MONTREAL PROTOCOL

ON SUBSTANCES THAT DEPLETE

THE OZONE LAYER

UNEP

REPORT OF THE
TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL

MAY 2014

VOLUME 1

PROGRESS REPORT

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

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TEAP thanks the Multilateral Fund Secretariat for the Montreal Protocol, Montreal, Canada for hosting the TEAP meeting, 4-9 May 2014, where the elements for this report were first discussed and decisions were taken for the submission of the final parts of the report.

Foreword

The May 2014 TEAP Report

The May 2014 TEAP Report consists of six volumes:

Volume 1: May 2014 TEAP Progress Report

Volume 2: May 2014 TEAP Essential Use Nominations Report

Volume 3: May 2014 TEAP Critical Use Nominations Report

Volume 4: TEAP Decision XXV/5 Task Force Report on information on alternatives to ODS

Volume 5: TEAP Decision XXV/6 Report on TOC appointment processes, future configurations and the streamlining of annual (progress) reports

Volume 6: TEAP Decision XXV/8 Task Force on the funding requirement for the 2015-2017 replenishment of the Multilateral Fund for the Implementation of the Montreal Protocol

- **Volume 1** contains the TOC progress reports, and a chapter "Other TEAP Matters", discussing the status of (re-) nominations and challenges to the participation of experts, as well as an annex with the list of TEAP and TOC members, status May 2014
- **Volume 2** contains the assessment of the 2014 essential use nominations by the CTOC and the MTOC
- **Volume 3** contains the assessment of the 2014 critical use nominations by the MBTOC
- **Volume 4** is the report of the TEAP Task Force responding to Decision XXV/5 on information on alternatives to ODS in the refrigeration and air conditioning, foams, medical uses, fire protection and solvent sectors
- **Volume 5** contains a description by the TEAP on the TOC appointment processes and their future configurations and the streamlining of the annual (progress) reports in response to Decision XXV/6
- **Volume 6** is the report of the TEAP Task Force responding to Decision XXV/8 on the funding requirement for the 2015-2017 replenishment of the Multilateral Fund for the Implementation of the Montreal Protocol.

This is Volume 1, the TEAP May 2014 Progress report.

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1 Introduction

This is volume 1 of 6 of the May 2014 TEAP Report and contains:

- the CTOC progress report;
- the FTOC progress report;
- the HTOC progress report;
- the MTOC status report;
- the MBTOC progress report;
- the RTOC progress report;
- TEAP and TOC organization issues; and

an annex of the TEAP and TOC membership list, status May 2014, which includes the terms for re-appointment, where available.

2 Chemicals TOC (CTOC) Progress Report

2.1 Introduction

The CTOC met on 8-10 April in Madrid, Spain. Ten out of fifteen CTOC members participated in the meeting. Attending members were from China (2), France, India, Japan, Kuwait, Mauritius, Russian Federation, and United States of America.

The meeting covered issues requested by the Parties including process agents, laboratory and analytical uses, n-Propyl Bromide, CTC issues and feedstocks. Attention was also given to considering TEAP/TOC operating procedures and the requirement of Decision XXIII/10 that the present terms of members would end in 2013 or 2014, although re-appointment was possible. The CTOC also reviewed twoessential use nominations (EUNs), one from the Russian Federation on solvent use of CFC-113 for aerospace industries and anoher from China on CTC laboratory and analytical use (testing oil, grease and total petroleum hydrocarbons in water). The results of the CTOC reviews on those EUNs have been in cluded in Volume 2 of the May 2014 TEAP Report (Essential Use Nominations).

2.2 Process Agents

Decision XXII/8(5) requested TEAP for 2011, to review in 2013, and every second year thereafter, progress made in reducing process agent uses and to make any additional recommendations to Parties on further actions to reduce uses and emissions of process agents. CTOC will prepare a report in 2015.

2.3 Feedstocks

2.3.1 Introduction

Feedstocks are building blocks to allow cost-effective commercial synthesis of other chemicals. Use of such compounds as carbon tetrachloride (CTC), 1,1,1-trichloroethane (TCA) (also referred to as methyl chloroform), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and several others, all ozone depleting substances, as feedstocks allow incorporation of fluorine atoms into molecule structures. Products used as refrigerants, blowing agents, solvents, polymers, pharmaceuticals and agricultural chemicals are produced to benefit society. The feedstocks used to produce these chemicals have been carefully selected for these uses as there are no other technologically and economically viable alternative routes available at this time. Such choices involve large investments of capital with plant lifetimes as long as 50 years when properly maintained and upgraded. Feedstocks are converted to other products except for *de minimus* residues and emissions. Emissions in feedstock use consist of residual levels in the ultimate products and fugitive leaks in the production, storage and/or transport processes. Significant investments and efforts are spent to handle these feedstocks in a responsible, environmentally sensitive manner.

2.3.2 Montreal Protocol definitions

The Montreal Protocol in Article 1, clause 5, defines Production as follows: “Production means the amount of controlled substances produced, minus the amount destroyed by technologies to be approved by the Parties and minus the amount entirely used as feedstock in the manufacture of other chemicals. The amount recycled and reused is not to be considered as Production.” The nature of feedstocks was amplified in Decision VII/30 and although concern was later expressed about emissions of ODS from feedstock uses (Decision X/12) it is argued that feedstocks are not controlled by the Montreal Protocol.

2.3.3 *How the ODS feedstocks are used*

These ODSs can be feedstocks by being fed directly into the process as a raw material stream or as an intermediate in the synthesis of another product. Losses can occur during production, storage, transport, if necessary, and transfers. Intermediates are normally stored and used at the same site therefore fugitive leaks are somewhat lower in this case. Extraordinary efforts are made to minimize such losses.

Table 2-1 shows common feedstock applications but is not necessarily exhaustive.

Table 2-1 Common feedstock applications of ozone-depleting substances

Feedstock ODS	Product	Further conversion	Comments
HCFC-21	HCFC-225		Product used as solvent.
CFC-113	Chlorotrifluoro-ethylene	Polymerized to poly-chlorotrifluoroethylene	Barrier film in moisture-resistant packaging.
CFC-11	HFC-134a		The sequence for production of this refrigerant gas may begin with CFC-113, which is converted to CFC-113a and thence to CFC-114a.
CFC-113 and –113a	HFC-134a and HFC-125		Very high-volume use.
HCFC-22	Tetrafluoroethylene	Polymerized to homopolymer (PTFE) and also co-polymers	Very high-volume use. Work has been done for decades to find an alternative commercial route, but without success.
1,1,1-trichloroethane	HCFC-141b, -142b, and -143a		Continues until 2030 Note alternative feedstock 1,1,-dichloroethylene (vinylidene chloride) that is not an ODS.
HCFC-142b	Vinylidene fluoride	Polymerized to poly-vinylidene fluoride or co-polymers.	Products are specialty elastomers, likely to have continuing uses and thus continuing feedstock use of 142b.
CTC	CFC-11 and CFC-12		Production and consumption of these CFCs, and thus this feedstock use, have fallen to very low levels.

Feedstock ODS	Product	Further conversion	Comments
CTC	Chlorocarbons	Feedstock for production of HFC-245fa and new HFOs.	HFOs have zero ODP and ultra-low GWP.
CTC with 2-chloropropene	Intermediates	Production of HFC-365mfc	
CTC with vinylidene chloride	Intermediates		Production of close to 1 million pounds annually.
HCFC-123, HFC-113a and HFC-133a	Intermediates for TFA and trifluoroethanol	Production of pharmaceuticals and agrichemicals	
HCFC-133a	Anaesthetic halothane		
Halon-1301	Production of the pesticide Fipronil		
HCFC-123	HFC-125		
HFC-124	HFC-125		
CTC	Intermediates Production of vinyl chloride monomer (VCM)	Pyrethroid pesticides.	CCl_3 groups in molecules of intermediates become $=CCl_2$ groups in pyrethroids.

The CTOC has received a listing of more than 50 examples of feedstock uses just in the EU. Many are small in nature for very specific niche manufacture in addition to the major uses cited above. Based on this list, the EU estimated in 2011 annual use of between 100,000 and 200,000 tonnes of ODSs as feedstocks in that region. The estimated annual use in China is about 200,000 tonnes, with quantities HCFC-22 > CTC > other ODS.

2.3.4 Estimated emissions of ODS

Data have been received from the Ozone Secretariat reporting production, import and export of ODS used as feedstocks for the year 2012. Table 2-2 summarizes the volume of ODSs used as feedstocks in 2012 These also include volumes used as process agents as Parties are directed to report such consumption in a manner consistent to what is done for feedstocks. Detailed information can be found in the spreadsheet provided by UNEP as an attachment. Total production for feedstock uses was 1,136,807 tonnes and represents a total of 461,314 ODP tonnes. Compared with production for feedstock uses in 2011, this represents a 4% increase (ca. 42.9K tonnes). The biggest increase was for CFC-113 which increased by 28K tonnes or 23%. CFC-113 is commonly used as a feedstock in HFC-134a production.

Estimation of emissions is an inexact science. Sophistication of the operating entity can heavily influence emission amounts. Highly automated, tight and well instrumented facilities with proper procedures closely observed can have emission levels as low as 0.1% of the amount used as feedstock. On the other extreme would be batch processes of limited scale with less tight and less concern for operational excellence, which can have emission levels up to 5%. The largest volumes of feedstock use are at the lower end of the scale as large capacity plants have the most investment and are able to control emission levels well. In order to generate some guidance values, the IPCC guideline for emissions of HFC plants of 0.5% of feedstock use, was used to estimate feedstock emissions. Based on using this guidance figure, the total emissions associated with feedstock and process agent use in 2012 was approximately 5,684 tonnes or 2,307 ODP tonnes.

In a recently published paper in Nature Geosciences, “Newly Detected Ozone Depleting Substances in the Atmosphere”, by Laube et al, the presence of CFC-113a, CFC-112, CFC-112a and HCFC-133a were reported. Sources of these compounds as pollutants were not defined. The use of CFC-113a and HCFC-133a has been included previously in reports of the CTOC and, as such, these are not new compounds. Their use is growing as they are feedstocks used in HFC production. HFC production, initially limited to non Article 5Parties, is leveling in these regions. Their production in Article 5 Parties is now growing rapidly. The atmospheric concentration of CFC-112 and CFC-112a is declining. If one were to hypothesize that all the atmospherically measured 113a and 133a were sourced from feedstock use (worst case scenario) and the accumulated production to date of associated HFCs- 134a, 125 and 143a were considered, the worst emission rate calculated would be on the order of 1.6%. This could be considered a realistic upper limit of feedstock and production emissions given these real life measurements.

The CTOC has also reviewed in detail the EU-sponsored study, the “Information Paper on Feedstock Uses of Ozone-Depleting Substances" conducted by Touchdown Consulting, December, 2012 provided by the European Union. As well as providing excellent background data including a full analysis of all previous CTOC and TEAP reports, it details best-case and worst-case (assuming all production is “small batch” with emissions of 5% of feedstock) emissions scenarios for the TEAP emissions factors when applied to feedstock production.

For 2011, analysis of the European Pollutant Release and Transfer Register (E-PRTR: www.prtr.ec.europa.ec) shows that the EU emissions of HCFCs were 245.9 metric tonnes of which 198.4 tonnes can be attributed to production and feedstock uses. EU Production of HCFCs in 2012 was reported (European Environment Agency) as 117,702.787 metric tonnes. In addition, the E-PRTR reports CTC emissions in the EU to be 167.7 tonnes (of which 110 tonnes is from a process agent use) from a production of 34,020 tonnes. This means that emission levels of approximately. 0.2% were achieved in this technologically advanced region where use of waste destruction capability is installed on vents. This level is much lower than the IPCC guidelines of 0.5% used in our estimate of emissions. This also serves to illustrate the effectiveness of local regulation and oversight, and industrial diligence in managing and control of ODS emissions in feedstock use.

Table 2-2 Amounts of ODSs used as feedstocks in 2012

2012 Feedstock production by compound				
	Substance	**ODP**	**(tonnes)**	**(ODP tonnes)**
	CFC-12	1	0	0
	CFC-113	0.8	151673	121338
	CFC-114	1	67601	67601
	Halon-1301	10	1471	14710
	Halon-2402	6	0	0
	CFC-112	1	0	0
	CFC-217	1	0	0
	CTC	1.1	191969	211166
	Methyl	0.1	101521	10152
	chloroform			
	HCFC-22	0.055	459116	25251
	HCFC-122	0.08	0	0
	HCFC-123	0.02	5787	116
	HCFC-124	0.022	37707	830
	HCFC-133	0.06	1279	77
	HCFC-141b	0.11	12748	1402
	HCFC-142	0.07		
	HCFC-142b	0.065	102174	6641
	HCFC-235	0.52	0	0
	HBCFC-22	0.74	77	57
	HBCFC-31	0.73	0	0
	Halon-1011	0.12	496	60
	Methyl	0.6	3188	1913
	Bromide			
Total			**1136807**	**461314**

2.5 n-PB update

For some years the CTOC has been reporting, on the one hand, the lack of data on production and consumption of nPB and, on the other hand, the growing concern over workplace toxicity of this substance. The American Conference of Governmental Industrial Hygienists (ACGIH) proposed a reduction of the TLV® for n-propyl bromide from 10 ppm to 0.1 ppm in 2012, and finally released 2014 editions of TLVs® and BELs book that shows 0.1ppm of TWA for nPB. Also, Japan Society for Occupational Health proposed to set the TLV of nPB to 0.5ppm in 2013.

2.6 Solvents

The development of new solvents is discussed in the report of the Task Force responding to Decision XXV/5, but the major trend is the introduction of substances with unsaturated molecules and thus short atmospheric lifetimes, near zero ODP and low GWP. Such substances are expected to replace HCFCs in a number of uses and also to compete with hydrofluoro-ethers (HFEs) in the solvent sector. The main groups of new substance sare unsaturated HFCs (HFOs) and unsaturated HCFCs (HCFOs). In the former category are the by now well know HFO-1234yf and HFO-1234ze. A recent development is the production of HCFC-1233zd (CF_3-CH=CH-Cl, *trans* isomer). This substance has a boiling point of 19^{o}C and useful solvency properties.

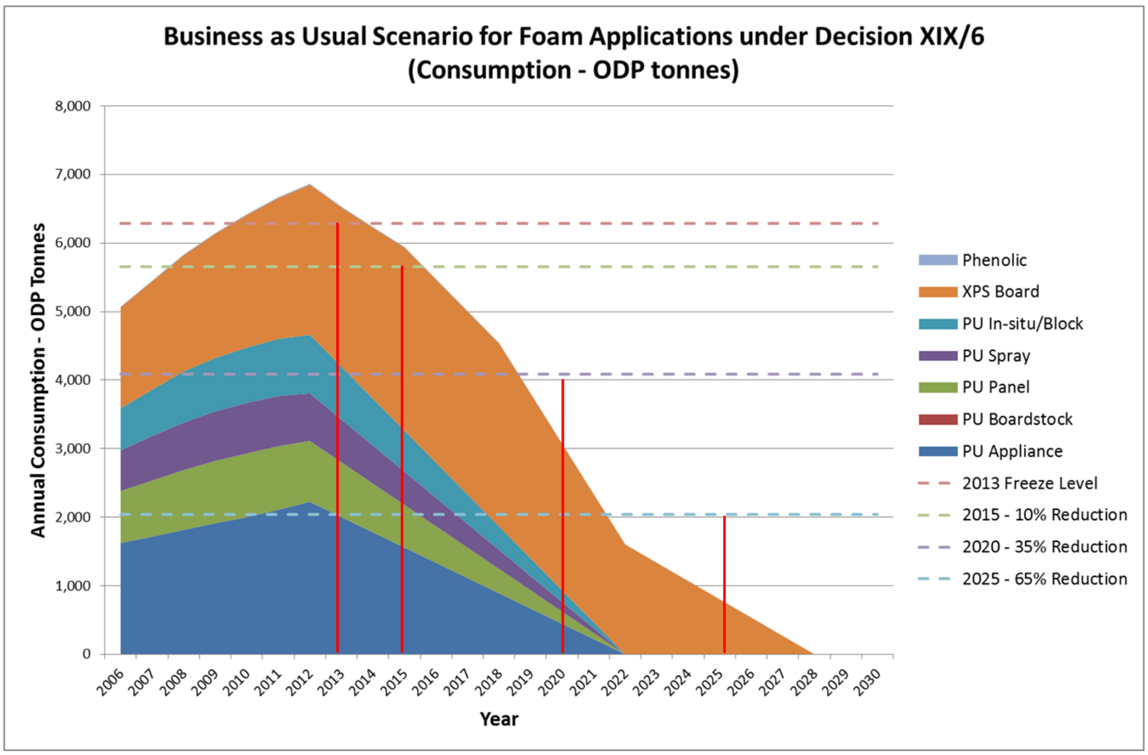
3 Foams TOC (FTOC) Progress Report

Much of the progress that has occurred in the foam sector over the last year is covered within other Volumes of the TEAP Report – most notably, Volume 4 (responding to Decision XXV/5 on alternatives to ODS) and Volume 6 (responding to Decision XXV/8 on Replanishment). Readers are therefore encouraged to refer to these Volumes for detailed information on each subject.

Nonetheless, it is believed appropriate to draw specific attention to a few important observations in this specific Progress Report. These are addressed in the following sub-sections.

3.1 Progress on phasing out ODS in Article 5 Parties

Although there has been considerable focus on the foam sector within Stage 1 of various HCFC Phaseout Management Plans (HPMPs), based on the requirement in Decision XIX/6 to take a "worst first" approach to prioritisation of transition projects, there is some evidence that the implementation of projects may not have been sufficiently rapid to achieve the 2013 freeze from a purely foam perspective. The following graph illustrates the scenario based on the best available information at this stage:



It can be seen that the sector may also struggle to meet its 10% reduction target in 2015. One of the more significant factors in this analysis is the level of baseline HCFC consumption associated with extruded polystyrene (XPS) production. Since this is primarily based on HCFC-22 and HCFC-142b, it does not feature in the 'worst first' approach and, for a large part, these projects are likely to appear in Stage 2 proposals. In other non-funded projects, the timing is likely to be determined by the strategies of multi-national producers and agreements reached with respective national governments.

While the overall compliance with Decision XIX/6 is not solely dependent on the foam sector and will not be known in full until the 2013 reporting of consumption for all sectors later in 2014, the FTOC felt that it was relevant to draw attention to these trends at this point. It should be noted that later reduction targets in 2020 and beyond do not appear to be under threat, since transitions in the foam sector will certainly be well advanced by that stage.

3.2 On-going work on low-GWP alternatives to ODS and HFCs

Manufacturers and potential manufacturers of unsaturated HFCs and HCFCs (so called HFOs) are continuing to report that their commercialisation timelines are on track. The gaseous blowing agent, HFO-1234ze(E) is already commercially available globally with most use currently in Europe. Two producers are now targeting commercial production of HFO-1233zd(E) with one large scale commercial plant already on stream. HFO-1336mzz(Z) is also being progressed and is expected to be commercially available in small scale by the end of 2014 and larger commercial quantities by 2016.

One less positive development has been the reporting of some stability issues for the gaseous blowing agent in certain low pressure two-component (froth) formulations. This may affect the ability to use them in the field unless it can be countered. A minimum shelf-life is essential for operation at contractor level and further developments are necessary to overcome these apparent short-comings if the fullest use of low-GWP blowing agents is to be achieved. This is understandably attracting significant amount of development attention at this time, but no immediate solution is in sight.

4 Halons TOC (HTOC) Progress Report

The Halons Technical Options Committee (HTOC) met from the 17th to 19th March, 2014 in Kyoto, Japan. Attending members were from Brazil, Canada, India, Italy, Kuwait, Japan, Jordan, Russia, South Korea, United Kingdom, and the United States of America. In addition, the HTOC visited a halon recycling facility in Kobe on the 20th March.

The following is the HTOC update for 2014.

4.1 Civil Aviation

Additional work is reported on-going for engine nacelles using the dry chemical fire suppressant that had failed the full-scale fire test required by the U.S. Federal Aviation Administration. Industry has formed a consortium to pool resources to determine a single halon replacement for engine nacelles.

Owing to the International Civil Aviation Organisation (ICAO) request for industry to provide them with a date that halon can stop being required in the cargo compartments of new aircraft designs, the International Coordinating Council of Aerospace Industries Associations (ICCAIA) has formed the Cargo Compartment Halon Replacement Working Group (CCHRWG) to provide them with an answer during the next General Assembly in September, 2016.

The European Aviation Safety Agency (EASA) has deleted all references to specific extinguishing agents in “Book 1” of its Certification Specifications. Thus halon is no longer mandated in new aircraft designs, but is allowed until the “cut-off” dates in EC Regulation 744/2010 (2011 for lavatory waste receptacles; 2014 for portable extinguishers; 2014 for engine nacelles and auxiliary power units; and 2018 for cargo bays). EASA has also established a Rulemaking Group to produce in 2014 a Notice of Proposed Amendment (NPA) to comply, as much as possible, with ICAO Annex 6. For engines / auxiliary power units and cargo compartments, even after the dates specified in the EC Regulation, industry may request derogation on the basis of Article 13.4 of EC Regulation 1005/2009 where no economically or technically feasible alternative exists.

4.2 Halon Supply/Demand

For at least one Party in Asia, and potentially more, the situation regarding halon availability has changed. The Party has become a net importer rather than a net exporter of halon. This finding is in line with global observations that the supply of recycled halons is diminishing. The HTOC is receiving more evidence that halon availability / accessibility is diminishing for a variety of reasons, which will be covered in detail in the 2014 HTOC Assessment Report.

There is growing evidence that halon users in many Parties are relying on suppliers in other Parties for recycled halons for the majority, if not all, of their most important uses, such as civil aviation and military. Some of these users are now encountering difficulties with obtaining sufficient quantities of halon for these important uses. Parties may not always be aware of such difficulties.

It is becoming clear that institutional memory has been lost on the specific issues and requirements of the Montreal Protocol relating to critical elements of halon management, such as import and export requirements. Parties may wish to consider directing the development of updated training and awareness materials and programs for the halon sector, which address import and export, purity and other bank management needs that would then be presented at regional ozone meetings.

4.3 Global Emissions

The manufacture of CF_3Br (halon 1301) as feedstock for the production of the pesticide Fipronil continues to increase. In the past, significant tail gas emissions have been reported and it is not clear whether or not proposed emission-reduction measures have been effective.

4.4 Halon Alternatives

The chemical agent 3,3,3-trifluoro-2-bromopropene (2-BTP) has been submitted to the United States Environmental Protection Agency for required regulatory approvals for commercialisation. It is not clear if the current development schedule for the agent will keep the aviation industry on track to meet the ICAO agreed-upon date of 31 December 2016 to use non-halon handheld extinguishers on all in-production aircraft.

Three new low GWP chemicals are being evaluated for potential use as fire extinguishing agents. Two are designated as streaming agents, and one is a total flooding agent.

In cases where space and weight are not limiting factors, there is recent, but limited, information that in some parts of the world inert gas systems can be cost competitive with halocarbon systems, a heretofore unanticipated situation.

5 Medical TOC (MTOC) Status Report

MTOC has assessed essential use nominations and reviewed reporting accounting frameworks for essential use exemptions of CFCs for the manufacture of metered dose inhalers (MDIs). This assessment appears in Volume 2, which includes any relevant new information on the phase-out of CFCs in MDIs. MTOC did not prepare a separate progress report this year.

The phase-out of CFCs in the manufacture of MDIs is approaching, with only one essential use nomination received from China for 217 tonnes for 2015. This nominated quantity represents less than 3 percent of the annual maximum of CFCs used in MDIs under essential use exemptions, which was nearly 9,000 tonnes in 1997.

6 Methyl Bromide TOC (MBTOC) Progress Report

6.1 Introduction

The MBTOC 2014 Progress Report provides analysis on trends in production and consumption of MB for both controlled and exempted uses and an update of adoption and development of alternatives for preplant and postharvest uses of MB.

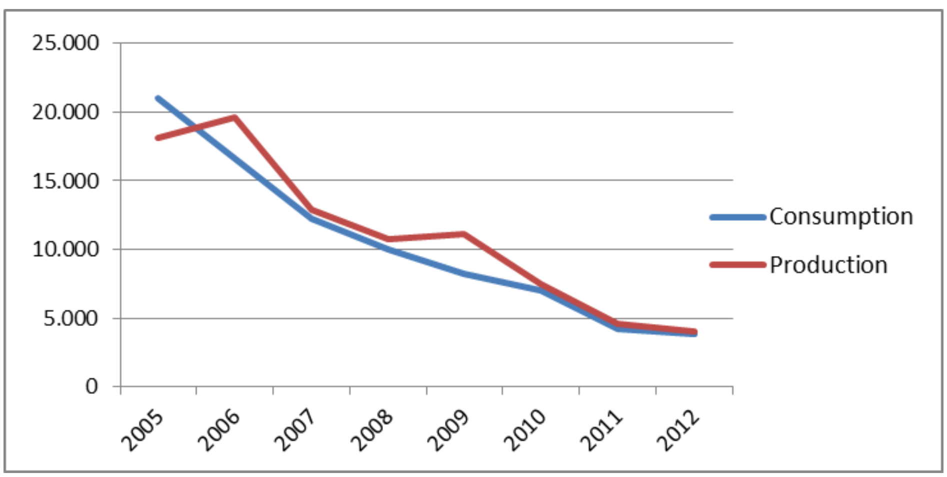
The report also includes responses or updates to Decisions XV/12 on high moisture dates and XXIII/12 on destruction and recapture of methyl bromide. It further addresses QPS uses of MB and their alternatives plus recent developments from the IPPC (International Plant Protection Convention).

6.2. Trends in Methyl Bromide production and consumption for controlled uses

Global production and consumption of methyl bromide (MB) for controlled uses have continued on a significant downward trend, in accordance with phase-out deadlines for non-A5 and A5 Parties of the Montreal Protocol as illustrated in Fig 6-1. Global consumption is now about 7.0% of the global aggregate baseline.

When comparing production vs. consumption, it shows that since 2005, a surplus of about 5,970 tonnes of MB produced for controlled uses has accumulated. This could be due to stocks or to lack of reporting of consumption in some countries.

Fig 6-1 Global production vs. global consumption of MB for controlled uses 2005 - 2012



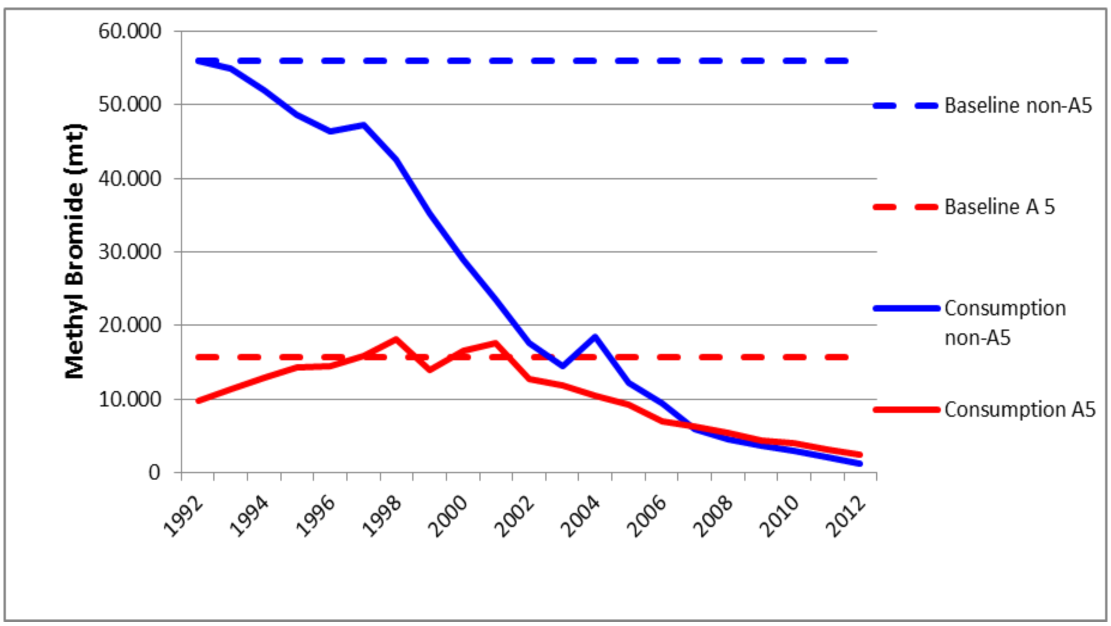
Source: Ozone Secretariat Data Access Centre, April 2014

Consumption for controlled uses at the end of 2013 was at 2.3% of the baseline for non-A5 Parties (entirely used for critical uses as approved for the Parties) and 15.8% for Article 5 Parties (Fig 6-2). Consumption for controlled uses in Article 5 Parties is due for complete phase-out by January 1st, 2015 (except for critical uses). At present, the largest quantity of MB that needs to be phased out before the 2015 deadline is in Latin America (Fig 6-3).

Complete phase-out has been achieved in many Article 5 countries in advance of the 2015 deadline e.g. Lebanon, Morocco, Turkey, and Kenya, and this has been most often with support of investment projects funded through the MLF. These projects have identified technically and economically feasible alternatives, which are as effective as MB alone or in combination.

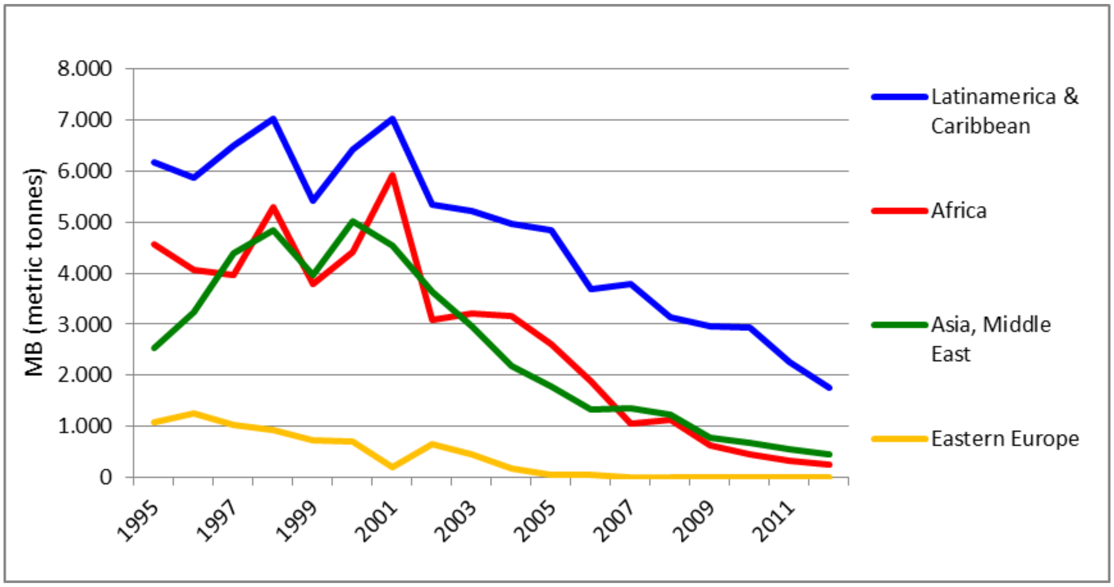
- Early MB phase-out for some crops in some Article 5 Parties has proven beneficial due to the consequent improvement in the production practices. This has increased the competitiveness of agricultural products in international markets and provided training for large numbers of growers, technical staff and other key stakeholders e.g. flower production in Kenya, vegetable, banana, ornamentals and strawberry production in Morocco, strawberry and vegetables in Lebanon.
- Some Article 5 Parties that agreed to phase out with the MLF support have not made the progress anticipated in some specific sectors (strawberry runners, tomato, peppers, ginger) and Critical Use Nominations for 2015 have been submitted. In some of these sectors, transition to use of alternatives has identified unexpected challenges.
- Further issues for crop sectors in some countries have led to additional challenges. Examples include the rapid growth of new sectors e.g. berry nursery industries in Mexico, and rapid expansion of existing sectors (ginger in China) and an increase in some important soil-borne pathogens (*Ralstonia* on ginger in China).

Fig 6-2 Global consumption controlled uses



Source: Ozone Secretariat Data Access Centre, April 2014

Fig 6-3 Consumption trends in Article 5 regions (controlled uses)



Source: Ozone Secretariat Database, April 2014

6.3. Progress on alternatives to MB for soil fumigation

6.3.1. Non chemical alternatives

Non-chemical alternatives such as substrates, resistant varieties, grafting, biofumigation, steam, solarisation, and anaerobic soil disinfestations (ASD) continue to expand and to replace MB in non-Article 5 and Article 5 countries as their technical and economical feasibility improves. Non-chemical alternatives to MB have gained importance mainly because of the negative health and environmental issues of most chemical alternatives.

Although not always replacing actual uses of methyl bromide the following technologies continue to show advancements in control of soilborne pathogens or increased commercial adoption. For instance:

- Adoption of soil less production systems has increased in many countries and is used as an alternative to MB fumigation mainly for vegetable and flowers (Kazaz and Yilmaz, 2009; Liu *et al.*, 2009; Marcic and Kacjan, 2010), but more recently for sectors where MB phase out has proven difficult e.g. ginger in protected cultivation and strawberry nursery plants (Hepperly *et al*., 2004; Sayed 1984; Singh and Singh 2012; Suhaimi *et al.*, 2012) .These industries may use both locally available or imported substrates according to their technical and economic feasibility.

- Cultivars with resistance to soilborne pathogens in combination with fumigants provide an excellent alternative to MB for the control of soil borne pathogens; new sources of resistance have been identified in some key crops such as strawberry (Daugovish *et al*., 2011b).

- Grafting is an important alternative to MB for controlling soilborne pathogens in solanaceous and cucurbit crops and is used worldwide (Besri, 2008). In addition to reducing disease severity, this technique can contribute to increased yield and fruit quality, more vigorous growth, longer production periods, increased crop longevity, and improved tolerance to abiotic stresses such as salinity (Keinath and Hassell, 2013; Foster and Naegele, 2013; Cohen *et al.,* 2012; Gilardi *et al.,* 2013; Suchoff *et al.,* 2013).

- Steaming (pasteurization) is a very effective alternative to MB for greenhouse-grown high-value crops (ornamentals, vegetables); it is also used for substrate disinfestation. However fuel costs, capital investment and speed of treatment impact the feasibility of this alternative. Recent research has focussed on the development of more effective and efficient steaming systems to help solve such limitations and is providing encouraging results (Daugovish 2011; Fennimore *et al.,* 2011, 2013).
- Biofumigation and biosolarisation are used in some particular conditions as part of an IPM program to replace MB for control of soil borne pathogens and weeds in many crops including vegetables and ornamentals with good results. Their success is influenced by the pest complex, soil characteristics, type and availability of the soil amendment, and climatic conditions (Morales-Rodríguez *et al.,* 2014; Klein *et al.,* 2012; Gamliel and Katan, 2012; Besri *et al.,* 2012; Ozores-Hampton *et al.,* 2012).
- Recent studies continue to show that overall efficacy of solarisation as an alternative to MB is significantly improved when combined with other options such as chemicals, grafting, anaerobic soil disinfestation (ASD) or biofumigation (Yilmaz *et al.,* 2011; Nyczepir *et al.,* 2012; Butler *et al.,* 2012; Lombardo *et al.,* 2012; Melero-Vara *et al.,* 2012; Gamliel and Katan, 2012; Besri *et al.,* 2012).
- ASD is now widely used in Japan and is being tested in other countries such as the USA, with encouraging results, but still with some inconsistency. The feasibility of this alternative is largely impacted by moisture and the availability of an appropriate carbon source (Katase and Ushio, 2010; Ebihara *et al.,* 2010; Daugovish *et al.,* 2011a; Shennan *et al.,* 2010; Rosskoph *et al.,* 2012; Butler *et a.,l* 2012; Shennan *et al.,* 2013; Kokalis-Burelle *et al.,* 2013).

6.3.2. Chemical alternatives and regulatory issues

- Chemical alternatives are a key option to replace MB worldwide (MBTOC 2011; Beede *et al.,* 2013) and mainly include Pic alone and its mixtures with 1,3-D, or metham sodium or metham potassium.
- Methyl iodide (MI) a key alternative to MB, which was withdrawn in the last few years in many markets (USA, Australia, South Africa, Canada and Mexico) is still registered for soil application in Japan, but not used.
- Dimethyl disulphide (DMDS) has recently been registered in the US, but not in California and thus not considered for the remaining critical use of strawberry fruit (Meyer and Hausbeck, 2013; Cao *et al.,* 2014; Belova *et al.,* 2013; McAvoy and Freeman 2013; Devkota *et al.,* 2013).
- The future viability of several alternative chemical fumigants is uncertain in several countries. In the EU for example, 1,3-D has been banned and MITC products are under review, whilst Pic can only be used under emergency provisions of individual countries and on a seasonal basis. In some cases, regulations limit the maximum rate at which registered alternatives can be used and this may reduce their efficiency as MB alternatives (Sullivan, 2013).
- A recent meta-analysis of a large number of experiments evaluating the technical feasibility of MB alternatives as soil fumigants for strawberry production in California, Florida, and

Spain and for tomato production in Florida, indicated that the results obtained do not support the technical superiority of MB over its alternatives, but do support the previous study conducted by MBTOC, which indicated that alternatives are generally as effective as MB (Porter *et al.*, 2006; Belova *et al.*, 2013; Grieneisen *et al.*, 2013).

6.3.3. Remaining and emerging challenges impacting MB phase-out for soils uses

- MB phase-out during the remaining months of 2014 is critical for developing countries as they move toward compliance with the final phase-out deadline of January 1, 2015.

- In non-Article 5 Parties, only two remaining CUNs, both in the strawberry nursery sector, appear to not yet have effective alternatives.

- Nursery crops present a special challenge for the development of alternatives to MB due to the need for complete sanitation in transplants, not just a level of reduction of soil-borne pathogens. Certification standards often mandate the use of high rates of methyl bromide and no other alternative. Without changes in these standards, little progress in transition to alternatives can be expected and this could lead to long term use of CUNs. In the US, MB continues to be classified under QPS for a number of preplant soil nursery applications, despite the target pathogens being similar to those occurring in similar sectors in other countries.

- The availability of alternatives, including those already adopted and those under development, could change in the medium to long term due to a number of issues including regulatory restrictions from environmental and health issues, increases in energy usage and application costs, etc., and thus continual review of the alternatives to replace MB is required.

- The cost and length of time required for obtaining registration at both the federal and local state levels for a limited market is still a major barrier to the availability of many chemical alternatives but especially for the development of new chemical biopesticides.

6.4. Progress on MB alternatives for Structures and Commodities

6.4.1. Chemical alternatives and regulatory issues

- A fairly comprehensive overview on the MB alternatives for pest control in stored product and material protection as well as for post harvest uses was presented recently (Ducom 2012).

- Phosphine is widely used to control various post harvest pests (Amoah *et al.*, 2013), however, continued issues with resistance to this chemical has been reported in several countries, for example Australia (Collins, 2013,) USA (Phillips and Opit, 2013; Hosoda, 2013) and this can seriously challenge the future use of this alternative.

- Adoption of sulfuryl fluoride (SF) as an alternative to MB continues to increase in the food industry in the United States. For example, the dried fruit and nut industries of California where rapid disinfestation of insect pests is required have transitioned to SF (Bonifacio *et al.*, 2013; Gautman *et al.*, 2013; Hosoda 2013). China has three factories producing SF for local use and export and is using this fumigant for the treating of grain, cotton and timber. In Japan and the USA, SF is in use for disinfestations of museums (structures) against insect pests. MBTOC notes that SF has a very high GWP.

- Propylene oxide is used in Japan for treatment of museums to control insects and in the USA against moulds.

- Vapormate, a mixture of ethyl formate and carbon dioxide, is now used in Australia, New Zealand and South Korea for disinfestation of stored grain.

- France and some Baltic countries have registered the Indian phosphine formulation of United Phosphorous.

- Cylinderized phosphine (ECO_2 and Vaporphos) is now registered in Thailand, Indonesia, Philippines, Australia, New Zealand, Papua New Guinea and Turkey. The registration process is still underway in Singapore (Tumambig and Dikin, 2013).

6.4.2. Non chemical alternatives

- Irradiation as a phytosanitary tool (IPT) was approved for all fresh fruit and vegetables imported into the US (Jeffers, 2013). However, the potential of this technology for reducing the use of MB is still not clear.

- Requests for using Modified Atmosphere Packaging (MAP) to slow the speed at which aerobic microorganisms develop have dramatically increased in recent years in the USA (Jeffers 2013).

- Facilities for the application of carbon dioxide and nitrogen are under development in Indonesia and the Philippines (they are expected to be operational by May 2014) for pest control of insects in stored tobacco.

- In the Philippines, high value stored products (e.g. cocoa powder) are treated with nitrogen from cylinders (less than 2 volume % oxygen) under tarpaulins to control cut feeding insects. In Albania and Western Australia, large steel bins and gas-tight concrete silos have recently been built for treatment of stored grain prior to export with nitrogen and a very low residual oxygen content (less than 1% by volume).

6.4.3. Alternatives to MB in ham house disinfestation

- Despite robust research supported by the US government, a viable alternative has not yet been found to replace MB as an effective and feasible procedure against the ham mite *Tyrophagus putrescentiae* and the ham beetle *Necrobiaru fipes.* There is an ongoing research program focusing on improving processing sanitation, IPM and pest control through a variety of possible fumigants and physical processes (Amoah *et al.*, 2012; Phillips *et al.*, 2012 a b; Phillips, 2013 ab). Trials with various alternative fumigants and nonchemical treatments do not yet provide sufficient control of the ham mite *Tyrophagus putrescentiae* (Abbar *et al*. 2012, 2013; Zhao *et al*., 2012 ab). Phosphine treatment using magnesium phosphide controlled the mites but let to inacceptable corrosion damage to exposed electronics (Phillips 2013 c).

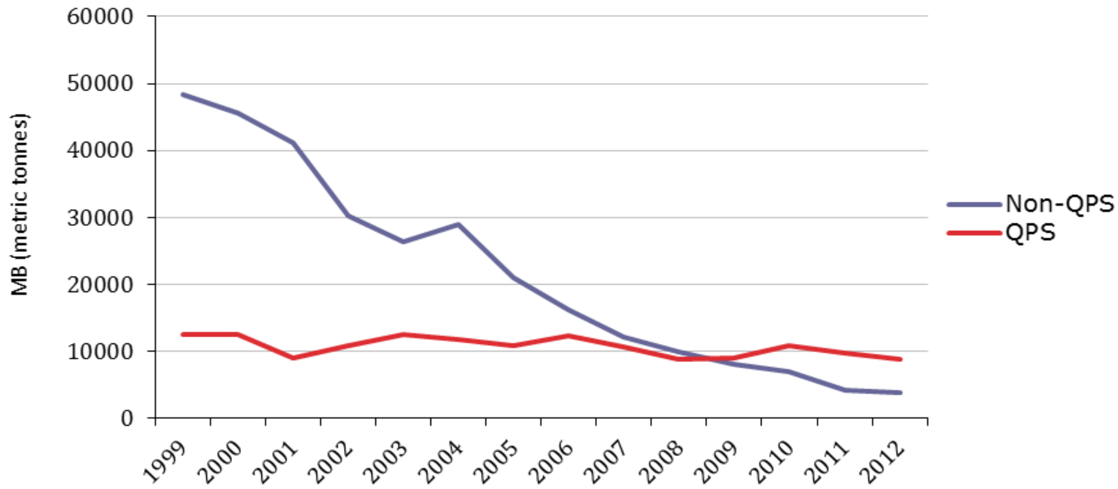
- An IPM program has been developed for trapping the ham mite, *Tyrophagus putrescentiae* (Amoah *et al*, 2013) and for stored grains (Arthur 2013), but the former has yet to be adopted commercially for southern dry cure pork.

6.5. QPS Uses of MB (exempted uses)

6.5.1. Consumption

Global QPS consumption was approximately 8860 metric tonnes in 2012. Due to the advanced phase-out currently in place for controlled uses, QPS consumption is now about 2.3 times more than the level use for controlled consumption for the same year (3,805 metric tonnes) (Fig 4).

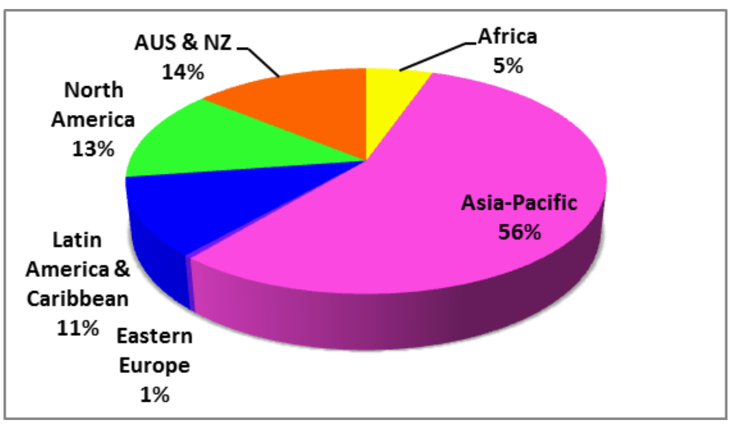
Fig. 6-4 Methyl bromide consumption for controlled and exempted uses 1999- 2012



Source: Ozone Secretariat Database, April 2014

When considering global consumption on a regional basis, Asia is by far the largest consuming region, followed by Australia and New Zealand and the United States (Fig 5).

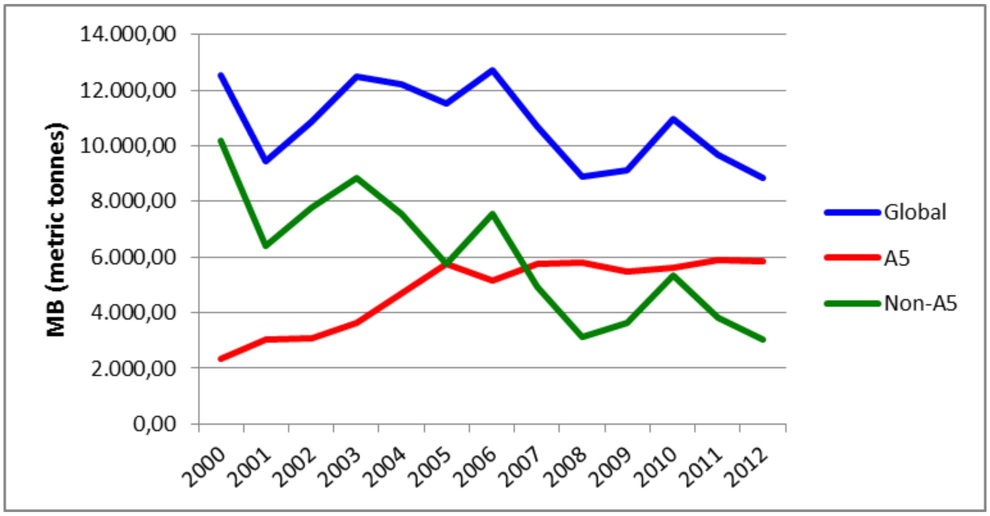
Fig 6-5 Relative global consumption of MB for QPS uses in 2012



Source: Ozone Secretariat Database, May 2014

Consumption for QPS uses in Article 5 Parties continues on an upward trend, with consumption in non-Article 5 Parties decreasing (Fig 6-6).

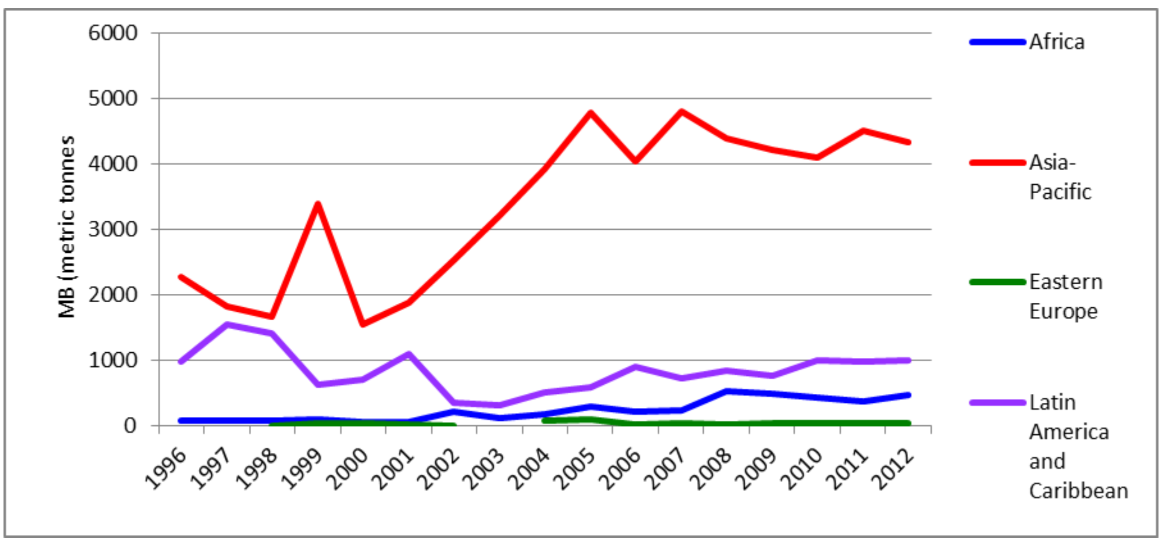
Fig. 6-6 Methyl bromide consumption for QPS purposes in Article 5 and non-Article 5 Parties 2000 - 2012



Source: Ozone Secretariat Database, April 2014

A general analysis of Article 5 countries reveals that MB consumption for QPS purposes is increasing in all regions (except Eastern Europe) although in different proportion, as shown in Fig. 6-7

Fig. 6-7 Methyl bromide consumption for QPS in Article 5 regions



Source : Ozone Secretariat Database, April 2014

6.5.2. Relevant issues for QPS use of MB

- A major challenge to estimating feasibility of adoption of alternatives to MB for QPS is the difficulty in tracking quantities used for particular QPS use categories found in some countries. While many parties have accurate and accessible tracking systems for MB production and consumption for individual categories of QPS use, others do not have such recording systems as suggested in Decision XXIII/5.

- A response to Decision XXIII/5 however showed that a significant number of parties do keep detailed records of QPS use (e.g. Australia, Japan). It further appears that other parties may have detailed information (import quarantine, export, quantities, key pests) at a certain level in government (often the Ministry of Agriculture, phytosanitary authorities), but this may not always get reported to the national focal point, which then reports to the Ozone Secretariat.
- In the US and other countries, the lack of trained entomologists at port facilities continues to be the cause of unnecessary quarantine treatments with MB at ports of entry. Import commodities found to be infested with insects (e.g. mites), which are not quarantine organisms are fumigated unnecessarily with MB at ports of entry, when this should only happen when the pest in question is identified and confirmed to be of quarantine significance.
- In the USA, a system has been developed to collect, analyse and report data from long term treatments performed in transit including ships at sea.
- Cold treatment has been shown to be an effective alternative to MB, but requires a long treatment time to be effective and should be regularly monitored to ensure treatment parameters are continuously met. This satellite-based technology will ensure success of the treatments and prevent MB having to be used at conclusion of transit if the cold treatments remain in compliance during transit.
- Ethanedinitrile (EDN) has been recently registered in Australia for the treatment of logs and timber, however restrictions on its use such as buffer zones, recapture and with holding period limit its adoption. Currently only Malaysia accepts EDN as a quarantine treatment. Registration is progressing in New Zealand, SE Asia, South Africa, Israel and reviews, including market acceptance tests, are under way in a number of additional countries (Jessup *et al*., 2012).
- Vapormate (ethyl formate + CO_2) is now registered in South Korea and used as a quarantine treatment for fumigating some imported fruits including bananas (Byung-Ho *et al*., 2009). This fumigant is registered in Australia and New Zealand for a range of postharvest durable commodities including grains, but not yet as a quarantine treatment. Registration is also progressing in SE Asia, South Africa, the US and Tunisia (Linde 2013). Vapormate is being increasingly used for fresh fruit and other perishables in situations where MB could also be used, particularly where target pests are on the outside of the treated commodity. It is rapid acting, non-residual and controls insects (adult, juveniles and eggs) in stored grain, oilseeds, dried fruit, nuts, fresh produce (e.g. bananas, blueberries) and cut-flowers, enclosed food containers and food processing equipment (Finkelman 2012). Ethyl formate residues break down quickly to levels occurring naturally in food and in the environment. It is effective at cool temperatures and therefore does not reduce the shelf life of products. Its activity is strongly synergised by CO_2. It is more expensive than MB, but is less phytotoxic and induces immediate pest kill.
- In Indonesia, ECO_2FUME (Phosphine + CO2) is used for QPS treatment of major commodities in the country such as rice and other stored grains, coffee, cocoa, tobacco, pineapple and mangosteen. Additional phosphine fumigation protocols are currently being developed for other commodities such as wood chips, cut flowers and other export fruits and vegetables. The Indonesian AQA is also working on bilateral agreement with importing countries in the adoption of ECO_2FUME for QPS treatment. A comprehensive "Technical Manual for Liquid Phosphine (ECO_2FUME)" was produced and later approved for implementation by the Indonesian AQA. This technical manual will serve as a reference guide

for all Indonesian fumigators involved in QPS treatment of different import and export commodities using ECO_2FUME .

- In 2013, a synthetic pyrethroid, usually applied premixed and propelled by CO_2, has replaced several tonnes of MB for the treatment of containerised export sawn timber infested with *Arhoplus ferus* beetles. The treatment is applied during the summer for shipments from New Zealand to Australia.
- Japan is introducing a process treatment whereby commodities such as rapeseed and soybean, which are used for extracting edible oil, can be exempted from MB fumigation under certain conditions. In particular, an oil extraction process involving an advanced automation system and a closed type conveyer is considered effective as a quarantine treatment to replace MB.
- Cold treatment has long been used for quarantine treatment of citrus fruit imported to the US from countries where for quarantined species of fruit flies are indigenous, however, the discovery of surviving fruit fly larva in cold treated fruit has cast doubt over the effectiveness of this protocol. USDA scientists, working with scientists from South Africa, Argentina and Kenya are revising the protocol to ensure its continued use as a MB alternative.
- Research is underway in the USDA to develop sulfuryl fluoride as a potential replacement for MB against invasive snail species taking harbourage in shipments of ceramic tiles imported into the USA. This research could potentially replace the substantial amount of MB used for this purpose.

6.5.3. International Plant Protection Convention (IPPC)

Under the Memorandum of Understanding (MOU) signed between the Montreal Protocol and the IPPC in 2012, MBTOC keeps up to date on developments originating from that body, which are relevant to MB use and its alternatives.

- The Commission on Phytosanitary Measures (CPM-8) of the IPPC (2013) revised and adopted the Annex 1of the International Standard for Phytosanitary Measures number 15 (ISPM-15) whereby dielectric heat treatment (e.g. microwave) was approved for the regulation of wood packaging material. This treatment is in addition to the heat treatment using conventional steam or dry kiln heat chamber.
- At the Expert Consultation on Cold Treatments (ECCT) meeting which was organized by the IPPC Secretariat and hosted by the National Plant Protection Organization (NPPO) of Argentina in December 2013, a series of issues were identified to be addressed by cold treatment researchers based on scientific, technical and logistical reasons.
- More recently during its ninth Session (2014), the CPM adopted new standards to be developed under the *Technical Panel on Phytosanitary Treatments* (TPPT) work programme on the treatment requirements appearing below, and MBTOC has been asked to review these standards once they are available.
    - Chemical treatments as a phytosanitary measure,
    - Fumigation as a phytosanitary measure,
    - Temperature treatments as a phytosanitary measure,
    - Modified atmosphere treatments as a phytosanitary measure,
    - Irradiation as a phytosanitary measure (Revision to ISPM 18)

6.6. Update on Decision XV/12 - Alternatives for the treatment of high moisture dates

Decision XV/12 reads:

> "…. *That the Implementation Committee and Meeting of the Parties should defer the consideration of the compliance status of countries that use over 80% of their consumption of methyl bromide on high-moisture dates until two years after the TEAP formally finds that there are alternatives to methyl bromide that are available for high-moisture dates"*

On the basis of new information and as already indicated in its 2013 Progress Report, MBTOC believes that alternatives to MB for high moisture dates are now available and in use. The Implementation Committee may thus wish to take action with respect to Decision XV/12. Some highlights of recent developments are presented below:

- Dates harvested from the *Phoenix dactilifera* palm have been a staple food in the Middle East and North Africa for thousands of years. World date production concentrates in a few countries in this region, particularly Algeria, Egypt, Iran, Iraq, Morocco, Oman, Pakistan, Saudi Arabia, Sudan, Tunisia and the United Arab Emirates. Together, these countries account for about 90% of the total world production (FAO Stat 2012).
- Field pest infestations pose a serious postharvest problem in all date varieties (Blumberg, 2008). Historically dates were disinfested with ethyl formate, ethylene dibromide or ethylene oxide before storage and also with MB in some other production regions, including Tunisia, Israel and the USA (Arar 2011; Belaifa, 2013; Besri, 2014; Boudifa, 2014; Dhouibi ,2013). MB forces a high proportion of larvae and adults to emerge from the fruit before they are killed, which is a requirement to meet some religious and food quality requirements (Navarro, 2006).
- In 2003, and later in 2006 and 2010, MBTOC noted that technically and economically effective alternatives to MB had not been identified for disinfestation and stabilisation of high-moisture dates. This was the basis for Decision XV/12, which permitted MB use for high moisture dates and encouraged work to develop technically and economically feasible alternatives in various countries.
- In its progress report of 2013 however (TEAP 2013), MBTOC indicated that technically and economically feasible alternatives, both chemical (phosphine, phosphine /CO_2, ethyl formate, sulfuryl fluoride) and non-chemical (heat treatment, cold treatment, controlled atmospheres, IPM in the field and in the packing houses) could be efficiently used to replace MB. These alternatives are available for all varieties of dates, including the "high moisture dates", c.v. Deglet Noor referred to in Dec XV/12 and which are particularly important in Algeria and Tunisia. Treatment choice is dependent on the date variety concerned and on the local registration of chemicals (Besri, 2014).
- In the USA, all date varieties including Deglet Noor are left to dry on the palm to a moisture content of about 23%, which is safe for storage at ambient temperatures without spoilage from moulding or fermentation. In Arizona for example, MB was never been used to disinfest dates. The Californian date sector has adopted alternatives to MB (Williams, 2009), mostly phosphine, but also sulfuryl fluoride. Research has found that ethyl formate is an efficient alternative (Finkleman *et al.*, 2010) but this fumigant is not registered for dates in the United States (Walse, 2012).

- Israel has adopted heat treatment (Navarro 2003, 2004) and ethyl formate (Navarro, 2006). Heat treatment forces insects to emerge from the fruit as required. Further, ethyl formate plus carbon dioxide (Vapormate) is now widely adopted for disinfestation of dates (Navarro, 2006).
- In Algeria and Tunisia, Deglet Noor dates are harvested at a moisture content of 35-40% (Besri 2010), posing additional challenges for pest control. Phosphine fumigation has replaced MB fumigation in packing houses in Algeria, Tunisia, Egypt, Jordan, UAE, KSA and other countries (Arar, 2011; Besri, 2014; Boudifa, 2014; Hammami, 2014). The fumigant is supplied in tablet formulations or with a phosphine generator and is efficient for high moisture dates.
- Two surveys conducted in Tunisia in 2011 (Belaifa, 2013; Dhouibi, 2013) showed that 60% of the exported dates were fumigated with phosphine and 40% with MB and other alternatives including cold, cold+ phosphine and heat. Only two packing stations out of 36 were still using MB. No decrease in date quality was reported by the exporting or importing countries, however it was reported that some successful chemical alternatives were not available in some countries (Besri, 2014).
- According to a new Tunisian law, MB is now banned from use in all newly built packing houses (Dhouibi pers.com). Registration of Vapormate (ethyl formate+CO_2) for dates is under way in Tunisia and controlled atmosphere treatments are being trialled (Dhouibi, 2013).

6.7 Update on Decision XXIII/12: Recapture and destruction technologies for methyl bromide

Plasma destruction has been considered for MB destruction to standards suitable for inclusion in Annex II of the 15th MOP approved destruction technology listing.

Decision XXIII/ 12 (2) requests *"the Technology and Economic Assessment Panel to continue to assess the plasma destruction technology for methyl bromide in the light of any additional information that may become available and to report to the parties when appropriate."* To date, there has been no successful reported demonstration of this technology for methyl bromide destruction.

6.7.1. Concentrated sources of methyl bromide

- There remain no approved destruction technologies in the sense of Decision XV/9 and Annex II of 15th MOP for destruction of concentrated sources of methyl bromide. Concentrated sources include unwanted stocks of liquid methyl bromide contained in metal cylinders under pressure as supplied typically for fumigation uses.
- Several countries, including someA5 countries, hold stocks of MB surplus to requirements. These stocks can be hazardous in storage under moist conditions because the pressurised cylinders may become weakened through corrosion and then leak methyl bromide into the surrounding environment. Weakened cylinders may also be hazardous to move and transport.

6.7.2. Dilute sources of methyl bromide

- Methyl bromide concentrations remaining after well-conducted fumigation treatments typically are 50% or more of applied initial concentrations, but seldom exceed 50 g/m^3. Residual MB concentrations after incomplete airing commonly may exceed workspace threshold limit values and may pose a hazard to workers unloading (unstuffing) or inspecting loaded freight containers.

- Scrubbing systems based on recapture on activated carbon have been available for some years and being used in several countries. Different systems have various processes for treating the MB-loaded carbon when it reaches sorption capacity. Processes include disposal in landfill (where permitted) or washing with aqueous thiosulphate solution followed by drying to reactivate the carbon.
- Recent installations of carbon-based recapture systems for fumigant concentrations of MB include in the port of Wellington for recapture of methyl bromide from container fumigations and in Orlando, Florida, USA on fumigations of fresh asparagus. Several customs authorities have adopted carbon-based scrubbers to remove residual toxic gases from freight containers prior to entry for inspection (Nordiko).
- A liquid-based scrubbing system has recently been introduced, with commercial installations including a unit at Chicago O'Hare International airport. Composition of the active ingredient reacting with scrubbed MB has not been disclosed nor patented and remains commercial proprietary knowledge.
- Research continues on improved and more economical methods of MB recapture and construction.

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7 Refrigeration, Air Conditioning and Heat Pumps TOC (RTOC)

The Refrigeration, Air Conditioning, and Heat Pumps Technical Options Committee (RTOC) met 5-6 December 2013 in the Multilateral Fund Secretariat in Montreal, Canada. Attending members were from Belgium, Brazil, China, Croatia, Czech Republic, Denmark, Egypt, France, Germany, India, Jamaica, Japan, Jordan, Lebanon, the Netherlands, United Kingdom, and the United States of America. The following is the RTOC update for 2014.

7.1 Task Force XXIV/7 report

7 RTOC members have participated in the Task Force for the Decision XXIV/7 report and are taking part also in the Task Forces for the reports addressing Decisions XXV/5 and XXV/8. The XXIV/7 final report was composed, taking into account the numerous comments and suggestions that were made by Parties during the report discussion at the 33rd OEWG in Bangkok (June 2013), and presented at the MOP-25 meeting in Bangkok (October 2013). This final report served as one of the references for the drafting discussions for the XXV/5 and XXV/8 reports

7.2 Task Force XXV/5 and XXV/8 reports

12 RTOC members have participated in the Task Forces for Decisions XXV/5 and XXV/8. The discussion on the outlines for the XXV/5 (and to some degree also the XXV/8) reports considered the interlinkage and overlapping that these reports have with the 2014 RTOC Assessment Report. This implies that there needs to be complete consistency with the chapters in draft for the 2014 RTOC Assessment Report.

7.3 2014 Assessment Report status

Draft chapters were circulated in November 2013 for the discussions on coherence and consistency during the RTOC Montreal meeting in December 2013. The development of the 2014 RTOC Assessment Report is now proceeding at a slower pace than for previous RTOC Assessment Reports, which is mainly due to the involvement of RTOC members in both the Task Force and the assessment reports. The RTOC is expected to finalise the assessment report following the schedule set out. The RTOC is going to have two meetings in 2014, one the end of May 2014 aimed at finalising the assessment report for peer review, the second one in October 2014 to discuss the peer review comments received and to finalize the report for a alst review by the entire RTOC membership.

7.4 Progress on alternatives

Regarding refrigerants, heat transfer for unsaturated HFCs and compatibility data continue to be investigated in many research and demonstration projects. Unsaturated HFCs are not yet being manufactured in significant quantities for use in refrigeration, air conditioning and heat pump equipment and OEMs are not yet mass producing equipment for these new refrigerants. Several new low-GWP refrigerants or blends continue to be developed and evaluated, some of them have a disclosed composition, are close to commercialisation and have received R-number designations.

The refrigerants that have recently been assigned with a R-number designation are:

- Recently published: R-444A (previously “AC-5), R-444B (previously “L-20), R-445A (previously “AC-6”), R-446A (previously “L-41-1”), R-447A (previously “L-41-2”).

- Waiting for final ASHRAE publication: R-448A (previously "N-40"), R-449A (previously "DR-33"), R-450A (previously "N-13").

For the US market, several domestic refrigeration appliance manufacturers produce HC-600a (isobutane) based appliances using a "reduced" charge of 57 g as required by UL. The use of HC-600a is further increasing in Article 5 countries.

R-744 (carbon dioxide) has become an important alternative option for commercial refrigeration supermarket centralised systems, especially in transcritical or cascade systems (with another refrigerant working at the medium temperature level).

In transport refrigeration, current and previous tests using R-744 suggest that the introduction of R-744 is already possible with compressors with more than one compression stage. Cryogenic or open loop systems, which evaporate liquid CO_2 or N_2 charged to an insulated container aboard the truck, are alternativesto the vapour compression cycle for recurring distribution routes.

In the split room air conditioner sub-sector, HFC-32 based products have been commercialized in several countries and it is expected that products for water heating heat pumps using HFC-32 will follow soon. For other types of air conditioners, such as self-contained, ducted and multi-split, various producers are continuing to look at various options including HCs, HFC-32 and various blends of HFCs and unsaturated HFCs. In split ACs, conversion of HCFC-22 production lines to HC-290 is continuing in China and products are available on the domestic market. HC-290 products are available on a wide scale in India and to some extent in Europe.

Regarding the issue of the flammability of HFC-1234yf, for use in vehicle air conditioning, a Cooperative Research Program by the SAE confirmed previous conclusions that HFC-1234yf could be used safely in cars. Another study, performed by Germany's KBA (Kraftfahrt Bundesamt) concluded that while HFC-1234yf was inherently more dangerous than HFC-134a under severe operating conditions, it could be applied safely. Some car models are now supplied with HFC-1234yf air conditioning both in the USA and Europe. Due to remaining safety concerns, some German OEMs work on introducing R-744 by 2017. In Germany, some buses already have air conditioning systems using R-744.

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8 Other TEAP matters

8.1 Status of TOC reappointments

Paragraph 9 of Decision XXIII/10 of the Twenty-Third Meeting of the Parties to the Montreal Protocol (Updating the nomination and operational processes of the Technology and Economic Assessment Panel and its subsidiary bodies) specifies: "*That the terms of all the members of the Panel and its technical options committees shall otherwise expire at the end of 2013 and 2014, respectively, in the absence of reappointment by the parties prior to that time, except for those experts that have already been nominated for four-year periods in past decisions;" subject to paragraph 10 of Decision XXIII/10: "That parties may revisit the status of the Panel and its technical options committee membership at the Twenty-Fifth and Twenty-Sixth Meetings of the Parties respectively if more time is needed by the parties to submit nominations."* In light of paragraph 10 of Decision XXIII/10, the TEAP provides the following information regarding the status of reappointments of existing TOC membership. The terms of these reappointments are all for no more than 4 years, with start dates of January 1st of the year following the reappointment. The appointments of experts to the TOCs by calendar years aligns the membership terms of appointment with the quadrennial Assessment Report periods.

Since 2012, the TOC co-chairs have been planning for the requirement in Decision XXIII/10, paragraph 9 that in the absence of re-appointment - following the procedures in paragraphs 6, 7 and 8 of the same decision - all other TOC member appointments would expire at the end of 2014. To date, the TOC co-chairs have made progress in implementing this requirement with limited difficulties. While each TOC is at a different stage of completion, with some being close to completion and others just beginning the process, the TEAP does not anticipate the need for the Parties to extend the 2014 expiration date based on the experience to date. As TEAP continues to implement the process for the nomination for the appointment or re-appointment of TOC members as described in the Decision XXV/6 report, TEAP believes that any difficulties that would result in not meeting this deadline will be identified before the 34th OEWG meeting. The progress of the individual TOCs on the appointment or reappointment of TOC members is further described below.

8.1.1 CTOC

The CTOC co-chairs started its re-appointment process in 2013. Of those members that attended the CTOC meeting in April, 7 members confirmed their interest in re-appointment to CTOC. CTOC co-chairs will consult with remaining members by the end of May and is also considering a new nomination.

8.1.2 FTOC

The FTOC co-chairs have canvassed its current membership on their aspirations with respect to on-going participation within the FTOC. This has led to the development of a two-year plan of staggered re-appointments. However, this has not yet been implemented awaiting agreement on procedures. Meanwhile, FTOC co-chairs have sought to identify and appoint new members in critical technology areas in consultation with appropriate relevant National Ozone Focal Points.

8.1.3 HTOC

In an attempt to stagger the appointments, the HTOC co-chairs started the re-appointment process in 2012. The HTOC has consulted on 10 nominations for re-appointment with Party ozone focal points, and has received responses to 7 of them, with 6 having been re-appointed by the HTOC co-chairs for a term of no more than 4 years and one for a term of one year only. In addition, HTOC has consulted on 3 new nominations with Party ozone focal points, and has received responses on all 3, with all 3 having been appointed by the HTOC co-chairs for a term of up to 4 years. Of the remaining 5 members, two may seek re-appointment and three will be stepping down from the HTOC at the end of 2014. All three HTOC co-chairs have been reappointed by the Parties.

8.1.4 MTOC

MTOC co-chairs are completing internal consultations and preparations on membership planning for the purposes of Decision XXIII/10, and commencing the formal process of consultation with ozone focal points on nominations for re-appointments. From 1 January 2015, MTOC is proposing to continue with a reduced membership of a core group of 13-15 members (from 26 members currently), who operate by correspondence where possible or meet face to face when necessary, and a wider circle of consulting experts whose advice is sought on a corresponding basis only. As of May 2014, 9 MTOC members have indicated that they do not wish to continue and will not be nominated for re-appointment.

8.1.5 MBTOC

MBTOC co-chairs have initiated the re-appointment process of members on the basis of required expertise as per the present workload and specific tasks assigned by the Parties. In observance of the current TOR, geographical and A5/non A5 balance are also being considered. Funding of non-A5 members to attend meetings is a very relevant factor impacting whether members can continue participating in MBTOC. The MBTOC cochairs will also only consider reappointment of members who have the relevant expertise required to respond to the current and future tasks assigned to the committee, and these appointments will be for terms of 1-4 years. At this time, the cochairs are also considering nominations of new members, to revitalise the committee and improve overall expertise and balance. As required, all appoitments (new or for re-appointment) made by the co-chairs will be consulted with Parties's ozone focal points. The three MBTOC co-chairs were reappointed by the Parties at the 25th MOP, for a period of four years, up to the end of 2017.

8.1.6 RTOC

In its meeting on 26-27 May, Torino, Italy, the RTOC discussed reappointments. RTOC co-chairs only consider reappointment of members who have the relevant expertise required to respond to the current and future tasks assigned to the committee, and these are being decided in consultation with the entire membership. The appointments will be for terms of up to 4 years. In that same process, RTOC co-chairs are also considering the nominations of new members so far received from Parties, to revitalise the committee and put the right expertise and balance in all chapters. This in particular taking into account that it can be expected that certain long-term valuable members may resign from the committee at the end of 2014, leaving gaps in expertise to be filled in. As required, all appointments (both new appoitments and re-appointments) made by the co-chairs will be consulted with the relevant Parties'ozone focal points.

8.2 Continuing challenges

TEAP continues to work so that its TOCs are structured in size and expertise to continue supporting the future efforts of the parties but takes the opportunity in this report to make Parties aware of the ongoing challenges. As has been discussed in previous reports, the TEAP and its TOCs continue to face the challenge of retaining the needed expertise and balance as some of its members become less directly engaged with the sectors and emerging technologies that originally qualified and sponsored their TEAP and/or TOCs membership. Fewer are now developing and implementing the latest technology directly. The shift of transition activities to Article 5 Parties has not always been reflected in membership of the TEAP and its TOCs, and this scenario heightens the need for a more comprehensive representation of Article 5 experts within the TOCs. Also discussed in previous reports, the continuing difficulties for non-Article 5 TOC members, even including TOC co-chairs, is to get support to attend meetings of the TOCs. Travel funding for non-Article 5 participants has continued to become an increasing burden and even more apparently so in the recent preparations for the 2014 Assessment Reports. TEAP seeks the support of Parties to address these challenges to its work for Parties.

ANNEX: TEAP and TOC membership list status May 2014

The disclosure of interest (DOI) of each member can be found on the Ozone Secretariat website at: http://ozone.unep.org/Assessment_Panels/TEAP/toc-members-disclosures.shtml. The disclosures are normally updated at the time of the publication of the progress report.

TEAP's Terms of Reference (TOR) (2.3) as approved by the Parties in Decision XXIV/8 specifies that "the Meeting of the Parties shall appoint the members of TEAP for a period of no more than four years…and may re-appoint Members of the Panel upon nomination by the relevant party for additional periods of up to four years each." TEAP member appointments end as of 31 December of the final year of appointment, as indicated in the last column of the table below.

As the process for reappointments is still underway in the TOCs, the TOCs membership tables that follow list current members. These will be updated by the next TEAP Progress Report to include members' appointment periods.

Technology and Economic Assessment Panel (TEAP)

Co-chairs	**Affiliation**	**Country**	**Appointment through**
Lambert Kuijpers	Technical University Eindhoven	Netherlands	2014
Bella Maranion	U.S. EPA	USA	2016
Marta Pizano	Consultant	Colombia	2014
Senior Expert Members	**Affiliation**	**Country**	
Marco Gonzalez	Consultant	Costa Rica	2015
Masaaki Yamabe	National Inst. Advanced Industrial Science and Technology	Japan	2015
Shiqiu Zhang	Center of Environmental Sciences, Peking University	China	2017
TOC Chairs	**Affiliation**	**Country**	
Paul Ashford	Anthesis - Caleb	UK	2016
Mohamed Besri	Institut Agronomique et Vétérinaire Hassan II	Morocco	2017
David V. Catchpole	Petrotechnical Resources Alaska	UK	2016
Sergey Kopylov	All Russian Research Institute for Fire Protection	Russian Federation	2017
Kei-ichi Ohnishi	Asahi Glass	Japan	2015
Roberto de A. Peixoto	Maua Institute (IMT), Sao Paulo	Brazil	2017
Jose Pons-Pons	Spray Quimica	Venezuela	2017
Ian Porter	Latrobe University and the Department of Environment and Primary Industries	Australia	2017
Miguel Quintero	Consultant	Colombia	2017
Helen Tope	Energy International Australia	Australia	2017
Daniel P. Verdonik	Hughes Associates	USA	2016
Ashley Woodcock	University Hospital of South Manchester	UK	2016
Jianjung Zhang	Sinochem Industries (University of Shanghai)	PRC	2017

Decision XXII/10 paragraph 9 specified that "the terms of all the members of the…technical options committees shall otherwise expire at the end of…2014…in the absence of reappointment." TEAP's TOR (2.5) specifies that "TOC members are appointed by the TOC co-chairs, in consultation with TEAP, for a period of no more than four years…[and] may be re-appointed following the procedure for nominations for additional periods of up to four years each." TOC member re-appointments start as of 1st January of the calendar year following appointment and end as of 31st December of the final year of appointment, as indicated in the last column of the following TOC tables. As indicated, most TOCs are in the process of completing their re-appointment process so these appointment dates will change.

New appointments to a TOC would start from the date of appointment by TOC co-chairs and end as of 31st December of the final year of appointment, up to four years.

TEAP Chemicals Technical Options Committee (CTOC)**

Co-chairs	**Affiliation**	**Country**	**Appointment through**
Kei-ichi Ohnishi	Asahi Glass	Japan	2015
Jianjung Zhang	Sinochem Industries (University of Shanghai)	China	2017

Members	**Affiliation**	**Country**
D. D. Arora	The Energy and Research Institute	India
Joan Bartelt	DuPont	USA
Steven Bernhardt	Honeywell	USA
Olga Blinova	Russian Scientific Center for Applied Chemistry	Russia
Jianxin Hu	College of Environmental Sciences & Engineering, Peking University	China
Abid Merchant	Consultant	USA
Koichi Mizuno	National Inst. Advanced Industrial Science and Technology	Japan
Claudia Paratori	Coordinator Ozone Programme -CONAMA	Chile
Hans Porre	Teijin Aramids	Netherlands
John Stemniski	Consultant	USA
Fatemah Al-Shatti	Kuwait Petroleum Corporation	Kuwait
Nee Sun Choong Kwet Yive (Robert)	University of Mauritius	Mauritius

** process of re-appointments is underway

TEAP Flexible and Rigid Foams Technical Options Committee (FTOC)**

Co-chairs	Affiliation	Country	Appointment through
Paul Ashford	Anthesis - Caleb	UK	2016
Miguel Quintero	Consultant	Colombia	2017

Members	Affiliation	Country
Samir Arora	Industrial Foams	India
Terry Arrmitt	Hennecke	UK
Chris Bloom	Dow	USA
Roy Chowdhury	Foam Supplies	Australia
Koichi Wada	Bayer Material Science/JUFA	Japan
Mike Jeffs	Consultant	UK
Ilhan Karaağaç	Izocam	Turkey
Candido Lomba	ABRIPUR	Brazil
Yehia Lotfi	Technocom	Egypt
Joseph Lynch	Arkema	USA
Christoph Meurer	Solvay	Germany
Ulrich Schmidt	Haltermann	Germany
Enshan Sheng	Huntsman Co	China
Helen Walter-Terrinoni	DuPont	USA
Dave Williams	Honeywell	USA
Allen Zhang	Consultant	China

** process of re-appointments is underway

TEAP Halon Technical Options Committee (HTOC)**

Co-chairs	**Affiliation**	**Country**	**Appointment through**
David V. Catchpole	Petrotechnical Resources Alaska	UK	2016
Sergey Kopylov	All Russian Research Institute for Fire Protection	Russian Federation	2017
Daniel P. Verdonik	Hughes Associates	USA	2016
Members	**Affiliation**	**Country**	
Tarik K. Al-Awad	King Abdullah II Design & Development Bureau	Jordan	2016
Jamal Alfuzaie	Kuwait Fire Department	Kuwait	
Seunghwan (Charles) Choi	Hanju Chemical Co., Ltd.	South Korea	
Adam Chattaway	Kidde Graviner Ltd.	UK	2015
Michelle M. Collins	Consultant- EECO International	USA	
Salomon Gomez	Tecnofuego	Venezuela	
Carlos Grandi	Embraer	Brazil	2016
Andrew Greig	Protection Projects Inc	South Africa	
Zhou Kaixuan	CAAC-AAD	PR China	
H. S. Kaprwan	Consultant – Retired	India	2017
John J. O’Sullivan	Bureau Veriitas	UK	2015
Emma Palumbo	Safety Hi-tech srl	Italy	2017
Erik Pedersen	Consultant – World Bank	Denmark	2016
Donald Thomson	Manitoba Ozone Protection Industry Association	Canada	2017
Filippo Tomasello	European Aviation Safety Agency	Italy	2015
Robert T. Wickham	Consultant-Wickham Associates	USA	
Mitsuru Yagi	Nohmi Bosai Ltd & Fire and Environment Prot. Network	Japan	2017
Yong Meng Wah	Singapore Civil Defence Force	Singapore	
Consulting Experts			
Thomas Cortina	Halon Alternatives Research Corporation	USA	
Matsuo Ishiyama	Nohmi Bosai Ltd & Fire and Environment Prot. Network	Japan	
Nikolai Kopylov	All Russian Research Institute for Fire Protection	Russian Federation	
David Liddy	United Kingdom Ministry of Defence	UK	
Steve McCormick	United States Army	USA	
John G. Owens	3M Company	USA	
Mark L. Robin	DuPont	USA	
Joseph A. Senecal	Kidde-Fenwal	USA	
Ronald S. Sheinson	United States Naval Research Laboratory – Retired	USA	
Ronald Sibley	Defense Supply Center, Richmond	USA	

** process of re-appointments is underway

TEAP Medical Technical Options Committee (MTOC)**

Co-chairs	Affiliation	Country	Appoitment through
Jose Pons Pons	Spray Quimica	Venezuela	2017
Helen Tope	Energy International Australia	Australia	2017
Ashley Woodcock	University Hospital of South Manchester	UK	2016

Members	Affiliation	Country
Emmanuel Addo-Yobo	Kwame Nkrumah University of Science and Technology	Ghana
Paul Atkins	Oriel Therapeutics Inc.	USA
Sidney Braman	Mount Sinai School of Medicine	USA
Hisbello Campos	Instituto Fernandes Figueira, FIOCRUZ, Ministry of Health	Brazil
Jorge Caneva	Favaloro Foundation	Argentina
Christer Carling	Private Consultant	Sweden
Davide Dalle Fusine	Chiesi Farmaceutici	Italy
Charles Hancock	Charles O. Hancock Associates	USA
Eamonn Hoxey	Johnson & Johnson	UK
Javaid Khan	The Aga Khan University	Pakistan
Katharine Knobil	GlaxoSmithKline	USA
Suzanne Leung	3M	USA
Gerald McDonnell	STERIS	UK
Hideo Mori	Private Consultant	Japan
Tunde Otulana	Boehringer Ingelheim Pharmaceuticals Inc.	USA
John Pritchard	Philips Home Healthcare Solutions	UK
Rabbur Reza	Beximco Pharmaceuticals	Bangladesh
Raj Singh	The Chest Centre	India
Roland Stechert	Boehringer Ingelheim	Germany
Ping Wang	Chinese Pharmacopoeia Commission	China
Adam Wanner	University of Miami	USA
Kristine Whorlow	National Asthma Council Australia	Australia
You Yizhong	Journal of Aerosol Communication	China

** process of re-appointments is underway

TEAP Methyl Bromide Technical Options Committee (MBTOC)**

Co-chairs	Affiliation	Country	Appoitment through
Co-chairs	**Affiliation**	**Country**	
Mohamed Besri	Institut Agronomique et Vétérinaire Hassan II	Morocco	2017
Marta Pizano	Consultant - Hortitecnia Ltda	Colombia	2017
Ian Porter	Latrobe University and the Department of Environment and Primary Industries	Australia	2017

Members	Affiliation	Country
Jonathan Banks	Consultant	Australia
Chris Bell	Consultant	UK
Fred Bergwerff	Oxylow BV	The Netherlands
Aocheng Cao	Chinese Academy of Agricultural Sciences	China
Peter Caulkins	US Environmental Protection Agency	USA
Ricardo Deang	Consultant	Philippines
Raquel Ghini	EMBRAPA	Brasil
Ken Glassey	MAFF – NZ	New Zealand
Eduardo Gonzalez	Fumigator	Philippines
Michelle Marcotte	Consultant	Canada
Takashi Misumi	MAFF – Japan	Japan
David Okioga	Ministry of Environment and Natural Resources	Kenya
Christoph Reichmuth	Honorary Professor	Germany
Jordi Riudavets	IRTA – Department of Plant Protection	Spain
John Sansone	SCC Products	USA
Sally Schneider	US Department of Agriculture	USA
JL Staphorst	Consultant	South Africa
Akio Tateya	Technical Adviser, Syngenta	Japan
Robert Taylor	Consultant	UK
Alejandro Valeiro	National Institute for Agriculture Technology	Argentina
Ken Vick	Consultant	USA
Nick Vink	University of Stellenbosch	South Africa
Chris Watson	Consulting fumigator	UK
Jim Wells	Environmental Solutions Group	USA
Eduardo Willink	Ministerio de Agricultura	Argentina
Suat Yilmaz	Ministry of Food, Agriculture and Livestock	Turkey

** process of re-appoitments is underway

TEAP Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC)**

Co-chairs	Affiliation	Country	Appoitment through
Lambert Kuijpers	Technical University Eindhoven	Netherlands	2014
Roberto de A. Peixoto	Maua Institute, IMT, Sao Paulo	Brazil	2017

Members	Affiliation	Country
Radhey S. Agarwal	IIT New Delhi	India
James M. Calm	Engineering Consultant	USA
Radim Cermak	Ingersoll Rand	Czech Republic
Guangming Chen	Zhejiang University, Hangzhou	China
Jiangpin Chen	Shanghai University	China
Denis Clodic	Ereie Consultancy	France
Daniel Colbourne	Consultant	UK
Richard DeVos	GE	USA
Sukumar Devotta	Consultant	India
Martin Dieryckx	Daikin Europe	Belgium
Dennis Dorman	Trane	USA
Bassam Elassaad	Consultant	Lebanon
Dave Godwin	U.S. EPA	USA
Marino Grozdek	University of Zagreb	Croatia
Samir Hamed	Petra Industries	Jordan
Kenneth E. Hickman	Consultant	USA
Martien Janssen	Re/genT	Netherlands
Makoto Kaibara	Panasonic, Research and Technology	Japan
Michael Kauffeld	Fachhochschule Karlsruhe	Germany
Jürgen Köhler	University of Braunschweig	Germany
Holger König	Consultant	Germany
Richard Lawton	CRT	UK
Tingxun Li	Guangzhou San Yat Sen University	China
Petter Nekså	SINTEF Energy Research	Norway
Horace Nelson	Manufacturer	Jamaica
Carloandrea Malvicino	Fiat	Italy
Tetsuji Okada	MEE	Japan
Alaa A. Olama	Consultant	Egypt
Alexander C. Pachai	Johnson Controls	Denmark
Andy Pearson	Star Refrigeration Glasgow	UK
Per Henrik Pedersen	Danish Technological Institute	Denmark
Rajan Rajendran	Emerson	USA
Giorgio Rusignuolo	Carrier Transicold	USA
Alessandro Silva	Consultant	Brazil
Paulo Vodianitskaia	Consultant	Brazil
Asbjorn Vonsild	Danfoss	Denmark

** process of re-appointments is underway