomination, Israel reported the formation of a task force to draw up a new strategy for the industry. No results have been obtained by this task force. The Party states that seeds must meet certification standards but many specified pathogens, which are the targets of MB fumigation are not carried on seeds (e.g. <i>Verticillium dahliae</i>, <i>Rhizoctonia</i>, <i>Pythium</i>, etc.). Due to lack of a research program, the Party has not provided an explanation for the lack of control with chemical alternatives such as chloropicrin, 1,3-D, formalin or MITC generating compounds or non chemical alternatives e.g. grafting (which is considered by the Party only for water melon but adopted in many other countries for other vegetables particularly tomato), resistant varieties and steam. In addition, soil less culture is considered by the Party to be a suitable alternative and is in use for 20% of the crop. The Party considers soilless culture economically feasible only for solanaceous crops, although no clarification is given as to why. No information is given on the acreages covered by the solanaceous crops and also on the areas fumigated from 2002 to 2007. The Party reports that the quantitative crop losses caused by soil-borne pests are not the main problem, but the seed quality is the main issue. In the nomination, no results on the seed health have been reported. The Party identifies economic constraints as the barrier to adoption of the non-chemical alternative, but no economic analysis is provided. In all other Mediterranean countries with similar climate, vegetable seeds are produced without MB. In the European countries, e.g. Holland, some seed companies are producing vegetable seeds without MB by the adoption of alternatives.</p>										

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	MBTOC comments on economics 2008: CUN argues that growing vegetable seeds requires that the seeds be completely clean, much as has been argued in the case of strawberry runners. CUN argues that this is a declining industry in Israel because of lower costs of labor in countries such as Thailand and China but does not state whether MB is used in those countries for this purpose. CUN argues that moving to soilless culture is not economically feasible. No economic data are provided									
Israel	Strawberry fruit - protected (Sharon and Ghaza)	196.000	196.000	93.000	105.960	None	52.250 (Sharon only)	77.750 (Sharon and Gaza)		
	<p>MBTOC comments 2008: MBTOC recommends a reduced CUE of 42.75 tonnes for Sharon and a reduced amount of 35 tonnes for Ghaza, totalling 77.75 tonnes for these uses in 2009. MBTOC has adjusted the nomination for Sharon based on information from the Party that out of the total of 380 ha, 25% (i.e. 95 ha) is grown on new land (not requiring MB) and an additional 30% (i.e. 114 ha) of the cultivated area is expected to apply MB alternatives. This leaves 171 ha for MB use totalling 42.75 t. MBTOC has adjusted the nomination to the Ghaza strip to conform with its standard presumption of 350 kg/ha used with barrier films. The key pests affecting strawberry fruit in Israel are fungi (<i>Rhizoctonia solani</i>, <i>Colletotrichum acutatum</i>, <i>Macrophomina phaseolina</i>, <i>Verticillium dahliae</i>, <i>Fusarium</i> spp.), nematodes (<i>Meloidogyne hapla</i>), and weeds (<i>Cyperus rotundus</i>, purple nutsedge). The Party states that buffer zones (250 m) restrict the use of key alternatives 1,3-D/Pic and MB/PIC 70:30. The Party confirmed that the existing buffers were 250 m for PIC, 100 m for 1,3-D and 100 m for metam sodium. MBTOC urges the Party to consider whether the widespread use of LPBF might reduce the buffers on these alternatives. MBTOC would also like to see data on the technical feasibility of MI/Pic and DMDS on strawberries. MBTOC also urges the Party to consider registration of other alternatives to MB (metham sodium 1,3-D) as well as other formulations of MB/Pic (e.g. 50:50) to assist further reductions in the use of MB. The CUN states that metham sodium showed promising results in the control of <i>Macrophomina phaseolina</i>, but these trials did not lead to a registration of metham sodium on strawberries. Substrates have been used on a small area in this CUN, but the Party states that further uptake is limited by cost, and commercial scale testing are expected in 2010. Detailed economic information on the suitability of such systems is necessary. MBTOC encourages the applicant to consider evaluation and adoption of low-cost substrate systems which are used in similar circumstances in other regions, including warm climates (Mutitu <i>et al.</i> 2006; Vos and Bridge, 2006; MBTOC, 2007; Sonneveld, 2004; Lieten, 2004).</p> <p>MBTOC comments on economics 2008: CUN states that Dazomet is not registered, and that Telone is not available because the supplier has not put it on the market. CUN provides a Table that shows that these alternatives deliver a higher net farm income than MB.</p>									

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Israel	Strawberry runners (Sharon and Ghaza)	None	None	0.000	31.900	None	15.800 (Sharon only)	28.075 (Sharon and Gaza)		
<p>MBTOC comments 2008: MBTOC recommends a reduced CUE of 28.075 tonnes for this use in 2009 (12.25 t for Ghaza Strip and 15.825 t for Sharon, Israel). The key pests affecting strawberry runner production are fungi (<i>Rhizotonia solani</i>, <i>Verticillium dahliae</i>, <i>Fusarium</i>, <i>Phytophthora</i>, <i>Sclerotinia sclerotiorum</i>, <i>Macrophomina phaseolina</i>), root knot nematodes and purple nutsedge. The Party stated that MB 98:2 at a rate of 500 kg/ha (50 g/m²) with standard polyethylene films and 250 kg/ha (25 g/m²) with barrier films are necessary to meet certification standards. The requested amount for the Ghaza region has been adjusted to MBTOC's standard presumption of 35 g/m² for 98:2 MB. The Party stated that 1,3-D + Pic mixture has been the leading alternative; however, adoption of this alternative is limited by the required 250 m buffer which significantly limits its use in the Sharon strawberry nursery growing area, which is heavily populated. Hot gas application method is used in the Ghaza Strip growing area because the plots are small, adjacent to houses and there are no injection tools or qualified applicators in the area. 10% of the treated area in the Ghaza strip will be tested with barrier films with a reduced application rate. MBTOC encourages faster adoption of LPBF in the Ghaza Strip. 100% of the treated area in Sharon uses barrier films (VIF).</p> <p>MBTOC comments on economics 2008: No economic data provided</p>										
Israel	Strawberry runners and Fruit (Ghaza only)						67.500 (Ghaza only)	refer above-		
<p>MBTOC comments 2008:</p> <p>MBTOC comments on economics 2008: CUN argues that the availability of MB for strawberry industry of the Ghaza strip is vital. Without MB growers will not be able to grow the crop and might lose their main source of income, which, it is argued, constitutes 'a genuine case of economic disruption'. No economic data are provided, as there are insufficient data on the use of MB alternatives in Ghaza.</p>										

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Israel	Sweet Potatoes	None	none	None	111.500	None	95.000	95.000		
<p>MBTOC comments 2008: MBTOC recommends 95 tonnes for this use in 2009. Sweet potato is a new crop in Israel that is rapidly expanding in production area. The pest complexes are just being identified and studies to identify alternatives have just commenced. The applicant indicates that MB is currently the only registered chemical for sweet potato production in Israel. The Party however, also states that the expected primary registration of MB alternatives by 2008 and that adoption of these alternatives by 2009 was the basis for the reduced quantity applied for in 2009. Although not clearly stated the Party indicates that 1,3-D/Pic and 1,3-D + metham sodium were effective control alternatives, but registration of 1,3-D has been discontinued by the companies and thus these alternatives are not likely to materialize. Formalin, which is registered for control of common scab on potatoes, is being tested alone and in combination with other chemicals for scab on sweet potatoes. Once efficacy trials are completed registration for formalin will be pursued. By 2009, MB will be applied on 80 ha of nurseries and on not more than 25% of the production area, viz. 300 ha. The MB rates stated in the CUN are consistent with MBTOC's standard presumptions and barrier film use. MBTOC recommends that the Party explore the use of nematode resistant varieties of sweet potato as these are available and widely used in countries where nematodes are the primary pest problem.</p> <p>MBTOC comments on economics 2008: Semi-commercial application of 1,3-D on a total area of 100 ha in the Central Coastal area in 2005 lead to unsatisfactory results and economic losses. Party suggests that Cadusafos is not a front-line nematicide in Israel and it cannot cope with the economic losses inflicted by root-knot nematodes in the Sharon region. CUN argues that the use of 1,3-D 200+MS 400 l/ha will increase the farmers' net margin by 53%, but 1,3-D is not yet registered.</p>										

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Japan	Cucumber	88.300	88.800	72.400	51.450	34.300	None	-	34.100	23.000
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 23 tonnes for this use in 2010. The recommended quantity represents a reduction of 33% from the nominated amount under the same adoption rate criteria already discussed with the Party. MBTOC has considered this nomination, which is based on the need to control particular viruses of cucumber, since 2005. Globally, such viruses are not considered as soilborne pathogens but can survive in crop debris for several years. The problem mainly arises from continuous monoculture. An integrated program including cultural practices e.g. sanitation, rotation with a non-host, removal and destruction of crop debris, cleaning and sanitation of the greenhouse and the surrounded area, and pathogen free seeds has proven very effective in similar situations around the world. The Party has indicated that rotation to non-susceptible hosts such as tomatoes and strawberries is an effective way to reduce virus incidence (Matsuo and Suga, 1993). As a transition strategy, MBTOC urges the Party to increase adoption of LPBF which allow for reducing MB doses by up to 50%. MBTOC has assumed that since the last nomination 1,3-D/Pic mixtures have become registered, however further clarification is required.</p> <p>MBTOC recognises the unique farming system used for cucumber in Japan that has been in place for many years. However, in many countries cucumber production has already shifted to substrates in greenhouse conditions and has become the most widely used technique for eliminating a wide array of soilborne plant pathogens. Inexpensive and simple systems (buckets, bags, etc.) are available for this kind of production and are widely used in around the world. (Leoni and Ledda, 2004; Budai, 2002; Savvas and Passam 2002; Akkaya <i>et al</i>, 2004; Engindeniz, 2004). The Party is encouraged to consider substrate production, which implemented correctly can produce higher yields than MB (MBTOC, 2002, 2007; Batchelor 2000, 2002; Savvas and Passam 2002). Studies conducted in Japan support soilless culture as a feasible option (Fukuda and Anami 2002, Sakuma and Suzuki 1995). MBTOC notes however that even when growing in substrates there is a critical need for a high degree of sanitation and for the use of pathogen free transplants. Large numbers of growers can be trained to use substrates systems in a short period of time as experienced in many MLF projects (TEAP, 2004). The CUN states that the Aichi Agricultural Research Centre (2005) identified the effectiveness of KGMMV control by methyl iodide in pot tests. MBTOC encourages the Party to continue to pursue the registration of methyl iodide for soil uses (methyl iodide was registered for imported timber in Japan in 2004, under JMAFF registration No. 21407).</p> <p>MBTOC comments on economics 2008: The Party states that the nominated amount is nearly half the nominated amount for 2009 and that it is 200 kg below the amount recommended by MBTOC and approved by MOP 19. Further key information provided by the Party is that “Technically and economically feasible alternative technology has not been developed yet.” “For economic feasibility evaluation, it is prerequisite that technically feasible alternative is existed. In fact there is no technically feasible alternative, and accordingly economic evaluation has not been carried out at all.” This CUN shares the same information as CUN for peppers and watermelon. A reference (45) compares costs of soilless systems to MB treatment of soils.</p>										

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Japan	Ginger (Field)	119.400	119.400	109.701	84.075	63.056	None	-	53.400	53.400
		<p>MBTOC comments 2008: MBTOC recommends 53.4 tonnes for this use in 2010. The nomination is for control of <i>Pythium</i> spp. (<i>Pythium ultimum</i> var. <i>ultimum</i>, <i>Pythium zingiberium</i>) in open field cultivated ginger fields using MB (98:2) applied from small cans. MBTOC recognized the difficulties that growers have in adopting some alternatives and the time required to introduce alternatives and new disease management strategies. The CUN states that the fungicide, cyazofamid, controls <i>Pythium</i> efficiently but application rates and methods need to be investigated in more detail. The use of fungicides specific to Oomycetes, such as phosphonates, has been tested but data as to efficacy is not provided. Reduced emission technologies such as LPBF films are now being used and should allow for much reduced dosage rates (e.g. 250 kg/ha (25g/m²) for 98:2 with LPBF). This current nomination provides hope that alternative treatments to MB are now applicable to Japanese production systems for ginger.</p> <p>MBTOC comments on economics 2008: Methyl iodide is not registered and there are concerns about phytotoxicity. Page 5: "Unavailability of technically and economically feasible alternative technology to methyl bromide at present, but reduction and phase-out shall be targeted by combining the existing alternative techniques and developing a reduction program for each region."</p> <p>Economic section compared MB system with untreated, Dazomet, and Metalaxyl. Negative revenues result in the case of all alternatives.</p>								
Japan	Ginger (protected)	22.900	22.900	14.471	11.100	8.325	None	-	8.300	8.300
		<p>MBTOC comments 2008: MBTOC recommends 8.3 tonnes for this use in 2010. The nomination is for control of <i>Pythium</i> spp. (<i>Pythium ultimum</i> var. <i>ultimum</i>, <i>Pythium zingiberium</i>) in protected ginger fields using MB (98:2) applied from small cans. MBTOC recognized the difficulties that growers have in adopting some alternatives and the time required to introduce alternatives and new disease management strategies. The CUN states that Cyazofamid controls pythium efficiently but application rates and methods need to be investigated in more detail. The use of fungicides specific to Oomycetes, such as phosphonates, has been tested but data as to efficacy is not provided. Reduced emission technologies such as LPBF films are now being used and should allow for much reduced dosage rates (e.g. 25g/m² for 98:2 with LPBF). This current nomination provides hope that alternative treatments to MB are now applicable to Japanese production systems for ginger.</p> <p>MBTOC comments on economics 2008: Methyl iodide is not registered and there are concerns about phytotoxicity. Economic section compared MB system with untreated, 1,3-D-Pic, and hot water treatment. Negative revenues result from untreated and 1,3-D-Pic. Hot water results in higher gross revenue but net revenue is 25% of that for MB. This is the same finding as last year. This net revenue decrease demonstrates hot water is not economically feasible.</p>								

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Japan	Melon	194.100	203.900	182.200	136.650	91.100	None	-	90.800	61.000
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 61.0 tonnes for this use in 2010. The recommended quantity represents a 33% reduction from the CUN amount based on transition to available alternatives, e.g. steam, soil less culture, grafting, pathogen free seeds and cultural practices such as rotation and sanitation. MBTOC has considered this nomination, which is based on the need to control a particular virus of melons since 2005. Globally, this virus is not considered as a soil-borne pathogen but can survive in crop debris for several years. The problem mainly arises from continuous monoculture. An integrated program including cultural practices has been proven to be effective in many other countries. The Party has indicated that rotation to non-susceptible hosts such as tomatoes and strawberries is an effective way to reduce virus incidence (Matsuo and Suga, 1993). MBTOC urges the Party to increase adoption of LPBF which allow for reducing MB doses by up to 50%. MBTOC recognises the unique farming system used for melons in Japan that has been in place for many years. However, in many countries some melon production has already shifted to substrates in greenhouse conditions and has become the most widely used technique for eliminating a wide array of soil-borne plant pathogens. Inexpensive and simple systems (buckets, bags, etc.) are available for this kind of production and are widely used in around the world (Leoni and Ledda, 2004; Budai, 2002; Savvas and Passam 2002; Akkaya & Ozkan, 2004; Engindeniz, 2004). Substrate production, when implemented correctly can produce higher yields than MB (MBTOC, 2002, 2006; Batchelor 2000, 2002; Savvas and Passam 2002). Studies conducted in Japan support soil less culture as a feasible option (Fukuda and Anami 2002, Sakuma and Suzuki 1995). MBTOC notes however that even when growing in substrates there is a critical need for a high degree of sanitation and for the use of pathogen free transplants. Large numbers of growers can be trained to use substrates systems in a short period of time as experienced in many MLF projects (UNEP/TEAP, 2004). Resistant root stocks are now available in Japan. However, according to the party, the root stocks are not resistant to all the pathogen races. High yielding varieties resistant to the PMMoV, to bacterial wilt and to Phytophthora are also available. Steam has also been found to control the virus, particularly in the upper soil layer.</p> <p>MBTOC comments on economics 2008: Methyl iodide is not registered and there are concerns about phytotoxicity that call for field trials before adoption. Some success has been achieved with resistant varieties. Economic information is brief. Shows significantly lower gross and net revenue for resistant varieties than with MB. "According to the data of Chiba Chosei district, melon resistant variety to MNSV shows only 73.8% for gross income and 30.8% for net revenue compared with those treated with MB. As mentioned above, fruits of resistant melon to MNSV are not in favor of market evaluation with poorer taste and shape. Furthermore, its yield is not necessarily competitive to the yield of product treated with methyl bromide. So melon of resistant variety is not economically feasible to replace methyl bromide treatment." Furthermore the CUN shows that the market price of the resistant varieties is significantly lower (about 50%) than the conventional variety.</p>										

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
Japan	Pepper (green & hot)	187.200	200.700	156.700	121.725	81.149	None	-	81.100	54.370
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 54.37 tonnes for this use in 2010. The recommended quantity represents a 33% reduction from the CUN based on transition to available alternatives, e.g. steam, soilless culture, resistant varieties, grafting, pathogen free seeds and cultural practices such as rotation and sanitation. MBTOC has considered this nomination, which is based on the need to control a particular virus of peppers (PMMoV) since 2005. Globally, this virus is not considered as a soil-borne pathogen but can survive in crop debris for several years. The problem mainly arises from continuous monoculture. Avoidance is the best means of control. Only seed that has been tested and determined to be free of the virus should be planted. Infected seed can be treated with heat, acid, or trisodium phosphate. In addition to using certified or treated seeds, follow rigid sanitation procedures. All workers that handle the plants, especially smokers, should wash their hands, fingernails, and forearms thoroughly with 70% alcohol or strong soap before handling plants. (Demski 1981, Watter 1984). Some cultivars are resistant to PMMoV. This virus does not affect tomato, eggplant or tobacco, which are in the same family (Solanaceae). Therefore these plants can be introduced in a crop rotation. Cultural practices, resistant varieties, biological control with attenuated virus, soilless culture, soil disinfection by hot water or steam, addition of the organic substance material (Tsuda 2006) should be included in an IPM program. This integrated program has been proven to be effective in many other countries (Demski 1981, Watter 1984, Tsuda 2006). MBTOC urges the Party to increase adoption of LPBF, which allow for reducing MB doses by up to 50%. In many countries some pepper production has already shifted to substrates in greenhouse conditions and has become the most widely used technique for eliminating a wide array of soil-borne plant pathogens. Inexpensive and simple systems (buckets, bags, etc.) are available for this kind of production and are widely used in around the world (Leoni and Ledda, 2004; Budai, 2002; Savvas and Passam 2002; Akkaya <i>et al</i>, 2004; Engindeniz, 2004). Substrate production, when implemented correctly can produce higher yields than MB (MBTOC, 2002, 2007; Batchelor 2000, 2002; Savvas and Passam 2002). Studies conducted in Japan support soil less culture as a feasible option (Fukuda and Anami 2002, Sakuma and Suzuki 1995). Resistant root stocks are now available in Japan. However, according to the Party, the root stocks are not resistant to all the pathogen races.</p> <p>MBTOC comments on economics 2008: The CUN states that there are no technically feasible alternatives and thus no economic evaluation was carried out. See page 9: "For economic feasibility evaluation, it is a prerequisite that technically feasible alternatives exist. In fact there is no technically feasible alternative, and accordingly economic evaluation has not been carried out at all." The CUN notes (page 4 under iii): "Technically and economically feasible alternative technology has not been developed yet. However, farmers might take into consideration the change to another crop. That is one of the reasons why the volume of methyl bromide critical use nomination for 2010 is shown less than for 2009." CUN notes on page 5 that substrates involve high costs for facility construction and difficulty mastering cultivation skill. Economic and technical potential for hydroponic cultivation of several crops is discussed in broad terms. CUN refers to Reference 45, a MAFF document on economics of soilless culture. Reference 45 compares the annualized (1/10 of capital cost for a soilless system) to a threshold limit based on the Agricultural Economics Task Force calculation of \$14.4/kg of MB. Assuming 40 kg of MB at \$14.4 each and converting to yen, results in a limit of 68,008 yen for any alternative to compete with MB. The annual cost for a soilless facility is 550,000 yen, meaning the AETF value placed on the MB to be replaced (68,008 yen) is far lower than the cost of the alternative soilless facility. The AETF value of \$14.4 kg represents a value that A5 governments were willing to accept to phase out MB use in MLF projects. The 550,000 yen for soilless facilities is the estimated annual cost to growers in non-A5 countries to remain in production without MB. Reference 45 goes on to present a budget table comparing soilless culture with MB based production. The conclusion is that net revenue with soilless production is about 80% less than MB net revenue. If the capital cost for a soilless facility is anywhere near the assumed 5,500,000 yen, the impact on grower net revenue will be so large that the soilless alternative should be deemed not economically feasible. Note—Reference 45 conducts similar analyses for soilless production of cucumber and watermelon.</p>										

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Japan	Watermelon	129.000	98.900	94.200	32.475	21.650	None	-	15.400	14.500
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 14.5 tonnes for this use in 2010. The recommended quantity represents a 33% reduction from the amount approved at the 19th MOP and a further reduction based on transition to available alternatives, e.g. steam, soil less culture, grafting, pathogen free seeds and cultural practices such as rotation and sanitation. MBTOC has considered this nomination, which is based on the need to control a particular virus of watermelons since 2005. Globally, this virus is not considered as a soil-borne pathogen but can survive in crop debris for several years. The problem mainly arises from continuous monoculture. An integrated program including cultural practices has been proven to be effective in many other countries. The Party has indicated that rotation to non-susceptible hosts such as tomatoes and strawberries is an effective way to reduce virus incidence (Matsuo and Suga, 1993). MBTOC urges the Party to increase adoption of LPBF, which allow for reducing MB doses by up to 50%. MBTOC recognises the unique farming system used for watermelons in Japan that has been in place for many years. However, in many countries some watermelon production has already shifted to substrates in greenhouse conditions and has become the most widely used technique for eliminating a wide array of soil-borne plant pathogens. Inexpensive and simple systems (buckets, bags, etc.) are available for this kind of production and are widely used in around the world (Leoni and Ledda, 2004; Budai, 2002; Savvas and Passam 2002; Akkaya <i>et al</i>, 2004; Engindeniz, 2004). Substrate production, when implemented correctly can produce higher yields than MB (MBTOC, 2002, 2007; Batchelor 2000, 2002; Savvas and Passam 2002). Studies conducted in Japan support soil less culture as a feasible option (Fukuda and Anami 2002, Sakuma and Suzuki 1995). MBTOC notes however that even when growing in substrates there is a critical need for a high degree of sanitation and for the use of pathogen free transplants. Large numbers of growers can be trained to use substrates systems in a short period of time as experienced in many MLF projects (TEAP, 2004). Resistant root stocks are now available in Japan. However, according to the Party, the root stocks are not resistant to all the pathogen races. High yielding varieties resistant to the PMMoV, to bacterial wilt and to Phytophthora are also available. Steam has also been found to control the virus, particularly in the upper soil layer.</p> <p>MBTOC comments on economics 2008: Key information Page 3: "Technically and economically feasible alternative technology has not been developed yet." Page 8: "For economic feasibility evaluation, it is a prerequisite that technically feasible alternatives exist. In fact there is no technically feasible alternative, and accordingly economic evaluation has not been carried out at all." This CUN shares the same information as CUN for peppers and cucumbers. Refers readers to Reference 45 where costs of soilless systems are compared to MB system.</p>										

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United States	Curcubits	1187.800	747.839	592.891	486.757	407.091	None	-	340.405	266.199
<p>MBTOC comments 2008: MBTOC recommends a reduced CUE of 266.199 tonnes for this use in 2010. From this amount, 89.698 t are for Georgia cucurbits, 156.908 t for the rest of the south east region, 5.72 t for Maryland and Delaware, and 13.875 t for Michigan. The rates reported by the Party in the BUNNIE were not in accordance with the MBTOC rates (125 kg/ha for pathogens and 150 kg/ha for nutsedge, both with barrier films) so they were adjusted. MBTOC acknowledged the reductions made by the Party, however further reductions were made for adoption of alternatives of 25.0% in Maryland/Delaware, 17.0% south east region and 3% for Georgia cucurbits. The Party is urged to further adopt grafting for commercial use in melon and watermelon.</p> <p>MBTOC urges the Party to disaggregate this nomination by major types of cucurbits comprised (melons, watermelons, cucumbers and squash) specifying the key pests in each case; submitting specific updated technical references (when pathogens are the issue); stating the limitations to the adoption of MB alternatives in each case; and indicating specific R&D efforts. In a similar way the Party has submitted, for example the economic information in the CUN. MBTOC notes the effort of the Party in gathering detailed information and understands that only limited information may be information. However, it is difficult for MBTOC to understand and assess the specific circumstances that prevent the use of MB alternatives in each of the crops, when separate data for each different sector is not provided. Since the key pest in the southeast and Georgia is nutsedge, in future nominations the Party is requested to provide up to date from recent trials of fumigants and herbicides trialed for nutsedge control for each specific crop included in the nomination in order to satisfy the requirements of Decision IX/6. MBTOC notes the absence of specific trial data and technical references on cucurbits in the U.S. If trial data from other crops (tomato, pepper) is considered, then alternatives are available for both karst and non-karst areas in Georgia (Noling <i>et al</i> 2006; Roskopf <i>et al</i>, 2005; Gilreath and Santos 2004a; Gilreath <i>et al</i> 2003a, 2005a; Gilreath 1999, Santos <i>et al</i> 2006; Chellemi <i>et al</i> 2004; Chellemi 2006) and can be adopted at least on areas of moderate pest pressure. The Party showed references which supported use of alternatives in combination with LDPF (Culpepper, 2006). Other studies on possible effective alternatives are available (Ristaino and Johnson, 1999, Babadost and Islam 2002, Johnston <i>et al</i> 2002, Driver and Lows 2003). A combination of 1,3-D or metham sodium with chloropicrin + herbicides (Trifluralin, napropamide, halosulfuron, s-metalochlor) is considered as the best alternative strategy in Florida for nutsedge control. The Party reported that research conducted at the University of Georgia examined the use of a 3 way combination of alternative fumigants, 1,3-D followed by chloropicrin followed by metham sodium and this combination was effective. Hausbeck and Lamour (2004) and others have reported many efficient management strategies to control Phytophthora on pepper, including crop rotation with non susceptible hosts (carrots, beans, onions, asparagus, soybeans, alfalfa), cultural control (water management, plant density, soil amendments, protective mulch, raised beds etc.) and use of registered fungicides (Mefonoxan, Dimethomorph, Zoxamide + Mancozeb, Copper hydroxide+dimethomorph). Seed treatment with Mephenoxan or metalaxyl control Phytophthora during seed germination. MBTOC notes that uptake of alternatives for peppers in regions with similar pests has occurred within 4 years or less in many countries e.g. Spain, Italy, Australia (Leoni and Leda, 2004; Spotti, 2004; Tostovrsnik <i>et al</i> 2005; Minuto <i>et al</i>, 2003). The use of grafting and resistant varieties are considered as alternatives for long lasting crops in many Mediterranean countries (Bello, <i>et al.</i>, 2001).</p>										

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	<p>MBTOC comments on economics 2008: The nomination is based on economic arguments. Economic statements provided in CUN. CUN states that the next best alternative in all regions is 1,3-D with chloropicrin with expected yield losses of 6% in Michigan, Maryland and Delaware and 29% 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 in 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. The 3 way research conducted at the University of Georgia is feasible and the CUN was adjusted to reflect this reduction in southern states in areas that do not face Karst geology issues as a replacement of a MB+ Pic spring time application.</p>									
United States	Eggplant (field)	76.721	82.167	85.363	66.018	48.691	None	-	34.732	26.149
	<p>MBTOC comments 2008: MBTOC recommends 26.149 tonnes for this use in 2010. From this amount 11.860 t is for Georgia, 12.036 t for Florida and 2.25 t for Michigan. A reduction of 4.574 t has been made to account for implementation of MBTOC's standard presumptions. Overall the Party's request of 34.732 t represents a reduction of 29% from the amount approved by the Parties in 2009 due to a significant reduction to alternatives in Georgia which is acknowledged by MBTOC, however there is little transition in Michigan and an increase in MB use in Florida. As alternatives are available for a portion of the nomination in Florida, a reduction of 28% of the nominated amount was made to account for uptake of alternatives. MBTOC notes that this recommended amount exceeds that approved for this region at the 19th MOP by 1.07 t and also that the area of usage had increased by 28%. In Michigan, the key pests are <i>Phytophthora capsici</i>. According to the Party, <i>P. capsici</i> has been found in the irrigation water in Michigan and occurred after soil treatment with 1,3-D/Pic and metham sodium; however MBTOC considers reinfestation can occur with any fumigants, including MB. MBTOC recognizes the Party's statement that 1,3-D/Pic may be an effective alternative, but growers will miss the optimal market window due to longer plant back times with this alternative. According to the Party, this treatment cannot be applied in autumn because of climatic conditions. In addition, a fall application of methyl bromide is not feasible because over the fall and winter months deer and other animals damage the plastic and irrigation tape. In Florida, the key pests are yellow and purple nutsedge, Phytophthora, nematodes, Pythium and Sclerotinia. In Georgia the key pests are yellow and purple nutsedge, Phytophthora, nematodes, southern blight, Pythium and Sclerotinia. Karst topography limits the use of alternatives which include 1,3- D that are the best alternatives for these pests on 40% of the growing acreage in Florida and 8% of the acreage in Georgia. A soil treatment recently developed by the University of Georgia is emerging as a promising methyl bromide replacement for Georgia's solanaceous spring crops, although not for the summer or fall crops. This treatment, known as UGA-3-WAY, consists of three successive soil fumigations, beginning with a 1,3-D (Telone II) application, followed by a chloropicrin application, followed by a metham application. Hausbeck and Lamour (2004) and others have reported many other efficient management strategies to control Phytophthora on pepper in Michigan including 3-4 years crop rotation with non susceptible hosts (carrots, beans, onions, asparagus, soybeans, alfalfa), cultural control (water management, plant density, soil amendments, protective mulch and raised beds) and use of registered fungicides in Michigan (Mefonoxan, Dimethomorph, Zoxamide + Mancozeb). The use of grafting is considered an alternative in many Mediterranean countries (Bello <i>et al.</i>, 2001). It is important to report that MB is not used any more in the European Community on eggplant.</p>									

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	<p>MBTOC comments on economics 2008: The nomination is based on economic arguments. Economic statements provided in CUN.This treatment, known as UGA-3-WAY, consists of three successive soil fumigations, beginning with a 1,3-D (Telone II) application, followed by a chloropicrin application, followed by a metam application. Further small plot and large-scale, on-farm research on various aspects is underway. In addition, the economics of transitioning to this alternative, including the cost and durability of films and the modification of fumigation equipment, still needs to be worked out. CUN states next best alternative in all regions is 1,3-D with chloropicrin with expected yield losses of 6% in Michigan and 29% in Georgia and Florida. CUN states 1,3-D with chloropicrin is considered technically feasible in Michigan. In Michigan, since the fall crop is dependent upon timely planting, the required waiting period would cost growers half the harvest season, thereby missing the higher market windows.</p>									
United States	Forestry nursery	192.515	157.694	122.032	131.208	122.060	None	-	120.853	117.826
	<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 117.826 tonnes for this use in 2010, which includes 66.3 t for Southern Forest Nursery, 4.94 t for International Paper, 13.78 t for Weyerhaeuser (SE), 15.19 t for Weyerhaeuser (NW), 12.096 t for NE Forest & Conservation Nursery, and 5.52 t for Michigan Seedling Assoc. The nominated amount has been adjusted to 260 kg/ha (26 g/m²) for nutsedge control and 200 kg/ha (20g/m²) for pathogen to conform to the standard presumption for dosage rate of MB/Pic formulation under HDPE. MBTOC notes that key pests are nutsedge, nematodes and fungi and that propagative material requires a very high level of pathogen control in order to avoid their widespread distribution from the nursery to the production fields. The CUN is for nurseries with moderate or high pest pressure where alternatives are not effective. Nutsedge has no effect on certification but the Party states that it does affect yield by 3-5%. MBTOC requests that further nominations clearly show the trend in yield loss caused by nutsedge, nematodes or fungal pathogens over the number of seasons following fumigation with MB and alternatives and a breakdown of the economic comparisons to methyl bromide treatment. For the Northeast Forest and Conservation Nursery, only 40% is for nutsedge control and 60% of the nomination was adjusted to conform to standard presumptions of 20 g/m². For Michigan Seedlings only 50% is for nutsedge control, so 50% of the nomination was adjusted to 20 g/m². The nomination is for certified forest seedlings produced in 6 forest nursery regions. The CUN is based on economic infeasibility of use of substrates and the lack of effective alternatives for control of nutsedge and a range of fungal pathogens and nematodes. The key alternatives are 1,3-D/Pic, 1,3-D /Pic/metham sodium and metham sodium + Pic. The Party acknowledged that Pic and metham when used in conjunction with LPBF, may provide an effective technical alternative and avoid crop injury. Enebak <i>et al.</i> (2007) found that with LPBF, use rates of MB can be significantly reduced. Party states that glueing of LPBF that is necessary for broadacre fumigation of nursery stock is not commercially available. LPBF will be adopted when the effective glueing technologies are locally, commercially available. MBTOC observed a demonstration of an effective heat welding technique used with barrier films (VIF) that was initially described for use with HDPE for solarization trials in Israel (Grinstein and Hetzroni, 1991; Grinstein, 1992). MBTOC urges the Party to evaluate these technologies in future nominations. MBTOC considers that glyphosate can be used as a pre-treatment to reduce pressure from nutsedge. However, this herbicide has been shown to cause phytotoxicity under nursery conditions. MBTOC acknowledges the initiation of large- scale demonstration trials for this sector by the Party. A report from this trial on the first year of the 5 year trial, indicates that seedling counts similar to MB were achieved by several other treatments, but no indication of pathogen or weed pressure was given (Quicke <i>et al.</i>, 2007). Limited substrate production of these crops is economical for small niche markets. Frequency of fumigation is once in two to four years, depending on the crop. Rotation and cover crops are not fumigated. Research is on-going to reduce rates from 98:2 MB/Pic commonly used where nutsedge populations are severe to using reduced rates of 67:33 MB/Pic. This transition has already been made in 70 % of the forest nurseries in the south where nutsedge populations are not severe.</p>									

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	<p>MBTOC comments on economics 2008: The nomination is based on economic arguments. Economic statements provided in CUN. Alternatives have 3-5% decrease in yield and higher costs resulting in estimated decreases in net revenue that varied from 11 percent to 53 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 of the production cycle. While direct yield losses, in terms of seedlings/hectare, may not be large on average, intensive seedling production relies on the ability of nursery managers to meet quality, as well as yield, goals.</p> <p>Converting the large volume of seedlings to containerized production would require significant investment and much higher costs both at the production stage and for end users planting the seedlings.</p> <p>Economic issues such as increased application costs (e.g., costs associated with application of metam-sodium and a separate chloropicrin application) may have an impact on overall feasibility of these alternatives for the forest seedlings sector.</p>									
United States	Nurseries stock (fruit, nut, flower)	45.800	64.528	28.275	51.102	25.326	None	-	17.954	17.363
	<p>MBTOC comments 2008: MBTOC recommends a total of 17.363 tonnes for this use in 2010. This comprises 9.408 t for raspberries, 0.955 t for roses, and 7.0 t for fruit and nut trees. This nomination is for propagation materials that need to be certified as free of pests and diseases, even if certification is voluntary in this state. MBTOC accepted the rates of 191 kg/ha (19.1 g/m²) for rose nursery and 196 kg/ha (19.6 g/m²) for raspberry nursery, and reduces the rate to 200 kg/ha (20.0 g/m²) for fruit and nut tree nursery to conform to MBTOC's standard presumptions. MBTOC recognises that propagative material requires a very high level of soilborne pest and pathogen control in order to avoid their wide spread distribution and notes the difficulty in protecting raspberry roots to a 1.5 m depth. MBTOC acknowledges the Party's adoption of MB/Pic formulations of 67:33 and 50:50 as is used in other countries. MBTOC acknowledges the federal registration of iodomethane for use in nurseries, but also recognizes that it is not yet registered in California and Washington.</p>									
	<p>MBTOC comments on economics 2008: No economic data or alternatives given</p>									

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United States	Orchard replant	706.176	527.600	405.400	393.720	292.756	None	-	226.021	215.800
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 215.800 tonnes for this use in 2010. This includes reduced amounts of 150.400 t for stone fruit, 7.400 t for raisins, 21.800 t for walnuts, 18.600 t for almond and 17.600 t for wine grapes. The CUN is for orchard/vineyard replant disorder of unknown etiology; heavy soils or soils, which cannot be treated to a sufficient depth to effectively use the reduced rates of 1,3-D now allowed in California. Regulatory constraints (maximum labeled rate) prevent the use of 1,3-D at the rates needed for effective kill of old roots and the associated pathogens in deeper soil layers for heavier (fine-textured) soils. Three alternatives, 1,3-D alone and 1,3-D combined with chloropicrin or metham sodium, are available technical alternatives according to the CUN for treatment in light soils. Although a two year fallow was found to be effective under Mediterranean conditions by Bello, <i>et al</i>, 2004, Schneider, <i>et al</i>. 2004 found that a four year fallow did not sufficiently eliminate the causative nematodes. Recent promising results with a one year fallow combined with non-Nemaguard rootstock have been reported by McKenry (2006). The Party confirms that MB/Pic 67:33 formulation is used for California Stone fruit, Raisin grapes and Wine grapes and now as well for Almond and Walnut. Commercial adoption of 67:33 formulation and others containing lower amounts of MB (eg 50:50) were used predominantly for orchard replant treatment in other countries before switching to alternatives. The recommended reduced amount is based on application of MBTOC's standard presumption of 200 kg/ha (20 g/m²) for control of pests and pathogens without the use of LPBF. This represents a reduction of 10.221 tonnes or 4.5% of the nominated amount. MBTOC recognizes that regulatory restraints prevent the use of LPBF barrier films with methyl bromide in California but urges the Party to consider continued evaluation of their use to improve the performance of alternatives. MBTOC acknowledges the federal registration of iodomethane for use in orchard replant, but also recognizes that it is not yet registered in California.</p> <p>MBTOC comments on economics 2008: The nomination was not based on economic arguments. Economic statements provided in CUN: In experimental plots, spot treatments (individual holes) rates of 0.2 to 0.5 kg chloropicrin per hole were at least as effective as methyl bromide. Technical issues remain with individual treatments including high labor costs. An economic analysis was not done for this sector because most of the losses cannot be quantified. Factors that contribute to losses include delayed planting, fallow, additional use of herbicides, tree loss, replant costs to replace tree losses, loss of trees replanted, yield loss of fruit or nuts, delayed achievement of full yield potential, earlier loss of productivity of whole orchard. McKenry 1999, suggests that in some cases tree losses are likely to be greater than 20 %. An economic assessment for 1,3-dichloropropene, 1,3-dichloropropene + chloropicrin, and 1,3-dichloropropene + metam-sodium, which were alternatives that were assessed as conditionally technically feasible, was made. The economic assessment of feasibility for pre-plant uses of methyl bromide, such as for orchard replant, included an evaluation of economic losses from three basic sources: (1) yield losses, referring to reductions in the quantity produced, (2) quality losses, which generally affect the price received for the goods, and (3) increased production costs, which may be due to the higher-cost of using an alternative, additional pest control requirements, and/or resulting shifts in other production or harvesting practices. In response to further MBTOC questions, the Party responded: "The lowest cost alternative to methyl bromide was 1,3-dichloropropene and ranged from a savings of US\$8 to US\$1,700/ha, including the cost of application. We assumed that this alternative is associated with the higher yield losses and replacement rate since it provides narrower control than when it is used in conjunction with chloropicrin or metam-sodium ... Economic losses in this scenario arise primarily from higher establishment costs caused by the necessity of replacing trees that succumb to the replant disorder. Additional losses occur due to the delay in establishing the orchard and in yield losses suffered by trees that are weakened, but not killed, by the pest complex comprising the replant problem. Despite reductions in fumigation costs, economic losses over the life span of the orchards could range from US\$1,600/ha in walnuts to nearly US\$7,000/ha in stone fruit and represent between 15 and 93 percent of value of the orchard."</p>										

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
United States	Ornamentals	154.000	148.483	137.835	138.538	107.136	None	-	111.391	92.912
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 92.912 tonnes for this use in 2010. This includes 57.963 t for California, 2.299 t for Michigan, 0.130 t for New York and 32.520 t for Florida. The nomination is for a large number of species, mostly grown in the field. In Florida, the main species using MB are gladioli, lilies and snapdragon. Additional species using MB in California include calla lily, delphinium, dianthus, eustoma, freesia, helianthus, hypericum, iris, larkspur, liatris, matthiola, and ranunculus. In Michigan, flower crops needing methyl bromide are herbaceous perennials grown from seed or root divisions. A new application was submitted for production of <i>Anemone coronaria</i> cut flowers in New York. MB is needed to control diseases (e.g., <i>Fusarium</i> spp., <i>Pythium</i> spp., <i>Phytophthora</i> spp., and <i>Rhizoctonia</i> spp.), plant parasitic nematodes (e.g., root knot, root lesion, stunt and dagger), weeds (e.g. <i>Cyperus</i> spp., <i>Portulacca</i>, <i>Ambrosia</i> and others), and previous crop propagules. MBTOC adjusted the California portion of the nomination to standard dosage rates from 211 kg/ha (21.1 g/m²) to 200kg/ha (20 g/m²) with standard polyethylene films. Similarly, the Florida and New York portions of the nomination have been adjusted from 224 kg/ha (22.4 g/m²) and 734 kg/ha (73.4 g/m²) respectively to the standard dosage rate of 200 kg/ha (20 g/m²). An adoption rate of 10% for phase in of alternatives proved to be effective for some flower types: in California for example 1,3-D/Pic, MS and combinations (Klose <i>et al</i>, 2007) and in Florida, for example 1,3-D/Pic and solarisation sometimes combined with chemicals (McSorley <i>et al</i>, 2006 ab). In Michigan, the recommended amount includes a 15% reduction to account for uptake of a newly registered alternative, methyl iodide, which has been shown to be effective (i.e. Uhlig <i>et al</i>, 2007) plus other registered and validated options such as 1,3-D, Pic and MS. MBTOC considers alternatives are available and are in use for anemone cut flower production particularly substrates (Rea <i>et al</i>, 2008). In future nominations MBTOC requires specific information as to areas that cannot be treated with MB using injection machinery.</p> <p>MBTOC comments on economics 2008: The nomination was not based on economic arguments. Economic arguments provided in the CUN: The economic analysis shows decreases in yield in California of 20% to 25% result in negative net revenues. In Florida net revenues decrease 65% to 81% because of yield losses with alternatives. In Michigan herbaceous perennials, yield losses of 25% lead to net revenue declines of 37%. Although container production may be possible in higher value cut flower crops, it is not generally feasible, especially for deeper rooted crops and on large acreage. Soilless systems are not a feasible alternative for the crops in the nomination due to high costs and the risks involved. High fuel oil costs also affect the economic feasibility of steam sterilization. In New York, there are additional costs due to a state requirement for an on-site operating engineer for high pressure steam. Generally, for most crops, there isn't an offsetting yield or quality increase to defer the costs associated with substrate production. Costs include a large increase in inputs, capital expenditures for the systems coupled with high costs of potting mix or substrates, plus the labor to move crates or install the system. Alternatives generally require more labor, which is often unavailable.</p>										

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
United States	Peppers (field)	1094.782	1,243.542	1,106.753	756.339	548.984	None	-	658.952	457.299
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 457.299 tonnes for this nomination. This represents 23.850 tonnes for the SE, 63.600 tonnes for Georgia, 361.348 tonnes for Florida and 8.500 tonnes for Michigan. MBTOC acknowledged the reductions made by the Party. Reductions represent a further transition rate of 18.04% Florida for adoption of alternatives in Karst and non-Karst areas of Florida only, a reduction of 12.2% in Georgia and 25% in Michigan based on adoption of iodomethane and a reduction to meet MBTOC standard presumptions. In the SE, the Party's nomination demonstrated significant transition to alternatives and the nominated amount was only adjusted to agree to MBTOC standard presumptions (125 kg/ha (12.5 g/m) for pathogens and 150 Kg/ha (15 g/m) for nutsedge). The Party did not request MB for California or for research. The key pests of peppers in Michigan are <i>Phytophthora capsici</i> and in the Southeastern United States, including Florida and Georgia, nutsedge and <i>P. capsici</i>. In Michigan, <i>P. capsici</i> has been found in the irrigation water in Michigan and occurred after soil treatment with Telone C35 and metham sodium. However MBTOC considers reinfestation can occur with any fumigants, including methyl bromide. 1,3-D/chloropicrin may be an effective alternative but the Party states growers will miss the optimal market window. According to the Party, this treatment cannot be applied in autumn because of climatic conditions. In Florida and Georgia the Party states that karst topography limits the use of alternatives which include 1,3-dichloropropene, which are considered the best alternatives for these pests, on 70% of the growing acreage in Florida and 8% of the acreage in Georgia. The Party has stated that metham sodium and metham potassium are promising alternatives. MBTOC, however, considers that alternatives are available for both karst and non-karst areas in Florida and Georgia (Noling <i>et al</i> 2006; Roskopf <i>et al</i>, 2005; Gilreath and Santos 2004a; Gilreath <i>et al</i> 2003a, 2005a; Gilreath 1999, Santos <i>et al</i> 2006; Chellemi <i>et al</i> 2004; Chellemi 2006) and can be adopted at least on areas of moderate pest pressure. The Party showed references which supported use of alternatives in combination with LDPF (Culpepper, 2006). Other studies on possible effective alternatives are available (Ristaino and Johnson, 1999, Babadost and Islam 2002, Johnston <i>et al</i> 2002, Driver and Lows 2003). A combination of 1,3-D or metham sodium with chloropicrin + herbicides (Trifluralin, napropamide, halosulfuron, s-metalochlor) is considered as the best alternative strategy in Florida for the nutsedge control. The Party reported that research conducted at the University of Georgia examined the use of a 3 way combination of alternative fumigants, 1,3-D followed by chloropicrin followed by metham sodium and this combination was effective. Hausbeck and Lamour (2004) and others have reported many efficient management strategies to control Phytophthora on pepper, including crop rotation with non susceptible hosts (carrots, beans, onions, asparagus, soybeans, alfalfa), cultural control (water management, plant density, soil amendments, protective mulch, raised beds etc.) and use of registered fungicides (Mefonoxan, Dimethomorph, Zoxamide + Mancozeb, Copper hydroxide+dimethomorph). Seed treatment with Mephenoxan or metalaxyl control Phytophthora during seed germination. MBTOC notes that uptake of alternatives for this crop in regions with similar pests has occurred within 4 years or less in many countries e.g. Spain, Italy, Australia (Leoni and Leda, 2004; Spotti, 2004; Tostovrsnik <i>et al</i> 2005; Minuto <i>et al</i>, 2003). The use of grafting and resistant varieties are considered as alternatives for long lasting crops (at least 6 months) in many Mediterranean countries (Bello <i>et al</i>, 2001).</p> <p>MBTOC comments on economics 2008: The nomination was based on economic arguments. Economic arguments provided in the CUN:CUN states next best alternative in all regions is 1,3-D with chloropicrin with expected yield losses of 6 percent in Michigan and California and 29 percent in other regions. CUN states 1,3-D with chloropicrin is considered technically feasible in Michigan. In Michigan, delayed planting and harvest with the alternatives results in lower average price (7.5%) received from missed market windows, and negative net revenue. In remaining regions yield losses significantly reduce net revenues. In southern states USG has reduced the request for MB to reflect the apparent feasibility of a 3 way combination (1,3 D followed by chloropicrin followed by metam-sodium) as a replacement for spring time application of MB and pic in the non-karst geographical areas. A transition rate was applied based on the best estimate of yield losses and feasibility associated with likely methyl bromide alternatives and use of high barrier films that could be made by USG biologists and economists.</p>										

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
United States	Strawberry (field)	2,052.846	1,730.828	1,476.019	1,349.575	1,269.321	None	-	1,191.815	998.063
<p>MBTOC comments 2008: MBTOC recommends a reduced CUE of 998.063 tonnes for this use in 2010. This comprises 855.736 t for California, 37.306 t for Eastern USA and 105.020 t for Florida. For California, the Party nominated 952.543 t, and increased the area of usage compared to that requested for 2009. The nomination is based on the grounds that township caps limit further adoption of 1,3-D and county regulations affect use of high rates of Pic in some counties. The BUNNIE assumed a yield loss of 14%, however data in the nomination showed that specific alternative treatments provide equal or higher yields compared to MB. Alternatives based on 1,3-D, Pic and metham sodium have been adopted. In the areas affected by township caps, trials with alternatives that do not contain 1,3-D (such as Pic, Pic EC, Pic + metham, Pic + dazomet, often with LPBF) provide yields that are statistically comparable with MB (Ajwa et al., 2002, 2003, 2004, 2005, 2006; Nelson et al., 2001ab; Shem-Tov et al., 2005, 2006ab). Pic EC provided an average 99% yield compared to MB, with low variance (TEAP, 2006). For California, based on 2009 projected data provided by the Party in 2008 and the BUNNIE, MBTOC assumes that neither 1,3-D nor Pic can be used on an area of 4366 ha, which is equivalent to 855.736 t (196 kg/ha). This calculation assumes that Pic based alternatives can be used on 50% of the area in counties subjected to Pic regulations. LPBF cannot be used with MB in California, but these films can be used with alternatives and can reduce the dosage rates required for effective pathogen and weed control. MBTOC encourages the Party to consider regulations which allow adoption of LPBF and other techniques that result in improved efficacy at lower application rates and/or reduced emissions that would result in more use of alternatives under township cap, VOC regulations and county commissioner constraints on Pic.</p> <p>For Eastern states the Party nominated 75.832 tonnes. The nomination is based on moderate to severe pest pressure (<i>Meloidogyne spp.</i>, <i>Pythium</i>, <i>Rhizoctonia</i>, <i>Phytophthora cactorum</i>, <i>Cyperus esculentus</i>, <i>C. rotundus</i>, <i>Lolium spp.</i>) affecting 37% of the crop area, and small farm buffer zones on 40% of the area which affects use of 1,3-D formulations. MBTOC considers that alternatives are available for part of the CUN area (on both buffer and non buffer areas) by use of combinations of 1,3-D, Pic and/or metham with herbicides (Ferguson et al. 2001; Sydorovich et al. 2004, 2006; Driver et al. 2005; López-Aranda et al. 2005; Norton et al. 2002; Gilreath et al. 2003c; studies cited in TEAP 2006). MBTOC accordingly reduced the nomination to allow for transition to alternatives and MB dose adjustment to 125 kg/ha (12.5 g/m²) for the areas of low nutsedge pressure affected by buffer zones (allowing 150 kg/ha (15.0 g/m²)) for the high pest pressure areas). In addition, MI/Pic is currently registered and technically feasible for the total nomination, and a further reduction has been made for its uptake.</p> <p>For Florida, the Party nominated 163.440 t. The nomination is based on the grounds that currently available alternatives are not able to control moderate-severe nutsedge (37% of area), 1,3-D is restricted in karst/seepage areas (63%), and economic issues. MBTOC considers that alternatives are available for part of the CUN area on both karst and non karst areas by use of combinations of 1,3-D, Pic, metham with herbicides and LPBF as studies provide evidence for yields that are statistically similar to MB (Gilreath et al. 2003bc; Norton et al. 2002; Ajwa et al. 2003, 2004, 2005,2006; López-Aranda et al. 2005; studies in TEAP 2006). Accordingly the nomination was reduced to 105.020 t to allow for transition to alternatives and dose adjustments to 12.5 kg/ha on areas of low nutsedge pressure or 150 kg/ha (15.0 g/m²) for high pest pressure areas with use of barrier films to conform to MBTOC's standard presumptions.</p>										

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
	<p>MBTOC comments on economics 2008: The nomination was not based on economic arguments. Economic comments provided in the CUN: CUN reports costs for three next best alternatives for California, Florida, and Eastern United States. 1,3-D with chloropicrin is reported to reduce yield by 10% to 14%. Resulting lower production leads to large losses of net revenue. Planting and harvesting delays with alternatives are reported to lead to lower average prices received in all regions, but are only shown in the revenue analysis for California. In the eastern U.S. strawberry production areas a transition to high barrier films should be feasible also, although possibly at a slower rate compared to Florida, primarily due to economic issues and diversity of the growing conditions. In addition, according to the California Strawberry Commission, the limitation in use of the primary alternative, 1,3-D/chloropicrin, is further limited by higher production costs due to longer production timeline for drip-applied fumigation. Economic analysis indicates that alternatives to methyl bromide can be economically feasible, but wide variability of efficacy and costs exist depending on the area within the region (Sydorovych, et al., 2006)</p>									
United States	Strawberry runners	54.988	56.291	4.483	8.838	7.944	None	-	7.381	4.690
	<p>MBTOC comments 2008: MBTOC recommends 4.69 tonnes for California, but does not recommend amounts for the south east. The CUN comprises 4.69 tonnes for California and 2.691 tonnes for SE. The key pests affecting strawberry runners are weeds (purple and yellow nutsedge), fungi (<i>Rhizoctonia</i> and <i>Pythium spp</i> in SE, <i>Phytophthora</i>, <i>Verticillium</i> in California), nematodes (root-knot, sting in CA). The CUN is for MB use on 28 ha of 2172ha, however a large proportion of hectares are exempted under QPS. MBTOC does not recommend use of MB for North Carolina and Tennessee, as MI/Pic formulations are registered and are technically suitable (TEAP, 2006). MBTOC believes distribution of MI/Pic across 11 ha should be very rapid and training is possible within the two year period for total adoption. For California, MBTOC recommends the nomination, but expects that future nominations will show reports of trials with key over the last few years in order to satisfy the criteria of Decision IX/6. In addition, MBTOC requests that locations receiving runners be specified in the nomination. The CUN states that MB at a dosage of 26.3 g/m² in CA and 25.5 g/m² in SE is required to meet the certification standards for strawberry runners. The Party's request exceeds MBTOC's standard presumption of 200 kg/ha (20 g/m²) of MB which is considered effective for production of 'high health' strawberry runners using LPBF and other emission control technologies (TEAP 2005); however, California's certification requirements specify minimum amounts of MB that must be applied. Furthermore, California regulations prohibit the use of LPBF with MB. The Party indicates that key alternatives include 1,3-D + PIC followed by dazomet, PIC followed by dazomet and MI/Pic, but that these have not been sufficiently tested on a commercial scale. MBTOC encourages the Party to expedite the commercial scale testing of these alternatives as well as the registration of MI in CA and to consider changes to there certification regulations in CA.</p> <p>MBTOC comments on economics 2008: The nomination was not based on economic arguments. Economic statements provided in CUN: 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. Certification requirements for strawberry nurseries (e.g., CDFA, 2003; TDA, 1999; NCDA, 1985) associated with the requesting states are strict—zero tolerance for any damaging diseases and plant-parasitic nematodes. Since there are no markets for plants that do not meet the certification standards, losses up to 100% are possible when inadequate pest control occurs. Failure to adequately manage pests in transplants will jeopardize the viability of the transplant and fruit production industries in the U.S., as well as the viability of fruit production in countries that purchase U.S. plants (e.g., Canada, Mexico, Spain, countries in South America, and others).</p>									

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
United States	Sweet Potatoes slips	None	0.000	0.000	18.144	18.144	None	-	18.144	14.515
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 14.515 tonnes for this use in 2010. 1,3-D, the alternative to MB, cannot be used in Dec-Jan and township caps are exceeded in Nov, which is the fumigation window for slips. MBTOC recognizes the importance of producing pest free seed stock. Test of reduced rates of 1,3-D are being carried out as this is the preferred fumigant of growers. Growers also will have available a desirable nematode resistant cultivar (Bienville) that will be available in California over the next two years should be useful in managing nematode pests. Uptake of such varieties by growers and new alternatives such as non host cover crops followed by application of registered nematicides (ethoprop, aldicarb, metam sodium) is expected to reduce the quantity of MB use and thus MBTOC recommends a reduced quantity for MB for 2010.</p>										
<p>MBTOC comments on economics 2008: The nomination was not based on economic arguments. No economic data on alternatives given. Factors that contribute to losses include delayed planting due to use of alternatives; fallow; additional use of herbicides; losses due to weeds, insects and diseases resulting in smaller, less attractive produce (quality loss).</p>										

Country	Industry	Quantity approved for 2005 (1ExMOP and 16MOP)	Quantity approved for 2006 (16MOP +2ExMOP+ 17MOP)	Quantity approved for 2007 (MOP17+ MOP18)	Quantity approved for 2008 (MOP18+ MOP19)	Quantity approved for 2009 (MOP19)	Quantity nominated for 2009 (additional or new)	MBTOC recommendation for 2009 (additional or new)	Quantity nominated for 2010 (new)	MBTOC recommendation for 2010 (new)
United States	Tomatoes (field)	2,876.046	2,476.365	2,065.246	1,406.484	1,003.876	None	-	994.582	704.715
<p>MBTOC comments 2008: MBTOC recommends a reduced amount of 704.715 tonnes for this use in 2010. This represents 12.315 t for Michigan, 6.75 t for Maryland, 128.960 t for SE, 32.072 t for Georgia and 530.691 t for Florida. MBTOC acknowledged the reductions made by the Party. Reductions represent a further transition rate for adoption of alternatives in Karst and non-Karst areas, a reduction of up to 25% for adoption of iodomethane and a reduction to meet MBTOC standard presumptions (125 kg/ha (12.5 g/m²) for pathogens and 150 kg/ha for nutsedge). In Michigan and the SE, the Party's nomination demonstrated significant transition to alternatives and the nominated amount was adjusted to agree to MBTOC standard presumptions. In Georgia and Maryland, the nominated amount was adjusted by 22.66 and 25% for uptake of alternatives and to agree to MBTOC standard presumptions. In Florida, the nominated amount was adjusted to agree with the standard presumptions and adjusted by 18.04% for transition to alternatives, such as 1,3-D/Pic and metham sodium combinations. Further reductions of 18.71% for Michigan, 24.51% for SE and 25.0% for Georgia were made for transition to iodomethane/Pic combinations, which were registered in these states in 2008. The key pest of tomatoes in the southeastern United States, including Florida and Georgia are nutsedge, nematodes and <i>P. capsici</i>. In Florida and Georgia, karst topography limits the use of 1,3-dichloropropene, which is considered as one of the best alternatives for these pests, on 55% of the growing acreage in Florida, 11% in Georgia and 6% of the acreage in SE. The Party stated that metham sodium and metham potassium are promising alternatives. MBTOC considers that alternatives are available for both karst and non-karst areas in SE, Florida and Georgia, which can be adopted at least in areas of moderate pest pressure (Noling <i>et al.</i> 2006; Santos <i>et al.</i> 2006; Noling and Gilreath 2004; Gilreath and Santos 2004bc; Gilreath <i>et al.</i> 2002, 2003, 2004, 2005bc, 2006; Roskopf <i>et al.</i> 2005; Chellemi and Browne, 2006; McMillan and Bryan 1998, 1999, 2002; Rich and Olson 2003). The Party provided references, which supported use of alternatives in combination with LPBF (Culpepper, 2006). Other studies on possible effective alternatives are available (Ristaino and Johnson (1999), Babadost and Islam (2002), Johnston <i>et al.</i> (2002), Driver and Lows (2003). A combination of 1,3-D or metham sodium with chloropicrin + herbicides (Trifluralin, Devrinol, napropamide, halosulfuron, s-metalochlor) is considered as the best alternative strategy in Florida. Hausbeck and Lamour (2004) and others have reported many efficient management strategies to control <i>Phytophthora</i> on vegetables, including crop rotation with non susceptible hosts (carrots, beans, onions, asparagus, soybeans, alfalfa), cultural control (water management, plant density, soil amendments, protective mulch, raised beds etc.) and use of registered fungicides (Mefonoxan, Dimethomorph, Zoxamide + Mancozeb, Copper hydroxide-dimethomorph) and seed treatment with Mephenoxan or metalaxyl. MBTOC considers that further reductions in MB amount is possible with changes to formulations of 50:50 MB/Pic or less (e.g. to 30:70) used in combination with barrier films, however the reduction in the nominated amount was not based on use of these formulations. The use of grafting and resistant varieties are considered as alternatives in many Mediterranean countries (Bello <i>et al.</i>, 2001).</p>										

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		<p>MBTOC comments on economics 2008: The nomination was based on economic arguments. Economic statements provided in the CUN: CUN reports yield losses for 1,3-D with chloropicrin as the next best alternative ranging from 1.75% to 6%. Net revenue declines reported for all regions. Changes in pest control costs are less than 4 percent of total variable costs so have little impact on economic measures. Missed market window in Michigan cited as main reason. Recent research by Gilreath and Santos (2008) has demonstrated that metam sodium fumigant system resulted in reduced root galls, nutsedge stands, and an increase in tomato yield. Assuming that an herbicide is used that is as effective as pebulate, growers using a 1,3-D + chloropicrin + herbicide mixture may suffer an average of 0 to 27% yield losses (Santos et al, 2006; Chellemi <i>et al.</i>, 2006). As the United States has consistently stated, our experience in that a 20% yield loss will force growers to no longer produce a crop. However, in areas of low to moderate pest pressure, information if given a reasonable time frame for the transition. The assessment of need was adjusted to account for this. In areas where karst features are not present it appears that tomato growers can use a combination of three pesticides applied sequentially (1,3-D, pic, and metam) and achieve yields that are comparable to those produced by using methyl bromide for spring crops only.</p>								

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APPENDIX I TO CHAPTER 11

Common Acronyms

1,3-D	1,3-dichloropropene
A5	Article 5 Party
CUE	Critical Use Exemption
CUN	Critical Use Nomination
DOI	Disclosure of Interest
EC	European Commission
EMOP	Extraordinary Meeting of the Parties
EPA	Environmental Protection Agency
EPPO	European Plant Protection Organisation
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
ISPM	International Standard Phytosanitary Measure
LPBF	Low Permeability Barrier Film (including VIF films)
MB	Methyl bromide
MBTOC	Methyl Bromide Technical Options Committee
MBTOC QSC	Methyl Bromide Technical Options Committee Quarantine, Structures and Commodities Subcommittee
MBTOC S	Methyl Bromide Technical Options Soils Subcommittee
MITC	Methyl isothiocyanate
MOP	Meeting of the Parties
MS	Metham sodium
Pic	Chloropicrin
QPS	Quarantine and Pre-shipment
SF	Sulfuryl fluoride
TEAP	Technology and Economics Assessment Panel
US	United States of America
VIF	Virtually Impermeable Film
VOC	Volatile Organic Compound

APPENDIX II TO CHAPTER 11

Decision IX/6

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).

APPENDIX III TO CHAPTER 11

Report of the Sixteenth Meeting of the Parties to the Montreal Protocol (Annex I), Prague, 22–26 November 2004, paragraph 15.

(Decision XVI/4. Review of the working procedures and terms of reference of the Methyl Bromide Technical Options Committee)

“15. An annual work plan will enhance the transparency of, and insight in, the operations of MBTOC.

Such a plan should indicate, among other things:

- (a) Key events for a given year;
- (b) Envisaged meeting dates of MBTOC, including the stage in the nomination and evaluation process to which the respective meetings relate;
- (c) Tasks to be accomplished at each meeting, including appropriate delegation of such tasks;
- (d) Timing of interim and final reports;
- (e) Clear references to the timelines relating to nominations;
- (f) Information related to financial needs, while noting that financial considerations would still be reviewed solely in the context of the review of the Secretariat’s budget;
- (g) Changes in the composition of MBTOC, pursuant to the criteria for selection;
- (h) Summary report of MBTOC activities over the previous year, including matters that MBTOC did not manage to complete, the reasons for this and plans to address these unfinished matters;
- (i) Matrix with existing and needed skills and expertise; and
- (j) Any new or revised standards or presumptions that MBTOC seeks to apply in its future assessment of critical-use nominations, for approval by the Meeting of the Parties.”

APPENDIX IV TO CHAPTER 11

Methyl bromide reduction trends, based on historical rates of adoption in the EC (EC Management Strategy 2007)

Major MB CUEs in 2006	1991 MB use estimate ¹ (tonnes) (ha) (No. MSs)	2005 MB use ² (tonnes) (ha) (No. MSs)	2006 MB licensed (tonnes) (ha) (No. MSs)	Short-listed existing MB alternatives ³	Historical rates of adoption in individual MSs from Table 4.3, Annex 7.A (ha/year per MS)	Predicted adoption trend, from 2006 ⁴
Tomato	> 4980 t > 7000 ha > 12 MS	733 t 2423 ha 4 MS	532 t 1772 ha 2 MS	Fumigants: 1,3-D, Pic, Metam Sodium, Dazomet	up to 838 ha/year/MS	Rate of up to 838 to 1000 plus 1570 ha/year/MS 1 year adoption time
				Grafting on resistant root stock	up to 1000 ha/year/MS	
				Substrates	up to 1570 ha/year/MS	
Strawberry fruit	~ 3420 t	497 t	265 t 2075 ha (900)	Fumigants: 1,3-D, Chloropicrin, Metam Sodium	up to 1627 – 2000 ha/year/MS	Rate of up to 1627 to 2000 plus 60 – 80

¹ Refer to Section 3 for data.

² Use data from Accounting Framework. Hectares calculated on doses stated in CUNs and CUNAs. If not stated, estimated based on mean dosage of MB for this use (tomato: 300 kg/ha; strawberry runners: 300 – 470 kg/ha; strawberry fruit: 100 – 300 kg/ha; cutflowers: 200 – 500 kg/ha; peppers: 150 – 300 kg/ha; mills and food processors: 20 g/m³)

³ Further details and alternatives in Annex 4.C.

Major MB CUEs in 2006	1991 MB use estimate ¹ (tonnes) (ha) (No. MSs)	2005 MB use ² (tonnes) (ha) (No. MSs)	2006 MB licensed (tonnes) (ha) (No. MSs)	Short-listed existing MB alternatives ³	Historical rates of adoption in individual MSs from Table 4.3, Annex 7.A (ha/year per MS)	Predicted adoption trend, from 2006 ⁴
	~ 5200 ha (>8000 ha in yr 2000) > 12 MS	3879 ha 4 MS	ha in 2007) 2 MS	Substrates Resistant varieties	up to 60 – 80 ha / year/MS ?	ha/year/MS 1 year adoption time
Cut flowers	~ 1610 t ~ 1,800 ha > 12 MS	259 t 855 ha 6 MS	140 t 540 ha 3 MS	Fumigants: 1,3-D, Chloropicrin, Metam Sodium, Dazomet Substrates Steam Resistant varieties	up to 313 ha/year/MS up to 60 ha/year/MS up to 917 ha/year/MS ?	Rate of up to 313 plus 60 plus 917 ha/year/MS 1 year adoption time
Pepper	~ 2410 t ~ 3,000 ha > 11 MSs	250 t 1336 ha 3 MSs	123 t 577 ha 2 MSs	Fumigants: 1,3-D, Metam Sodium, Dazomet Substrates	up to 400 ha/year/MS 175 ha / year/MS	Rate of up to 400 plus 175 ha/year/MS 1 year adoption time
Strawberry runners	~ 740 t ~ 930 ha ~ 5 MSs	346 t ~ 1500 ha 4 MSs	353 t ~ 1500 ha 4 MSs	Fumigants: 1,3-D, Chloropicrin, Metam Sodium Plug plants	up to 870 ha/year/MS ?	Rate of up to 870 plus ? ha/year/MS 2 years adoption time

Major MB CUEs in 2006	1991 MB use estimate ¹ (tonnes) (ha) (No. MSs)	2005 MB use ² (tonnes) (ha) (No. MSs)	2006 MB licensed (tonnes) (ha) (No. MSs)	Short-listed existing MB alternatives ³	Historical rates of adoption in individual MSs from Table 4.3, Annex 7.A (ha/year per MS)	Predicted adoption trend, from 2006 ⁴
Mills and food processing structures	640t 12,800,000 m ³ ⁵ ~ 15 MSs	150 t ~7,500,000 m ³ ⁶ 5 MSs	91 t 4,536,000 m ³ 6 MSs	Heat + IPM	up to 3,500,000 – 4,600,000 m ³ / year/ MS	Rate of up to 3.5 to 4.6 plus ? plus ?? plus 0.2 million m ³ /year/MS 1 year adoption time
				Sulfuryl fluoride		
				Phosphine	?	
				Controlled atmosphere	??	
				Modified atmosphere (structures)	200.000 m ³ / year	

⁵ Assuming average dose was about 50 g/m³ in 1991

⁶ Assuming dose of about 20 g/m³

APPENDIX V TO CHAPTER 11 – Part A: Preplant Soil Applications

List of nominated (2005 – 2010 in part) and exempted (2005 – 2009 in part) amounts of methyl bromide granted by Parties under the CUE process for each crop or commodity.

Party	Industry	Total CUN MB Quantities						Total CUE MB Quantities				
		2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009
Australia	Cut Flowers – field	40.000	22.350					18.375	22.350			
Australia	Cut flowers – protected	20.000						10.425				
Australia	Cut flowers, bulbs – protected Vic	7.000	7.000	6.170	6.150			7.000	7.000	3.598	3.500	
Australia	Strawberry Fruit	90.000						67.000				
Australia	Strawberry runners	35.750	37.500	35.750	35.750	29.790	29.790	35.750	37.500	35.750	35.750	29.790
Belgium	Asparagus	0.630	0.225					0.630	0.225			
Belgium	Chicory	0.600	0.180					0.180	0.180			
Belgium	Chrysanthemums	1.800	0.720					1.120				
Belgium	Cucumber	0.610	0.545					0.610	0.545			
Belgium	Cut flowers – other	6.110	1.956					4.000	1.956			
Belgium	Cut flowers – roses	1.640										
Belgium	Endive (sep from lettuce)		1.650						1.650			
Belgium	Leek & onion seeds	1.220	0.155					0.660				
Belgium	Lettuce(& endive)	42.250	22.425					25.190				
Belgium	Nursery	Not Predictable	0.384					0.900	0.384			
Belgium	Orchard pome & berry	1.350	0.621					1.350	0.621			
Belgium	Ornamental plants	5.660						0.000				
Belgium	Pepper & egg plant	5.270	1.350					3.000	1.350			
Belgium	Strawberry runners	3.400	0.900					3.400	0.900			
Belgium	Tomato (protected)	17.170	4.500					5.700	4.500			
Belgium	Tree nursery	0.230	0.155					0.230	0.155			
Canada	Strawberry runners (PEI)	14.792	6.840	7.995	7.462	7.462	7.462	(a)14.792	6.840	7.995	7.462	7.462
Canada	Strawberry runners (Quebec)		1.826	1.826				(a)	1.826	1.826		
Canada	Strawberry runners (Ontario)			6.129						6.129		

Party	Industry	Total CUN MB Quantities						Total CUE MB Quantities				
		2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009
France	Carrots	10.000	8.000	5.000				8.000	8.000	1.400		
France	Cucumber	85 revised to 60	60.000	15.000				60.000	60.000	12.500		
France	Cut-flowers	75.000	60.250	12.000				60.000	52.000	9.600		
France	Forest tree nursery	10.000	10.000	1.500				10.000	10.000	1.500		
France	Melon	10.000	10.000					7.500	6.000			
France	Nursery: orchard, raspberry	5.000	5.000	2.000				5.000	5.000	2.000		
France	Orchard replant	25.000	25.000	7.500				25.000	25.000	7.000		
France	Pepper	Incl in.tomato cun	27.500	6.000					27.500	6.000		
France	Strawberry fruit	90.000	86.000	34.000				90.000	86.000			
France	Strawberry runners	40.000	4.000	35.000				40.000	40.000	28.000		
France	Tomato (and eggplant for 2005 only)	150(all solanaceous)	60.500	33.250				125.000	48.400			
France	Eggplant		27.500	33.250					48.400			
Greece	Cucurbits	30.000	19.200					30.000	19.200			
Greece	Cut flowers	14.000	6.000					14.000	6.000			
Greece	Tomatoes	180.000	73.600					156.000	73.600			
Israel	Broomrape			250.000	250.000	250.000				250.000		
Israel	Cucumber - protected new 2007			25.000	18.750					25.000		
Israel	Cut flowers – open field	77.000	67.000	80.755	53.345	42.777		77.000	67.000	74.540	44.750	
Israel	Cut flowers – protected	303.000	303.000	321.330	163.400	113.821		303.000	240.000	220.185	114.450	
Israel	Fruit tree nurseries	50.000	45.000	10.000				50.000	45.000	7.500		
Israel	Melon – protected & field	148.000	142.000	140.000	87.500	87.500		125.650	99.400	105.000	87.500	
Israel	Potato	239.000	231.000	137.500	93.750	75.000		239.000	165.000	137.500	93.750	
Israel	Seed production	56.000	50.000			22.400		56.000	28.000			
Israel	Strawberries – fruit	196.000	196.000	176.200	64.125	52.250		196.000	196.000	93.000	105.960	
Israel	Strawberry runners	35.000	35.000		20	15.800		35.000	35.000	28.000	31.900	
Israel	Strawberry runners and fruit Ghaza				87.875	67.500						
Israel	Tomatoes			90.000						22.750		
Israel	Sweet potato					95.000					111.500	
Italy	Cut flowers (protected)	250.000	250.000	30.000				250.000	187.000	30.000		

Party	Industry	Total CUN MB Quantities						Total CUE MB Quantities				
		2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009
Italy	Eggplant (protected)	280.000	200.000	15.000				194.000	156.000			
Italy	Melon (protected)	180.000	135.000	10.000				131.000	131.000	10.000		
Italy	Pepper (protected)	220.000	160.000	67.000				160.000	130.000	67.000		
Italy	Strawberry Fruit (Protected)	510.000	400.000	35.000				407.000	320.000			
Italy	Strawberry Runners	100.000	120.000	35.000				120.000	120.000	35.000		
Italy	Tomato (protected)	1300.000	1030.000	418.000				871.000	697.000	80.000		
Japan	Cucumber	88.300	88.800	72.400	68.600	61.400	34.100	88.300	88.800	72.4	51.450	34.300
Japan	Ginger – field	119.400	119.400	112.200	112.100	102.200	53.400	119.400	119.400	109.701	84.075	63.056
Japan	Ginger – protected	22.900	22.900	14.800	14.800	12.900	8.300	22.900	22.900	14.471	11.100	8.325
Japan	Melon	194.100	203.900	182.200	182.200	168.000	90.800	194.100	203.900	182.2	136.650	91.100
Japan	Peppers (green and hot)	189.900	200.700	169.400	162.300	134.400	81.100	187.200	200.700	156.700	121.725	81.149
Japan	Watermelon	126.300	96.200	94.200	43.300	23.700	15.400	129.000	98.900	94.2	32.475	21.650
Malta	Cucumber		0.096						0.127			
Malta	Eggplant		0.128						0.170			
Malta	Strawberry		0.160						0.212			
Malta	Tomatoes		0.475						0.594			
New Zealand	Nursery material	1.085	1.085						0.000			
New Zealand	Strawberry fruit	42.000	42.000	24.780				42.000	34.000	12.000		
New Zealand	Strawberry runners	10.000	10.000	5.720				8.000	8.000	6.234		
Poland	Strawberry Runners	40.000	40.000	25.000	12.000			40.000	40.000	24.500		
Portugal	Cut flowers	130.000	8.750					50.000	8.750			
Spain	Cut Flowers – Cadiz	53.000	53.000	35.000				53.000	42.000			
Spain	Cut Flowers – Catalonia	20.000	18.600	12.840	17.000 (+Andalu cia)			20.000	15.000	43.490 (+Andalu cia)		
Spain	Pepper	200.000	155.000	45.000				200.000	155.000	45.000		
Spain	Strawberry Fruit	556.000	499.290	80.000				556.000	499.290	0.0796		
Spain	Strawberry Runners	230.000	230.000	230.000	215.000			230.000	230.000	230.000		
UK	Cut flowers		7.560						6.050			
UK	Ornamental tree nursery	12.000	6.000					6.000	6.000			

Party	Industry	Total CUN MB Quantities						Total CUE MB Quantities				
		2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009
UK	Strawberry (& raspberry in 2005)	80.000	63.600					68.000	54.500			
UK	Raspberry nursery		4.400						4.400			
USA	Chrys. Cuttings/roses	29.412						29.412	0.000			
USA	Cucurbits – field	1187.800	747.839	598.927	588.949	411.757	340.405	1187.800	747.839	592.891	486.757	407.091
USA	Eggplant – field	76.761	101.245	96.480	79.546	62.789	34.732	76.721	82.167	85.363	66.018	48.691
USA	Forest nursery seedlings	192.515	157.694	152.629	133.140	125.758	120.853	192.515	157.694	122.032	131.208	122.060
USA	Ginger	9.200						9.200	0.000			
USA	Orchard replant	706.176	827.994	405.415	405.666	314.007	226.021	706.176	527.600	405.400	393.720	292.756
USA	Ornamentals	210.949	162.817	149.965	138.538	137.776	111.391	154.000	148.483	137.835	138.538	107.136
USA	Nursery stock - fruit trees, raspberries, roses	45.789	64.528	12.684	51.102	27.663	17.954	45.800	64.528	28.275	51.102	25.326
USA	Peppers – field	1094.782	1498.530	1151.751	919.006	783.821	658.952	1094.782	1243.542	1106.753	756.339	548.984
USA	Strawberry fruit – field	2468.873	1918.400	1733.901	1604.669	1336.754	1191.815	2052.846	1730.828	1476.019	1349.575	1269.321
USA	Strawberry runners	54.988	56.291	4.483	8.838	8.837	7.381	54.988	56.291	4.483	8.838	7.944
USA	Tomato – field	2876.046	2844.985	2334.047	1840.100	1406.484	994.582	2876.046	2476.365	2065.246	1406.484	1003.876
USA	Turfgrass	352.194	131.600	78.040	52.189	0		206.827	131.600	78.04	0	
USA	Sweet potato	224.528			18.144	18.144	18.144				18.144	18.144

APPENDIX V TO CHAPTER 11– Part B: Post-harvest Structural and Commodity Applications

List of nominated (2005 – 2010 in part) and exempted (2005 – 2009 in part) amounts of methyl bromide granted by Parties under the CUE process for each crop or commodity.

Party	Industry	Total CUN MB Quantities						Total CUE MB Quantities				
		2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009
Australia	Almonds	1.900	2.100					1.900	2.100			
Australia	Rice consumer packs	12.300	12.300	10.225	9.200 +1.8	9.200	7.820	6.150	6.150	9.205	7.400	7.820
Belgium	Artefacts and structures	0.600	0.307					0.590	0.307			
Belgium	Antique structure & furniture	0.750	0.199					0.319	0.199			
Belgium	Churches, monuments and ships' quarters	0.150	0.059					0.150	0.059			
Belgium	Electronic equipment	0.100	0.035					0.100	0.035			
Belgium	Empty silo	0.050	0.043					0.050	0.043			
Belgium	Flour mill see mills below	0.125	0.072					See mills below	0.072			
Belgium	Flour mills	10.000	4.170					9.515	4.170			
Belgium	Mills	0.200	0.200					0.200	0.200			
Belgium	Food processing facilities	0.300	0.300					0.300	0.300			
Belgium	Food Processing premises	0.030	0.030					0.030	0.030			
Belgium	Food storage (dry) structure	0.120	0.120					0.120	0.000			
Belgium	Old buildings	7.000	0.306					1.150	0.306			
Belgium	Old buildings and objects	0.450	0.282					0.000	0.282			
Belgium	Woodworking premises	0.300	0.101					0.300	0.101			
Canada	Flour mills	47.200	34.774	30.167	28.650	26.913	22.878	(a)47	34.774	30.167	28.650	26.913
Canada	Pasta manufacturing facilities	(a)	10.457	6.757	6.067	5.319		(a)	10.457	6.757	6.067	
Canada	Commodities					0.068						
France	Seeds sold by PLAN-SPG company	0.135	0.135	0.100				0.135	0.135	0.096		
France	Mills	55.000	40.000	8.000				40.000	35.000	8.000		

Party	Industry	Total CUN MB Quantities						Total CUE MB Quantities				
		2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009
France	Rice consumer packs	2.000	2.000					2.000	2.000			
France	Chestnuts	2.000	2.000	1.800				2.000	2.000	1.800		
Germany	Artefacts	0.250	0.100					0.250	0.100			
Germany	Mills and Processors	45.000	19.350					45.000	19.350			
Greece	Dried fruit	4.280	3.081	0.900				4.280	3.081	0.45		
Greece	Mills and Processors	23.000	16.000	1.340				23.000	15.445	1.340		
Greece	Rice and legumes		2.355						2.355			
Ireland	Mills		0.888	0.611					0.888			
Israel	Artefacts	0.650	0.650	0.600				0.650	0.650			
Israel	Dates (post harvest)	3.444	3.444	2.200	1.800	2.100		3.444	2.755	2.200	1.800	
Israel	Flour mills (machinery & storage)	2.140	1.490	1.490	0.800	0.300		2.140	1.490	1.040	0.312	
Israel	Furniture- imported	1.422	1.422	2.042				1.422	0.000			
Italy	Artefacts	5.500	5.500	5.000				5.225	0.000	5.000		
Italy	Mills and Processors	160.000	130.000	25.000				160.000	65.000	25.000		
Japan	Chestnuts	7.100	6.500	6.500	6.300	5.800	5.400	7.100	6.800	6.500	6.300	5.800
Latvia	Grains		2.502						2.502			
Netherlands	Strawberry runners post harvest		0.120	0.120		0.120			0	0.120		
Poland	Medicinal herbs & dried mushrooms as dry commodities	4.000	3.560	1.800	0.500			4.100	3.560	1.800	1.800	
Poland	Coffee, cocoa beans	(a)	2.160	2.000	0.500				2.160	1.420	1.420	
Spain	Rice		50.000						42.065			
Switzerland	Mills & Processors	8.700	7.000					8.700	7.000			
UK	Aircraft			0.165						0.165		
UK	Mills and Processors	47.130	10.195	4.509				47.130	10.195	4.509		
UK	Cereal processing plants		8.131	3.480				(a)	8.131	3.480		
UK	Cheese stores	1.640	1.248	1.248				1.640	1.248	1.248		
UK	Dried commodities (rice, fruits and nuts) Whitworths	2.400	1.256					2.400	1.256			
UK	Herbs and spices	0.035	0.037	0.030				0.035	0.037			
UK	Mills and Processors (biscuits)	2.525	1.787	0.479				2.525	1.787			
UK	Spices structural equip.	1.728						1.728	0.000	0.479		

Party	Industry	Total CUN MB Quantities						Total CUE MB Quantities				
		2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009
UK	Spices stored	0.030						0.030	0.000			
UK	Structures buildings (herbs and spices)	3.000	1.872	0.908				3.000	1.872	0.908		
UK	Structures, processors and storage (Whitworths)	1.100	0.880	0.257				1.100	0.880	0.257		
UK	Tobacco equipment	0.523						0.050				
UK	Woven baskets	0.770						0.770				
USA	Dried fruit and nuts (walnuts, pistachios, dried fruit and dates and dried beans)	89.166	87.719	91.299	67.699	58.912	43.007	89.166	87.719	78.983	58.921	45.623
USA	Dry commodities/ structures (cocoa beans)	61.519	61.519	64.028	52.256	51.002		61.519	55.367	64.082	53.188	
USA	Dry commodities/ structures (processed foods, herbs and spices, dried milk and cheese processing facilities) NPMA	83.344	83.344	85.801	72.693	66.777	37.778	83.344	69.118	82.771	69.208	54.606
USA	Smokehouse hams (Dry cure pork products) (building and product)	136.304	135.742	40.854	19.669	19.699	4.465	67.907	81.708	18.998	19.699	18.998
USA	Mills and Processors	536.328	505.982	401.889	362.952	291.418	191.993	483.000	461.758	401.889	348.237	291.418

12 Decision XIX/8: Scoping Study on Alternatives to HCFC Refrigerants under High Ambient Temperature Conditions

12.1 Introduction

At MOP-19 in Montreal, the Parties took Decision XIX/8 related to HCFC alternatives and specific climatic conditions, which reads as follows:

1. To request the Technology and Economic Assessment Panel to conduct a scoping study addressing the prospects for the promotion and acceptance of alternatives to HCFCs in the refrigeration and air-conditioning sectors in Article 5 Parties, with specific reference to specific climatic conditions and unique operating conditions, such as those as in mines that are not open pit mines, in some Article 5 Parties;

2. To request the Technology and Economic Assessment Panel to provide a summary of the outcome of the study referred to in the preceding paragraph in its 2008 progress report with a view to identifying areas requiring more detailed study of the alternatives available and their applicability.

In preparing the response to this Decision, the RTOC Co-Chairs under the auspices of the TEAP assembled a preliminary Subcommittee with seven RTOC members from India, The Netherlands and the USA. If needed, the Subcommittee decided to draw on other individuals with specific expertise from Article 5 and non-Article 5 Parties as needed, specifically those engaged in air conditioning design in warm climates and deep mine air conditioning. A summary of the scoping study as requested in XIX/8 can not yet be presented in this TEAP Progress Report, since the start of the work was delayed until the first quarter of 2008 (and is still underway), owing to a number of logistic and technical difficulties. A brief description of the current work-plan can be found below.

The background for Decision XIX/8 is the need for air conditioning in very hot ambient conditions, such as hot climates or deep mines. According to the US National Climate Data Center [NCDC], the highest temperature recorded on Earth was 58°C (136°F) measured at El Azizia, Libya on 13 September 1922. This is approximately one degree Celsius hotter than the record in North America (in Death Valley, CA, on 10 July 1913). The ASHRAE Handbook of Fundamentals [ASHRAE Handbook editions from 1997 and 2005] provides extreme temperatures for many specific locations. Kuwait experiences the maximum annual daily mean temperature in the world, 49.4° C (121°F).

HCFC-22 is the most widely used refrigerant in refrigeration and air-conditioning equipment. It is being phased out globally, and since recently, under an accelerated phase-out schedule in Article 5 Parties, pursuant to Decision XIX/6. Because of this accelerated schedule for Article 5 Parties, the performance of alternatives and replacements to HCFC-22 under extreme weather conditions has become an important issue for commercial refrigeration and unitary air conditioning equipment.

The critical temperature of a refrigerant is an important parameter in the effectiveness of equipment. In the conventional vapour compression cycle the condensing temperature is kept well below the critical temperature, because thermodynamic principles result in declining capacity and efficiency as heat-rejection (refrigerant condensing) temperatures increase and approach the critical temperature. One of the important parameters in the study is therefore

related to the critical temperature of HCFC-22 refrigerant alternatives, next to a large number of other criteria.

The study focuses on four topics, which are elaborated upon below.

12.2 Focus of the Study

12.2.1 Refrigerants for High-ambient Temperature Air Conditioning

The driving concern here is the impact of refrigerant replacements for air conditioners operating at high ambient conditions, such as those operating in equatorial regions, the Middle East, and northern Africa. Most small, packaged, equipment in common usage world-wide employs HCFC-22 as a refrigerant. The primary global replacement, especially for the dominant air-cooled designs, is R-410A, a blend of hydrofluorocarbon (HFC) refrigerants. One component of this blend, HFC-125, has a comparatively low critical point temperature (66°C), resulting in rapidly declining capacity and efficiency as condensing temperatures approach the critical temperature of the blend. Another blend of HFC refrigerants, R-407C, is also used in air conditioning; however, one component of this blend is again HFC-125, with thermodynamic consequences as described above. The RTOC 2006 Assessment Report mentions that, for unitary air conditioning, HFC-134a, HC-290 (propane) and carbon dioxide (R-744) may be the only pure fluid replacement options for HCFC-22.

The scoping study examines the suitability of R-410A, as well as the suitability of a large number of other candidate HCFC-22 alternatives for very hot climates such as encountered in the identified regions. It pays attention to:

- Global Warming Potential,
- capacity at elevated ambient temperatures,
- input power and related impacts on electricity supplies,
- efficiency and its implications for greenhouse gas emissions,
- associated environmental and safety characteristics of the alternatives with focus on the consequences of initial, servicing, accidental, and retirement emissions,
- availability of the alternatives and suitable equipment, and
- associated cost implications.

12.2.2 Refrigerants for High-ambient Temperature Refrigeration

The focal concern is the impact of refrigerant replacements for commercial, transport, and industrial use for food preparation, storage, and marketing operating at high ambient conditions, such as those operating in equatorial regions, the Middle East, and northern Africa. The fundamental concerns are similar to those for unitary air conditioners but for both R-22 and R-502, the latter a blend containing HCFC-22 and a chlorofluorocarbon (CFC-115). This blend has already been phased out in non-Article 5 Parties, and will soon be phased out in Article 5 Parties. The primary replacement for commercial refrigeration world-wide is R-404A, a blend of HFC refrigerants. Two components of this blend are HFC-125 and HFC-143a, both having relatively low critical temperatures; the result is that compression systems show a rapidly declining capacity and efficiency as condensing temperatures approach the critical temperature of the blend.

Whereas R-404A is a primary replacement in commercial refrigeration, the main non-HCFC refrigerants currently used in transport refrigeration and in cold storage are HFC-134a (as well as some R-404A) and ammonia, respectively.

The application conditions for the refrigeration sector differ in several significant ways, among them the temperature at which heat is removed – generally categorised as low temperature (for frozen foods), medium temperature (for fish, meats, and prepared foods), and high temperature (for dairy products and typical beverages) – are colder than for comfort air-conditioning. The equipment used is factory designed and assembled, but systems require a much higher degree of application engineering and often are based on more diverse component selections with more significant piping considerations and burdens. In addition, internal refrigerant volumes and charge amounts generally are much higher, based on application and especially store layouts, and more prone to system and catastrophic failure leakage. The scoping study examines the suitability of R-404A, as well as the suitability of a number of other, possible candidate HCFC-22 alternatives for very hot climates such as encountered in the identified regions. While the application conditions and system options differ, the key examination issues (seven preceding bulleted items) are the same for refrigeration as for high-ambient temperature air conditioning (section 2.1).

12.2.3 Refrigerants for Deep Mines

The questions for deep mines are rather different than for high-ambient temperature operation. The ambient heat rejection (refrigerant condensing) temperatures generally are less extreme. In addition, heat rejection typically employs cooling towers rather than air-cooled condensers, so the governing performance parameter is wet-bulb rather than dry-bulb temperature. Moreover, high-ambient temperature locations actually have an advantage in this regard, since they typically are dryer and have greater wet-bulb depression. Conversely, they often are in regions with more-limited water supplies, evaporated to reject heat (by exploiting the latent heat of vaporisation of water). In contrast, the heat absorption temperatures often are lower for chillers for deep mines, to minimise pumping burdens since equipment generally is installed at the surface. Extra cold water, ice slurries, and less commonly brines or other heat transfer fluids are used for heat transport to depths currently as low as 3.8 km (2.4 miles) with expected extension to depths approach 5 km (3.1 miles) in coming years. The virgin rock temperatures will increase from the current 55°C (131°F) to 59°C (138°F), demanding continuous cooling on year-around basis to enable miners to survive. The required equipment sizes are quite large, resulting in significant energy requirements and heightened concerned with energy-related greenhouse gas emissions. Most mine chillers in the last decade have used HFC-134a, or ammonia (R-717); neither is considered an ozone-depleting substance. However, some older and some small mines use HCFC-22 and some newer installations use HCFC-123 to attain high efficiencies; both are HCFCs. Some recent systems use water (R-718) as a refrigerant in a vacuum, vapour-compression flash cycle to produce ice slurries directly. Some proposed systems would use air (R-729) in air-standard Brayton cycles. Older equipment tends to be retired more quickly, than with systems for comfort conditioning, based on sustained versus intermittent operation. While the technologies are in place to deal with the ODS issue for deep mines, refrigerant questions remain with respect to future acceptability of options. The current plan is to meet with leading mining companies, engineering firms supporting them, researchers, and possibly government contacts to verify the problems and confirm needs; the group then will investigate those issues.

12.3 Prospects for Promotion and Acceptance of Alternatives

This approach for this topic (as explicitly mentioned in XIX/8) will depend on the findings of the three preceding topics.

12.4 Priorities and Time Schedule

In the completion of the scoping study, the priorities of the first three topics are as listed, namely for air conditioning first and for deep mines last. The studies for the three sectors will be limited to technical options for new equipment. Studies are based on an assessment of all available literature published so far on this topic, as well as on modelling using sophisticated models for refrigerant and component (heat exchangers and compressors) properties.

Additional considerations for the three sectors and for existing equipment conversions will be deferred for the next RTOC assessment report, publication of which is scheduled for end 2010, or identified as areas requiring more detailed study (as mentioned in Decision XIX/8).

Where it relates to the parts of the scoping study on air conditioning and refrigeration, the initial analyses for these two topics are being circulated within the Subcommittee. They are planned to be ready for technical review by September-October 2007, so that it should be possible to forward a preliminary summary of the findings to the 20th Meeting of the Parties in Doha, November 2008. The study on air conditioning for deep mines is anticipated to cost more time before finalisation.

The prolonged schedule reflects the time need to complete the study on an unfunded basis without real opportunities for Subcommittee meetings. While information requests and exchanges are already underway for some time, some of the work depends on other planned travel (for example a scheduled travel to South Africa that will facilitate data gathering and consultations).

13 Climate Aspects of Ozone Layer Protection

13.1 Background

The Preamble to the 1987 Montreal Protocol includes the sentence: "Conscious of the potential climatic effects of emissions of these substances," reflecting the recognition that ODSs are greenhouse gases. However, climate protection concerns were secondary in the early implementation of the Protocol because 80% of ODS replacement was with zero-ODP not-in-kind alternatives, most chemical replacements had a lower GWP than the ODS replaced, and it was not yet clear how fast and how far an emerging climate treaty would need to go to accomplish its objectives. The UN Framework Convention on Climate Change (FCCC) was agreed in 1992 (seven years after the 1985 Vienna Convention) and the Kyoto Protocol was agreed in 1997 (ten years after the Montreal Protocol--following the 1995 Berlin Mandate). The Kyoto Protocol does not include the ODSs controlled by the Montreal Protocol, but includes HFCs and PFCs that are alternatives to ODSs in the basket of greenhouse gases. Concerns regarding a number of possible scientific and technical interrelationships between the Montreal and Kyoto Protocols provided the impetus for a number of reports, including:

- The 1998 TEAP Task Force on HFCs and PFCs;
- The 1999 Joint IPCC/TEAP Expert Meeting at Petten Proceedings;
- The Annex to Chapter III in the IPCC Third Assessment report;
- The 2005 IPCC TEAP Special Report on Safeguarding the Ozone Layer (SROC) and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons (SROC); and
- The 2005 Supplement to the IPCC / TEAP Report.

13.2 New Emphasis on Climate in the Montreal Protocol

Following the publication of these reports, the Parties to the Montreal Protocol have sought to harness the potential climate benefits arising from the on-going phase-out of ODSs through a series of further actions. At MOP-17 in 2005, Decision XVII/19 requested the organisation of a one-day Workshop (July 2006) to assess the 'practical measures' identified in the SROC, including assessing the ozone, climate and other benefits of implementing those measures. The outputs of that workshop provided a finalised list of practical measures but no time-related prioritisation. This additional assessment was included in the TEAP Task Force Report responding to Decision XVIII/12 published in August 2007.¹ Other influential reports included a paper published by the National Academy of Sciences about the importance of the Montreal Protocol in protecting the climate, and papers contained in a book commissioned by UNEP celebrating ozone and climate protection.²

¹TEAP, "Report Of The Task Force On HCFC Issues (With Particular Focus On The Impact Of The Clean Development Mechanism) And Emissions Reduction Benefits Arising From Earlier HCFC Phase-Out And Other Practical Measures—Response To Decision XVIII/12," 2007.

² See Guus J.M. Velders et al, "The Importance of the Montreal Protocol in Protecting Climate" (Proceedings of the National Academy of Sciences (vol. 104, no. 12, pp 4814-4819, March 20, 2007,

Following these reports, Parties agreed in Decision XIX/6 at the MOP-19 in 2007, to make additional efforts to protect the climate as ODSs are phased out. They added the principle of climate protection in Decision XIX/6 to the aspects to be considered when taking actions to comply with the Montreal Protocol. Parties also directed the Executive Committee when “developing and applying funding criteria for projects and programmes... (to) give priority to cost-effective projects and programmes, which focus on, inter alia: ... substitutes and alternatives that minimise other impacts on the environment, including on the climate, taking into account global-warming potential, energy use and other relevant factors...” The fact that the Kyoto Protocol excludes ODSs and the previous absence of formal climate considerations under the Montreal Protocol served as factors in drafting the language for the 2007 Montreal Protocol Adjustment on HCFCs in Decision XIX/6.

13.3 Past Climate Protection Contributions by Actions Under the Montreal Protocol

As is now well known, the Montreal Protocol on Substances that Deplete the Ozone Layer has reduced successfully the global production, consumption and emissions of ozone-depleting substances (ODSs). However, it is also well known that most HCFC and HFC substitutes are potent greenhouse gases (GHGs) that can contribute to radiative forcing if emitted. They are used in refrigeration, air conditioning, and thermal insulating foam applications that contribute energy-related carbon dioxide (CO₂) emissions to the atmosphere. Actions taken under the Montreal Protocol have led to the replacement of CFCs with HCFCs, HFCs, and other substances as well as the adoption of not-in-kind products and processes. Because replacement chemicals generally have lower global warming potentials (GWPs), and because total halocarbon emissions have decreased, their combined CO₂-equivalent (direct GWP-weighted) emissions have been reduced, even though some replacements for CFCs and HCFCs still have significant GWPs themselves. In some instances the climate impact of these chemicals can be offset in full or in part by chemical containment practices and end-of-life recovery, recycle and disposal practices. More importantly, making the right choice of alternative substances and technologies can lead to better use-phase energy efficiency and a superior overall lifecycle climate performance (LCCP).

The implementation of the Montreal Protocol has already resulted in significant climate protection through the avoidance or reduction of ODS emissions, which are comparable in magnitude to Kyoto Protocol and other national and regional actions when expressed in CO₂ equivalent. Compared to the original schedule, the acceleration of the HCFC phase-out agreed in 2007 for Article 5 Parties can result in a further significant contribution to climate protection through the selection of the technology with the most favourable LCCP. This can be achieved by:

- Ensuring that energy efficiency is optimised
- Ensuring that emissions of substitute fluorocarbon gases, where used, are well managed (contained, recovered, recycled, and destroyed), or
- Using alternative or substitute fluids with lower GWPs, where possible and appropriate.

Washington DC); and Donald Kaniaru (editor), “The Montreal Protocol: Celebrating 20 Years of Environmental Progress—Ozone layer and Climate Protection,” Cameron May Publishers, 2007, London.

13.4 Future Opportunities for the Montreal Protocol to Further Protect the Climate

Careful consideration could also be given to what might be defined as ‘wise substitution’ strategies. Where rapid phase-out of HCFCs could create unwanted climate consequences, because of the lack of availability of alternative technologies with more favourable LCCP and where compliance with a Party’s ozone obligations can still be achieved by reductions in other applications in which uncompromised alternatives are available, it might still be logical to delay substitution pending further developments. Wise substitution strategies may also require continued use of HFC technologies in applications where HFC phase-out could have unwanted climate consequences, because of the lack of availability of alternative technologies with superior LCCP.

Other opportunities and options exist to further protect both ozone and climate protection, for both Article 5 and non-Article 5 Parties, by managing and reducing emissions. Those include:

- 1) Further acceleration of the scheduled phase-outs of ODSs for Article 5 Parties beyond the requirements of Decision XIX/6; (the current controls provide about 66% reduction in consumption, with a potential to reduce 70 or 75% or more via Protocol, national and regional initiatives by Article 5 Parties).
- 2) Collection and destruction of ODSs and HFCs;
- 3) Restrictions or controls on exempted uses (process agents, feedstocks, laboratory and analytical uses, and essential uses;
- 4) Practical measures to contain, recover, and reuse ODSs and HFCs; and
- 5) Requirements and incentives to offset the ozone-depletion and climate impact of any continuing uses, including consideration of atmospheric interactions of ozone depletion and climate change.

Decision XIX/6 clearly directed that efforts and investments to protect the ozone layer should be done in a way that enhances or, at least, does not adversely affect other parts of environment, including climate. Until now, the Montreal Protocol Multilateral Fund (MLF) has been approving and implementing projects primarily in accordance with the mandate to cover incremental costs, as contained in the indicative list of incremental costs approved by the 4th MOP, and taking into consideration the most cost-effective technologies (as defined by the Executive Committee of the Multilateral Fund) to phase out ODS, calculated through the application of established “cost-effectiveness” factors. The preferences of some of the enterprises in Article 5 Parties for conversions to well established technologies also played a part in choosing non-optimal technologies from a climate perspective. Therefore, ways and means need to be found to address these new directions in the future, if other environmental aspects, including climate, are to be taken into account.

The recent Adjustment to the Protocol and the associated Decision XIX/6 have directed the Executive Committee of the Multilateral Fund to consider protecting the environment, including climate, while funding the phase-out of HCFC and other ODSs. This dual protection of ozone and climate by the Montreal Protocol is an opportunity to increase the cost-effectiveness of protecting the global environment by, for example, supplementing the funds under the (MLF) with available funds from other sources, if needed. The choice of one window at the MLF is recommended because the MLF is recognised by many as an efficient and effective international funding mechanism and because delay is less likely with financing managed by a single

organisation. The current guidelines and cost-effectiveness thresholds of the MLF may then also have to be adjusted to optimise ozone protection in connection with better protection of the climate, in harmony with Decision XIX/6. Guidelines are likely to be adjusted in order to deal with HCFC phase-out projects on a basis of costs per kg or ODS kg.

This is because the cost effectiveness factors that have been used historically to fund projects to phase out non-HCFC ODS cannot be applied directly and meaningfully compared to HCFCs and other high-GWP alternatives. Cost effectiveness of ODS phase-out projects have been historically, measured as the USD cost to phase out a unit of ozone depletion, such as ODP tonne or ODP kg. There are no technical reasons that the cost of phasing out a physical quantity of an HCFC should differ appreciably from the cost of phasing out an equal quantity of another ODS. For example, the cost of phasing out a tonne of HCFC-141b will be similar in magnitude to the cost of phasing out a tonne of CFC-11. However, the ODP of the HCFC is only a fraction of that of the CFC or other ODS. This means that using an ODP-weighted comparison would make it appear that the cost effectiveness of an HCFC conversion was many times lower than the conversion of another ODS.

Alternative approaches can be adopted to calculate cost effectiveness for high-GWP ODS alternatives that would give a more realistic comparison of technology.

Life Cycle Climate Performance (LCCP) and other Life Cycle Assessment (LCA) approaches can provide the basis for a comparable cost-effectiveness metric for HCFCs and other high-GWP alternatives. These techniques estimate the total greenhouse gas emissions of each technology choice, including the energy embodied in the chemicals and materials, the direct climate impact of chemical emissions, the indirect climate impact of energy use including end-of-life recycle or destruction. In many cases within the refrigeration, air conditioning and thermal insulating foam sectors, the technology with superior LCCP will be zero-ODP, not-in-kind or low-GWP alternatives. However, in some cases there may be high-GWP alternatives that offer significantly higher energy efficiency such that the LCCP is superior despite the direct chemical emissions and there may be low-ODP options that offer such high energy efficiency that continued use is environmentally justified either within the allowed ODS use or under an essential use exemption.

For example, high-GWP HFC foam is thermally superior in many applications to alternatives and HCFC-123 building air conditioners achieve significantly higher energy efficiency in many applications. Each case is quite different, and requires careful technical evaluation and choice. For example, high GWP HFC thermal insulating foams or low-ODP thermal foams can be environmentally superior and low-ODP, low-GWP HCFC-123 can be superior, particularly if managed for near-zero emissions or if offset by ODS destruction..

There will be a small number of cases where an alternative has higher climate impacts than the ODS technology it replaces. For example, steam soil pasteurisation likely results in higher greenhouse gas emissions than the use of methyl bromide, but is the proper choice for the overall environment because its use protects the ozone layer and does not expose farm workers and local residents to toxic pesticides. Where steam pasteurisation is implemented to replace methyl bromide, additional investment can reduce the energy intensity.

Parties to the Montreal Protocol may wish to consider the following courses of action (see also the actions proposed in the decision tree below):

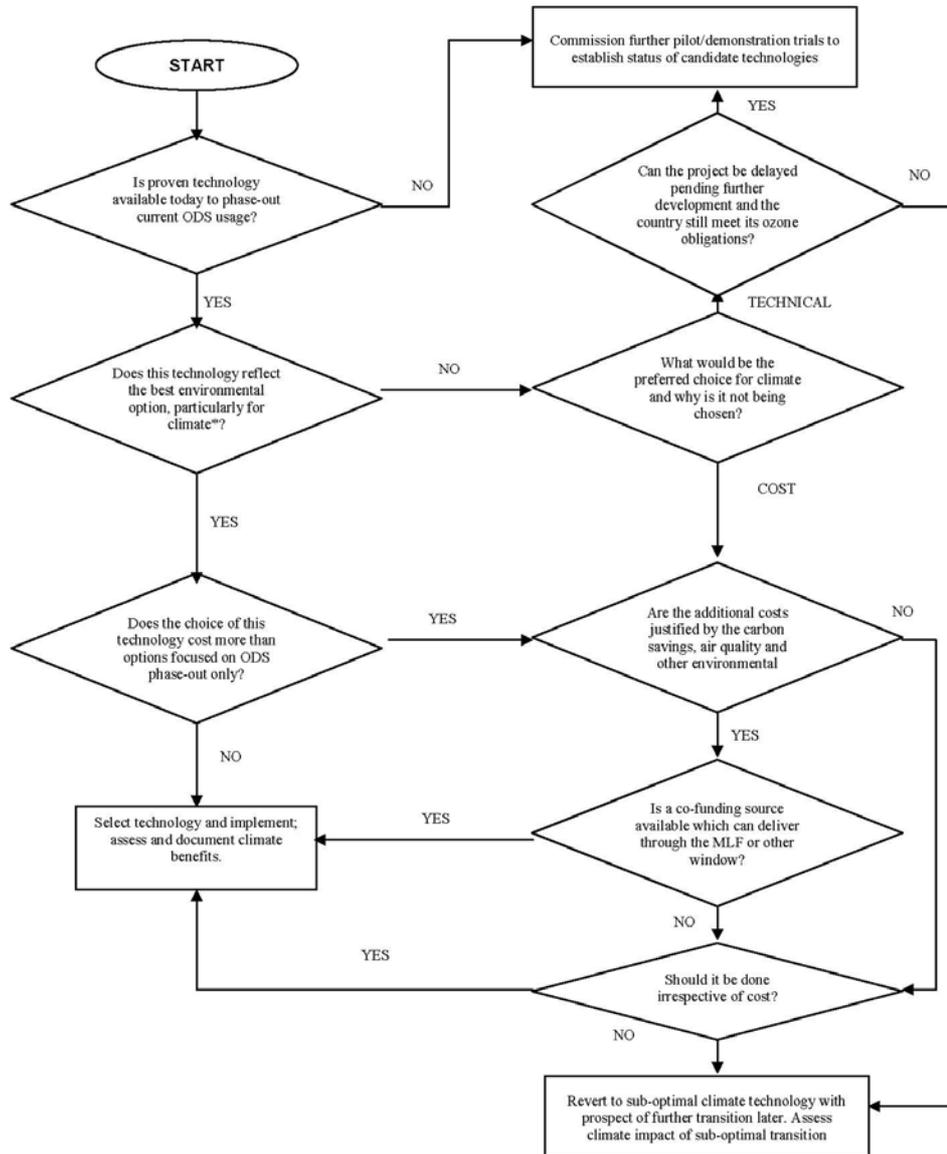
- a) The first priority by each Party could be to invest in sectors where good technically mature alternatives are available but where environmentally superior alternatives are not yet

under development. Examples of such investments include containment and service of refrigeration and air conditioning equipment; alternatives to most solvent and aerosol ODS uses, and the use of HCs, CO₂, and other natural refrigerants in applications where safety and energy efficiency can be achieved.

b) The second priority by each Party could be to adopt technically mature alternatives where additional investment (from any source, but via the MLF for Article 5 Parties) can mitigate climate impacts by containing greenhouse gases, improving energy efficiency, and implementing best practices to recover ODSs at product end-of-life.

The last priority for each Party (and for the Executive Committee of the Multilateral Fund in case of Article 5 Parties) could be to delay investment, still consistent with compliance obligations under the Protocol, and deprioritise any projects or activities where available alternatives have significant climate and other environmental impacts.

Decision Tree – Maximising Climate Benefit while Achieving Ozone Compliance



LCCP tools are available for many applications that allow global selection of environmentally superior refrigerants. For example, GREEN MAC LCCP (www.epa.gov/cppd.mac) is guiding the world-wide selection of the refrigerant to replace HFC-134a in vehicle air conditioning and public and private software is available to measure the life-cycle energy use of alternative building air conditioning systems installed in specific buildings and climates. Results from this LCCP analyses can easily be translated into greenhouse gas emissions by considering the fuel mix and energy efficiency of available electric sources and the expected annual and end-of-life refrigerant emissions.

13.5 Technical Options for Improving Climate Protection

TEAP and the IPCC Special Report on Safeguarding the Ozone Layer and Climate have identified, by sector, technically and economically feasible in-kind and not-in-kind options for reducing greenhouse gas emissions. Options are categorised for intentionally emissive applications, evaporation and leakage from banks contained in equipment and thermal insulating foam products during use, testing and maintenance of fire protection and refrigerated equipment, and end-of-life practices.

Carbon dioxide, ammonia and hydrocarbons (HCs) used as halocarbon substitutes have a negligible direct effect on global climate. Provided concerns on toxicity, flammability etc. can be addressed, they can be applied in a range of products to achieve equal or perhaps better energy efficiency relative to the high-GWP HFCs. New low-GWP substitutes such as HFC-1234yf (ODP=0; GWP=4), which is currently proposed to replace HFC-134a (ODP=0; GWP=1400) in vehicle air conditioning, may well have a comparable LCCP to other low GWP refrigerants such as CO₂ (ODP=0; GWP=1) and HFC-152a (ODP=0; GWP=140). Time will tell whether CO₂ or HFC-152a will become next generation refrigerants. CO₂ equipment is newly designed and so far has difficulties under normal conditions in achieving efficiencies comparable to the other alternatives. [Please note that HFC-1234yf is also referred to by its developers as HFO-1234yf, but that TEAP uses the standard nomenclature that designates this substance as an HFC.]

In some foam applications, the high-GWP HFC substitutes for CFC and HCFC thermal insulating foam have superior LCCP to foam made with low-GWP options although in these cases, assumptions about end-of-life disposition of the blowing gas may still have a significant effect on the calculation of overall climate benefits.

Previously, TEAP and its Technical Options Committees identified cost-effective technology and management practices to reduce both direct and indirect GHG emissions:

Technically and economically feasible options to reduce direct GHG emissions include:

- Not-in-kind technologies;
 - Improved containment of substances;
 - Reduced charge of substances in equipment;
 - End-of-life recovery and recycling or destruction of substances; and
 - Alternative substances with low-global warming potential.
- Technically and economically feasible options to reduce indirect GHG emissions include:
- Improved designs and controls;
 - Heat exchangers designed for better heat transfer;
 - Superior foam structure and application techniques to avoid voids and spaces; and
 - Technical innovations.

Policy Options for Improving Climate Protection

Application of policy measures used in the CFC phase-out can speed and reduce the cost of the HCFC phase-out, and can maximise the contribution of the Montreal Protocol to climate protection.

The successful policy measures adopted by many Parties include:

- Regulations (e.g., non-essential product bans, performance standards, certification, restrictions, end-of-life HFC recovery, in some cases paid by product manufacturers and importers);
- Economic instruments (e.g., taxation, emissions trading, carbon offsets, financial incentives, and chemical use deposits and refunds);
- Voluntary agreements (e.g., voluntary reductions in use and emissions, industry partnerships, release of patented technology to public domain, and implementation of best practice guidelines); and
- International co-operation (e.g., ozone financing from the MLF with additional contributions from climate funding mechanisms such as the Clean Development Mechanism, Global Environment Facility (GEF) to enable MLF to ensure that the projects financed for developing countries to protect ozone also better protect climate and environment).

13.6 Conclusion

In conclusion, TEAP notes it is technically and economically feasible to implement Decision XIX/6 to: "...give priority to cost effective projects and programmes, which focus.....substitutes and alternatives that minimise environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations." However, Parties may not always consider these measures to be cost-effective in the terms normally considered by the Montreal Protocol funding mechanisms. Nonetheless, co-ordinated investment to protect both ozone and climate will almost always be more cost-effective than independently pursuing these goals.

Additionally, technological developments underway in several foam, refrigeration and air conditioning products may make the achievement of climate benefits more cost-effective in future. Accordingly, there may be value in delaying some transitions to await these new products where such delays do not jeopardise Protocol compliance. It will be important to review and strengthen the existing guidelines and procedures followed by the Parties and the institutions of the Protocol, such as those of the MLF, in order to comply with the new climate protection and other environmental priorities as agreed in Decision XIX/6.

Some aspects of the Adjustment and Decision apply to all Parties while others specifically consider action by Article 5 Parties. Action by Article 5 Parties will be guided by the direct instructions given to the Executive Committee when "developing and applying funding criteria for projects and programmes". Parties may wish to ensure therefore that actions to include the climate factors in Article 5 Parties are consistent with technologies and policies (and resulting products) pursued in non Article 5 Parties because markets are now global and there is a business and consumer demand to make all choices sustainable. Success in these efforts will require co-operation by all organisations involved with the success of the Montreal Protocol.

14 TEAP/TOC Organisation Issues

14.1 Budget

TEAP is grateful for the continuing support of national governments, the European Commission, associations and companies that finance the time and expenses of the participation of experts in the TEAP, TOCs and Task Forces. TEAP and its TOCs are concerned over the resignations and retirements of some of their most experienced members, who are critical to the quality, objectivity, and timeliness of TEAP findings.

TEAP requests for emergency funding of US\$ 100,000 per year for 2008 and 2009 to cover travel for non-Article 5 members of TEAP and TOCs and for miscellaneous meeting expenses. If direct funding out of the Ozone Trust Fund through the Secretariat is not possible, TEAP respectfully requests that assignments to TEAP be paid on time and a cost basis from the Ozone Secretariat, the Multilateral Fund or other appropriate sources. Mindful that Parties have repeatedly rejected requests for financing, individual TEAP and TOC members will continue to seek adequate funding from governments, associations, and companies, while TEAP itself will investigate funding from foundations.

TEAP continues to look for ways to minimise its costs including: choosing cost-effective locations for meetings; seeking hosts for meeting rooms and discounts for hotel rooms; using internet for communications and discussions; and rationalising membership, as needed. MBTOC and RTOC, which currently has a larger than needed membership, have indicated it will review membership to ensure cost efficiency.

14.2 Methyl Bromide Technical Options Committee

TEAP is pleased to report that the recent strengthening of the MBTOC has further improved the efficiency of meetings and simplified the process of coming to consensus. TEAP finds that MBTOC Sub-Committees need not meet together and that separate meeting locations can be selected to minimise costs and to make important visits.

Dr. Jonathan Banks has assumed the position of Co-Chair of MBTOC Structures and Commodities Sub-Committee in 2007, following the response to the nomination.

14.3 Likely Future Changes in TEAP Organisation

It is likely that work of the MTOC will diminish after 2011 as both Article 5 and non-Article MDI EUEs decrease and that work of the MBTOC will also probably diminish after 2012 when CUEs decrease. At that time, TEAP will further consolidate and simplify its organisation.

14.4 Notice of Positions Available on the TEAP and its TOCs

TEAP welcomes nominations of experts for all committees at any time. Currently, TEAP is particularly seeking:

- Article 5 Co-Chair for the Halons Technical Options Committee

- Expert in nutsedge control, orchard replant, forestry, and nursery propagation for the Methyl Bromide Technical Options Committee (MBTOC-S Subcommittee)
- Experts in aviation fire protection for the Halons Technical Options Committee
- Article 5 experts in the manufacture of MDIs

14.5 Conflict of Interest

TEAP now maintains the latest Disclosure of Interest information on the Ozone Secretariat web site.

ANNEX I: TEAP Member Biographies

The following contains the background information for all TEAP members as at April 2008.

Dr. Radhey S. Agarwal

(Refrigeration TOC Co-chair)

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Dr. 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 Delhi (IIT Delhi). He co-chaired the 2003 HCFC Task Force, the 2004 Chiller Task Force, Force and the 2007 Task Force on the Strengthening the Protocol (Decision 18/12). IIT Delhi has an interest in the topics of the Montreal Protocol since it is one of the academic institutes of higher learning in India. Dr. Agarwal holds a M. Tech. and a Ph.D. from IIT Delhi. Dr. Agarwal has been actively pursuing research in the area of refrigeration & air-conditioning. He has guided a number of Ph.D. and M. Tech. theses and published research papers in the field of refrigeration and air-conditioning. Dr. Agarwal has no proprietary interest in alternatives or substitutes to ODSs, does not own any stock in companies producing ODS or alternatives/substitutes to ODSs. Dr. Agarwal's spouse has no interest in matters related to the Protocol. Dr. Agarwal occasionally takes consultancies and advisory roles operated through IIT Delhi from the engineering industry, UNEP, GTZ and INFRAS for research & development, technical advice, developing technical manuals and training materials etc. IIT Delhi makes in-kind contribution for wages. Cost of travel and other expenses related to participation in the TEAP and the RTOC are paid by UNEP's Ozone Secretariat.

Dr. Stephen O. Andersen

(Panel Co-chair)

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Stephen O. Andersen, Co-chair of the Technology and Economic Assessment Panel since 1989, is Director of Strategic Climate Projects in the Climate Protection Partnerships Division of the U.S. Environmental Protection Agency and previously Deputy Director of the Stratospheric Protection Division. He created EPA's first voluntary partnerships including accelerated phaseout agreements in food packaging foam, mobile AC, and solvents and he helped organize the Halon Alternatives Research Corporation and the Industry Cooperative for Ozone Layer Protection. Prior to joining EPA he was a university professor, a consultant, and an employee of environmental,

law, and energy NGOs. With K Madhava Sarma he is author of “Protecting the Ozone Layer: The United Nations History,” (Earthscan 2002); with Durwood Zaelke he is author of “Industry Genius: Inventions and People Protecting the Climate and Fragile Ozone Layer,” (Greenleaf 2003); with K. Madhava Sarma and Kristen N. Taddonio he is author of “Technology Transfer for the Ozone Layer: Lessons for Climate Change,” (Earthscan 2007); and with Guus J.M. Velders, John S. Daniel, David W. Fahey, and Mack McFarland he is author of “The Importance of the Montreal Protocol in Protecting Climate,” Proceedings of the National Academy of Sciences, 20 March 2007. He earned his M.S. and Ph.D. from the University of California Berkeley. He chaired and co-chaired the Solvents TOC from 1989 to 1995, chaired the 1999 HFC and PFC Task Force, and co-chaired several Task Forces. He served on the Steering Committee to the “IPCC/TEAP Special Report Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons” and he participated in the Science Assessment Panel in 2006. Dr. Andersen’s spouse works for the U.S. EPA Office of Pesticide Programs and Toxic Substances in a division that registers bio-pesticides, including potential substitutes for methyl bromide. The U.S. EPA makes in-kind contributions of wages, travel, communication, and other expenses and some travel is sponsored by the U.S. DoD. 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)

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Paul Ashford, Co-chair of the Rigid and Flexible Foams Technical Options Committee since 1998 is the owner and managing director of Caleb Management Services Ltd., a consulting company working in the chemical regulatory and sustainability arenas. He co-chaired the TEAP Task Force on the Supplement Report to the “IPCC/TEAP Special Report: Safeguarding the ozone layer and the global climate system: issues related to hydrofluorocarbons and perfluorocarbons” (2005) and the Task Force on Emissions Discrepancies in 2006. Until 1994, he worked for BP Chemicals in the division that developed licensed foam technology using ODS and was responsible for the adoption of alternatives. He has over 25 years direct experience of foam related technical issues and has conducted numerous studies to characterise the foam sector and inform future policy development. His funding for TEAP activities, which includes some sponsorship of time, is provided jointly under contract by the Department of Trade and Industry (DTI) and the Department of Environment, Food and Rural Affairs (DEFRA) in the UK. Much of his recent work on banks, emissions and foam end-of-life management, performed to inform both IPCC and TEAP processes has been supported by the US EPA. There is increasing overlap with IPCC and UNFCCC objectives in support of greenhouse gas emissions reporting by Governments. 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. A considerable portion of the work with private clients relates to the lifecycle assessment of products based on ODS alternatives and advice on carbon management strategies.

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Dr. Jonathan Banks, Chair of TEAP's QPS Task Force, is a private consultant. He was a member of the 1992 Methyl Bromide Assessment and from 1993 to 1998 and 2001 to 2005 co-chaired the Methyl Bromide TOC. He worked as a Research Scientist with the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) from 1972 to 1999 on grain storage technologies, including use of improved use of fumigants. He is co-inventor of carbonyl sulfide, an alternative fumigant to methyl bromide in some applications. Patent rights have been assigned to his employer, CSIRO. Dr Banks has no proprietary interest in alternatives or substitutes to ODSs, does not own stock in companies producing ODS or alternatives or substitutes to ODSs. He has stock in Brambles Ltd, a company that inter alia leases wooden pallets for freight. The pallets may or may not be treated with methyl bromide or alternatives. His spouse is co-owner of their commercial organic apple orchard. She has no financial interests relating to ozone-depleting substances. He has served on some national committees concerned with ODS and their control, and within the last 4 years has received contracts from UNEP, other institutions and public companies related to methyl bromide alternatives and grain storage technology--including training in fumigation (methyl bromide and alternatives) and fumigation technology and recapture systems for methyl bromide. In 2005 and 2006 he received some support from UNEP for TEAP and MBTOC activities. Other funding for his MBTOC activities has been through grants or contracts from the Department of Environment and Heritage, Australia or from personal contributions.

Prof. Mohamed Besri
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Prof. Mohamed Besri, is a full time Professor of Plant Pathology and Integrated Disease Management at the Hassan II Institute of Agronomy and Veterinary Medicine, Rabat, Morocco (HII IAVM). The HII IAVM has an interest in the topics of the Montreal Protocol because it houses specialists in Soil-borne Plant Pathogens and MLF projects (strawberries, bananas, cut flowers). It advises the Ministry of Agriculture on all aspects of alternatives to Methyl Bromide. Dr Besri, his spouse, his business partner and dependant children have no proprietary interest in alternatives or substitutes to ODSs, nor do any of them own stock in companies producing ODS or alternatives or substitutes to ODSs. Dr Besri works occasionally as a consultant to UNEP on matters related to the Montreal Protocol. Costs associated to travel, communication, and others related to participation in the TEAP, MBTOC, and relevant Montreal Protocol meetings, are paid by UNEP's Ozone Secretariat.

Mr. David Catchpole
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Mr. David V. Catchpole, Co-Chair of the Halons Technical Options Committee and Member of the Technology and Economics Assessment Panel since 2005, works part time for Petrotechnical Resources Alaska (PRA), an Anchorage, Alaska based company that provides consulting services to oil companies in Alaska. From 1991 to 2004 he was a member of the HTOC. From 1970 until 1999, he was an employee of the BP group of companies, most recently BP Exploration Alaska, where he worked for nine years in the environmental department on alternatives to halon and on halon banking. Mr. Catchpole advises BP Exploration Alaska on fire protection and halon issues as his main activity for PRA. BP Exploration Alaska has an interest in the topics of the Montreal Protocol because it uses halon 1301 for explosion prevention and fire suppression in its enclosed oil and gas processing modules on the North Slope of Alaska. Mr. Catchpole has no proprietary interest in alternatives or substitutes to ODSs, does not own stock in companies producing ODS or alternatives or substitutes to ODSs, however his retirement portfolio contains stock in BP plc. Mr. Catchpole's spouse does not work for or consult for any organisation that has an interest in the topics of the Montreal Protocol. His spouse has no proprietary interest in alternatives or substitutes to ODSs, does not own stock in companies producing ODS or alternatives or substitutes to ODSs and does not consult for organisations seeking to phase-out ODSs. Mr. Catchpole typically receives funding to support salary and travel to TEAP/TOC meetings from the United States Environmental Protection Agency and the United States Department of Defense; and the Halon Recycling Corporation and the Halon Alternatives Research Corporation, which are not-for-profit industry coalitions that in turn receive contributions for this funding from members. Contributors are: BP Exploration Alaska, ConocoPhillips Alaska, DuPont, Chemtura, American Pacific, Firetrace, Halon Banking Systems, Westco and Remtec.

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Dr Biao Jiang, Co-chair of the Chemicals Technical Options Committee since 2005, is Professor of Chemistry of Shanghai Institute of Organic Chemistry, Chinese Academy Of Sciences and a member of editorial advisory board of Chemical Communication, Royal Society of Chemistry, United Kingdom. Professor Jiang involves in the research and the development of new methodology of organic synthesis, medicinal chemistry, fluorine chemistry as well as organic process research and development of clean chemistry. Dr Jiang has no proprietary interest in alternatives or substitutes to ODSs, nor does he own stock in companies producing ODS or alternatives or substitutes to ODSs. Costs of travel, communication, and other expenses related to participation in the TEAP, its Chemicals TOC, and relevant Montreal Protocol meetings, are paid by UNEP's Ozone Secretariat.

Dr. Lambert Kuijpers

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Lambert Kuijpers, Co-chair of the Technology and Economic Assessment Panel since 1992 and Co-chair of the Refrigeration, Air-conditioning and Heat Pumps Technical Options Committee since 1989, works on a part-time basis for the Department “Technology for Sustainable Development” at the Technical University Eindhoven, The Netherlands. He co-chaired the TEAP Replenishment Task Forces between 1996 and 2005, as well as the latest (2008) TEAP Replenishment Task Force. He served on the Steering Committee to the “IPCC/TEAP Special Report “Safeguarding the ozone layer and the global climate system: issues related to Hydrofluorocarbons and Perfluorocarbons”, he co-chaired the 2005 Task Force for the TEAP Supplementary Report to the IPCC/TEAP Special Report, the 2006 Task Force on Emissions Discrepancies and the 2007 Task Force on the Response to Decision XVIII/12. He was a Lead Author for both the Third and the Fourth IPCC Assessment Report. He was a member of the Ozone Science Assessment Panel in 2005-2006. Until 1993, he worked for Philips in the development of refrigeration, air conditioning, and heat pump systems to use alternatives to ozone-depleting substances. He is financially supported (through the UNEP Ozone Secretariat) by the European Commission (and in certain years by some EU member state governments) for his activities related to the TEAP and the Refrigeration TOC. Dr. Kuijpers has no proprietary interest in alternatives or substitutes to ODS and does not own stock in companies producing ODS or alternatives or substitutes to ODS. He occasionally is a consultant to governmental and non-governmental organisations, such as the World Bank, UNIDO, UNEP DTIE and the Multilateral Fund (e.g. for the 2006 Expert Meeting). Dr. Kuijpers is also an advisor to the Re/genT Company, Netherlands, which he co-founded in 1993 and where he still has a minority interest (R&D of components and equipment for refrigeration, air-conditioning and heating).

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Ms Michelle Marcotte was a member of the 1992 Methyl Bromide Assessment and subsequently a member of the Methyl Bromide Technical Options Committee between 1992 and 2005; she was confirmed as Co-Chair in 2005. Until 1993 she worked for MDS Nordion, a supplier of radiation processing equipment which is an alternative to the use of methyl bromide in some commodity and quarantine situations. Since then, Ms Marcotte, through Marcotte Consulting, has provided consulting services to governments and agri-food companies in eight countries on agri-environmental issues, food technology, regulatory affairs and radiation processing. Marcotte Consulting has an interest in the topics of the Montreal Protocol because of its long time market development work in food irradiation, an alternative to some methyl bromide uses, and because of

its interest in food processing, food safety and trade. In the field of methyl bromide alternatives, Ms Marcotte has published case studies in pest control in food processing, in stored commodities, in alternatives for quarantine and in greenhouse use. She is a member of the Canada Industry-Government Methyl Bromide Working Group and the Canada-US Methyl Bromide Working Group; both organisations work to achieve the phase-out of methyl bromide in the agri-food sector. Marcotte has consulted to companies, industry associations, the International Atomic Energy Agency and US AID on irradiation as a methyl bromide alternative in food processing, quarantine and trade. She has also prepared consulting reports summarising research in methyl bromide alternatives and case studies on food processing for the U.S. Environmental Protection Agency. Ms Marcotte has no proprietary interest in alternatives or substitutes to ODSs, does not own stock in companies producing ODS or alternatives or substitutes to ODSs. Ms Marcotte's spouse works for United States Department of Agriculture managing research in methyl bromide alternatives and is a member of MBTOC. He does not have proprietary interest in alternatives or substitutes to ODS and does not own stock in companies producing ODS or alternatives or substitutes to ODSs. Ms Marcotte receives a consulting contract from the Government of Canada, Environment Canada. The funds for Ms Marcotte for travel to TEAP, MBTOC and Montreal Protocol meetings and to support her work on the MBTOC are provided by the the Government of Canada, Environment Canada.

Mr. E. Thomas Morehouse

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Thomas Morehouse, Senior Expert Member for Military Issues since 1997, is a Research Adjunct at the Institute for Defense Analyses (IDA), Washington D.C., USA. From 1989 until 1996 he co-chaired the Halons TOC. From 1986 to 1989 he was an officer in the United States Air Force responsible for developing alternatives to halon. From 1989 until 1994 his responsibilities as an Air Force officer included broader environmental and energy policy issues for the U.S. Department of Defense. Mr. Morehouse's spouse works for the U.S. National Oceanographic and Atmospheric Administration (NOAA) in a position that plans long term spending for NOAA, including research and operations affecting stratospheric ozone and climate. 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 Federally Funded Research Center (FFRDC) that undertakes work exclusively for the US Department of Defense. He also occasionally consults independently to corporate clients, national laboratories and other government agencies on environmental and energy related issues. Mr Morehouse –and his spouse- have no proprietary interest in alternatives or substitutes to ODSs, nor do they own stock in companies producing ODS or alternatives or substitutes to ODSs.

Ms. Marta Pizano

(MBTOC Co-chair)

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Ms Marta Pizano is a consultant on methyl bromide alternatives, particularly for cut flower production, and has actively promoted methyl bromide alternatives among growers in many countries. She is a regular consultant for the Montreal Protocol Multilateral Fund (MLF) and its implementing agencies. In this capacity, she has contributed to the methyl bromide phaseout programs in nearly twenty Article 5 Parties around the world, assisting growers with the adoption of sustainable alternatives and the implementation of IPM programs. She is a frequent speaker at national and international methyl bromide conferences and has authored numerous articles and publications on alternatives to this fumigant. She has been a member of MBTOC since 1998 and a co-chair since 2005. Neither Ms Pizano nor her husband or their children own stock or have proprietary interest in companies producing ODS or their alternatives or substitutes. Costs associated to travel, communication, and others related to participation in the TEAP, MBTOC, and relevant Montreal Protocol meetings, are paid by UNEP's Ozone Secretariat.

Mr. Jose Pons Pons

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Jose Pons, Co-chair of the Technology and Economic Assessment Panel and the Medical Technical Options Committee and Member of the 2007 Task Force on the TEAP Legacy, is President of Spray Química C.A. Jose Pons is a full time manager/engineer at the Spray Química aerosol filling plant in La Victoria, Venezuela. Spray Química has an interest in the topics of the Montreal Protocol because it used, and still uses, ODS in some of its aerosol products for industrial maintenance. Mr Pons has no proprietary interest in alternatives or substitutes to ODS, does not own stock in companies producing ODS or alternatives or substitutes to ODS, does not have an interest in the outcome of essential use nominations, and does not consult for organisations seeking to phase out ODS. Mr Pons's spouse has no interest in matters before the Protocol; she is also a manager/engineer at Spray Química. Mr Pons has worked occasionally as a consultant to MLF on matters related to the Montreal Protocol. The Task Force worked by e-mail and there was no travel or other expenses paid by any organisations to participate in this activity. Travel related to participation in the TEAP and MTOC, and relevant Protocol meetings, are paid by UNEP's Ozone Secretariat. Spray Química makes in-kind contributions of wage, and miscellaneous and communication expenses.

Dr. Ian J. Porter

(MBTOC Co-chair)
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Dr Ian Porter is the Statewide Leader of Plant Pathology with the Victorian Department of Primary Industries (DPI). DPI has an interest in developing sustainable control measures for plant pathogens and biosecurity. 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 26 years experience in researching sustainable methods for soil disinfestation of plant pathogens with over 200 research publications. He has been a member of MBTOC since 1997, Soils sub committee chair since 2001 and MBTOC Co-chair since 2005. Neither Dr Ian Porter, wife or children have any proprietary interest in alternatives or substitutes to ODSs, nor own stock in companies producing ODS or alternatives or substitutes to ODSs. Dr Porter is presently assisting national research agencies in Australia develop national priorities for IPM and soil health. He has acted occasionally as a key consultant for UNEP and UNIDO in developing programmes to assist China, Mexico and CEIT countries to replace methyl bromide. The Victorian DPI has in the past made in-kind contributions to attend MBTOC and UNEP meetings, but provides no support at present. In 2007, Dr Porter funds his own participation. The Australian Federal Government Research Fund and funds obtained through the Ozone Secretariat have provided support to finance travel and expenses for MBTOC activities.

Prof. Miguel W. Quintero

(Foams TOC Co-chair)
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Prof. Miguel W. Quintero, Co-chair of the Foams Technical Options Committee since 2002, has been a professor at the Chemical Engineering Department at Universidad de los Andes in Bogota, Colombia, in the areas of polymer processing and transport phenomena during 2000- 2006, where he is now a visiting professor. Prof. Quintero worked during 21 years (until 2000) for Dow Chemical at the Research & Development and Technical Service & Development Departments in the area of rigid polyurethane foam. In January 2007, he returned to Dow Europe as Development Leader for Polyurethane Product Research, located in Freienbach, Switzerland. He owns stock in companies that now or previously manufactured ozone-depleting substances and products made with or containing ozone-depleting substances and their substitutes and alternatives. He has been a regular consultant for the Montreal Protocol's implementing agencies. The participation of Prof. Quintero in TEAP and FTOC related activities is funded by Dow Chemical.

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Dr. Rae, Co-chair of the Chemicals Technical Options Committee since 2005, is a Honorary Professorial Fellow at the University of Melbourne, Australia, and a member of advisory bodies for several Australian government agencies dealing with chemical issues and in particular the Stockholm Convention. He co-chaired the 2001 and 2004 Process Agent Task Forces. He is a member of the POPs Review Committee for the Stockholm Convention. On occasions, he acts as consultant to government agencies and to universities and companies and he has been an expert witness in a case involving alleged patent infringement involving HFC- 134a and its lubricants. He contributes the time for his own participation in TEAP activities. The Australian Government Department of the Environment and Water Resources finances the cost of travel and accommodation for Dr. Rae's attendance at meetings of the CTOC, TEAP, OEWG and MOP.

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K. Madhava Sarma, Senior Expert Member since 2001, and member of the Task Force on the TEAP Legacy, 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 of the Ozone Cell, MOEF, Government of India. He is working on a research and writing project on technology transfer and change for the protection of the ozone layer financed by the Global Environmental Facility (GEF). Neither he or his spouse own stock in any company connected to ODS or alternatives or substitutes. Costs of travel, communication, and other expenses related to participation in the TEAP and relevant Montreal Protocol meetings, are paid by UNEP's Ozone Secretariat.

Dr. Helen Tope

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Helen Tope, Co-chair Medical Technical Options Committee since 1995, Member of the 2007 Task Force on the TEAP Legacy, is Principal Consultant of Energy International Australia (since 2006) and also Director of Planet Futures (since 2007) with whom she is an independent consultant providing strategic, policy and technical advice and facilitation services to government, industry and other non-governmental organisations on climate change, ozone-depleting substances, and other environmental issues. Dr Tope's business has an interest in the topics of the Montreal Protocol because her potential clients are also interested in these topics. Dr Tope has no proprietary interest in alternatives or substitutes to ODS, does not own stock in companies producing ODS or alternatives or substitutes to ODS, does not have an interest in the outcome of essential use nominations, and does not currently consult for organisations seeking to phase out ODS. Dr Tope's spouse has no interest in matters before the Protocol. The Ozone Secretariat provides a grant for travel, communication, and other expenses of the Medical Technical Options Committee from funds granted to the Secretariat unconditionally by the International Pharmaceutical Aerosol Consortium (IPAC). IPAC is a non-profit corporation.

Dr. Daniel P. Verdonik

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Dr. Daniel P. Verdonik, Co-Chair, Halons Technical Options Committee and Member, Technology and Economic Assessment Panel is the Director, Environmental Programs, Hughes Associates, Inc. Dr. Verdonik is a full time, salaried employee at Hughes Associates, Inc., in Baltimore, MD and Arlington, VA providing consulting services in fire protection and environmental management. Hughes Associates, Inc. has an interest in the topics of the Montreal Protocol because it provides a wide range of fire protection research, design and consulting services to government and corporate clients, including work related to halons and halon alternatives. Dr. Verdonik has no proprietary interest in alternatives or substitutes to ODSs, does not own stock in companies producing ODS or alternatives or substitutes to ODSs and through Hughes Associates, Inc. provides consulting services for organisations seeking to phase-out ODSs. Dr. Verdonik is a partner in Hughes Associates, Inc., which does not own stock in companies producing ODS or alternatives or substitutes to ODSs. Dr. Verdonik currently provides consulting services through Hughes Associates, Inc, for the U.S. Army and U.S. Navy on matters related to the Montreal Protocol and has previously provided services through Hughes Associates Inc. for Implementing Agencies, U.S. EPA, U.S. Air Force and Chemtura. Dr. Verdonik's spouse works for the U.S. Army, which has an interest in the topics of the Montreal Protocol because it is trying to phase-out halons but in the interim, continues to rely on halons for purposes of national

security. Dr. Verdonik's spouse and dependant child have no proprietary interest in alternatives or substitutes to ODSs, do not own stock in companies producing ODS or alternatives or substitutes to ODSs, and do not consult for organisations seeking to phase out ODSs. Hughes Associates, Inc. typically receives funding to support Dr. Verdonik's salary and travel to TEAP/HTOC/TSB meetings from MLF, UNEP, the U.S. Department of Defense, the U.S. EPA, the U.S. National Aeronautics and Space Administration, the Halon Recycling Corporation, and the Halon Alternatives Research Corporation, who in-turn currently receives funding to support these efforts from the following sponsors: BP Exploration, Alaska, ConocoPhillips, Alaska; DuPont; Chemtura; American Pacific; Firetrace; Halon Banking Systems; Wesco; Remtec. From time-to-time, Hughes Associates, Inc may also provide support for labor and travel.

Prof. Ashley Woodcock

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Prof. Ashley Woodcock, Co-chair of the Medical Technical Options Committee and Member of the Technology and Economic Assessment Panel, is a Respiratory physician at the South Manchester University Teaching Hospital. Prof. Woodcock is a full time physician and academic at the North West Lung Centre Manchester United Kingdom. The Hospital and University have no direct interest in the topics of the Montreal Protocol. Prof. Woodcock has no proprietary interest in alternatives or substitutes to ODS, does not own stock in companies producing ODS or alternatives or substitutes to ODS, does not have an interest in the outcome of essential use nominations. Prof. Woodcock carries out unrelated consulting and educational lectures for pharmaceutical companies, all of which are completing phase out of CFC MDIs. He advises companies on study design for new drugs, some of which have been ODS replacements. Prof. Woodcock's spouse has no interest in matters before the Protocol. Prof. Woodcock does not work as a consultant to the UN, UNEP, MLF or Implementing Agencies. In the past, he has responded to requests for technical information on CFC MDI phase-out from the European Community and the United Kingdom Government. Travel and subsistence for meetings of TEAP, MTOC, OEWG, MOP meetings is paid from Hospital and University funds, and Prof. Woodcock's employers allow leave of absence.

Dr. Masaaki Yamabe

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Dr. Masaaki Yamabe, Co-Chair of the Chemical Technical Options Committee since 2005, is research coordinator (Environment and Energy) at the AIST. He is a member of the Task Force on the TEAP Legacy and he co-chaired the 2004 Process Agent Task Force. He was a member of the Solvents TOC during 1990-1996. Until 1999, Dr. Yamabe was Director of Central Research for Asahi Glass Company, which previously produced CFCs, methyl chloroform, and carbon

tetrachloride, and currently produces and distributes HCFC, carbon tetrachloride, and HFCs. He is the co-inventor of HCFC-225, which is controlled under the Montreal Protocol as a transitional substance in the phase-out of ozone-depleting substances and is a substitute for CFC-113 in solvent and process agent applications. He owns stock in Asahi Glass Company that produces ozone-depleting substances and their substitutes. He also works for the Japan Industrial Conference for Ozone Layer and Climate Protection (JICOP) as a senior advisor. AIST generally pays wages, travelling and other expenses, except in some cases where JICOP sponsors travel.

Prof. Shiqiu Zhang

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Dr. Shiqiu Zhang, Senior Expert Member for economic issues of the TEAP since 1997, is a Professor on Environmental Economics and Policy at the College for Environmental Sciences of Peking University. She is a member of the Task Force on the TEAP Legacy and co-chaired the 2002 and 2005 Replenishment Task Forces. She is involved in the work to help the Chinese government to develop the country program for the phase-out of ODS, and in studies of related relevant policies. She occasionally consults for UNEP. Dr. Zhang has no proprietary interest in alternatives or substitutes to ODSs, nor does she own stock in companies producing ODS or alternatives or substitutes to ODSs. Costs of travel, communication, and other expenses related to participation in the TEAP and relevant Montreal Protocol meetings, are paid by UNEP's Ozone Secretariat.

ANNEX II: TEAP TOC Membership List Status April 2008

Co-chairs	Affiliation	Country
Stephen O. Andersen	Environmental Protection Agency	USA
Lambert Kuijpers	Technical University Eindhoven	Netherlands
Jose Pons Pons	Spray Quimica	Venezuela
Senior Expert Members	Affiliation	Country
Thomas Morehouse	Institute for Defense Analyses	USA
K. Madhava Sarma	Consultant	India
Shiqiu Zhang	Center of Environmental Sciences, Peking University	China
TOC Chairs	Affiliation	Country
Radhey S. Agarwal	Indian Institute of Technology Delhi	India
Paul Ashford	Caleb Management Services	UK
Jonathan Banks	Consultant	Australia
Mohamed Besri	Institut Agronomique et Vétérinaire Hassan II	Morocco
Biao Jiang	Shanghai Institute of Organic Chemistry	China
David Catchpole	Petrotechnical Resources Alaska	UK
Michelle Marcotte	Marcotte Consulting LLC and Marcotte Consulting Inc	Canada
Marta Pizano	Consultant	Colombia
Ian Porter	Department of Primary Industries	Australia
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
Masaaki Yamabe	National Institute of Advanced Industrial Science and Technology	Japan

TEAP Chemicals Technical Options Committee (CTOC)

Co-chairs	Affiliation	Country
Biao Jiang	Shanghai Institute of Organic Chemistry	China
Ian Rae	University of Melbourne	Australia
Masaaki Yamabe	National Institute of Advanced Industrial Science and Technology	Japan
Members	Affiliation	Country
D. D. Arora	The Energy Research Institute	India
Steven Bernhardt	Honeywell	USA
Olga Blinova	Russian Scientific Center "Applied Chemistry"	Russia
Nick Campbell	Arkema Group	France
Bruno Costes	Airbus Industries	France
Jianxin Hu	Center of Environmental Sciences, Peking University	China
A.A. Khan	Indian Institute of Chemical Technology	India
Michael Kishimba	University of Dar-es-Salaam	Tanzania
Abid Merchant	Consultant	USA
Koichi Mizuno	National Institute of Advanced Industrial Science and Technology	Japan
Claudia Paratori	Environmental Consultant	Chile
Hans Porre	Teijin Twaron	Netherlands
Shuniti Samejima	Asahi Glass Foundation	Japan
John Stemniski	Consultant	USA
Fatemah Al-Shatti	Kuwait Petroleum Corporation	Kuwait
Peter Verge	Boeing Manufacturing	USA
Nee Sun Choong Kwet	University of Mauritius	Mauritius
Yive (Robert)		

TEAP Flexible and Rigid Foams Technical Options Committee (FTOC)

Co-chairs	Affiliation	Country
Paul Ashford	Caleb Management Services	UK
Miguel Quintero	Dow Europe GmbH / Universidad de Los Andes	Switzerland
Members	Affiliation	Country
Kyoshi Hara	JUFA	Japan
Mike Hayslett	Maytag/AHAM	USA
Mike Jeffs	ISOPA	Belgium
Shigeru Wakana	Dow	Japan
Candido Lomba	ABRIPUR	Brazil
Yehia Lotfi	Technocom	Egypt
Kirsten Makel	Arkema	USA
Christoph Meurer	Solvay	Germany
Mudumbai Sarangapani	Polyurethane Council of India	India
Ulrich Schmidt	Haltermann/Dow	Germany
Bert Veenendaal	RAPPA	USA
Mark Weick	Dow	USA
Dave Williams	Honeywell	USA
Allen Zhang	Owens Corning	China

TEAP Halons Technical Options Committee (HTOC)

Co-chairs	Affiliation	Country
David V. Catchpole	Petrotechnical Resources Alaska	UK
Daniel P. Verdonik	Hughes Associates	USA
Members	Affiliation	Country
Ahmad Al-Khatib	Ministry of Environment	Jordan
Fareed I. Bushehri	UNEP	Bahrain
Seunghwan (Charles) Choi	Hanju Chemical Co., Ltd.	South Korea
Michelle M. Collins	Consultant- EECO International	USA
Salomon Gomez	Tecnofuego	Venezuela
Andrew Greig	Protection Projects Inc.	South Africa
H.S. Kaprwan	Consultant – Retired	India
Nikolai P. Kopylov	All Russian Research Institute for Fire Protection	Russia
David Liddy	Ministry of Defence	UK
Bella Maranion	US EPA	USA
John J. O'Sullivan	Bureau Veritas	UK
Peter Lim Sin Pang	Singapore Civil Defence Force	Singapore
Emma Palumbo	Safety Hi-tech srl	Italy
Erik Pedersen	Consultant – World Bank	Denmark
Donald Thomson	Mantoba Hydro & MOPIA	Canada
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