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Eighteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer
New Delhi, 30 October–3 November 2006
Item 7 of the provisional agenda*

Consideration of the report of the Secretariat's expert group meeting on the ozone-depletion-related results of the Technology and Economic Assessment Panel/Intergovernmental Panel on Climate Change special report and the Technology and Economic Assessment Panel's supplementary report.

Report of the Ozone Secretariat Workshop on the Intergovernmental Panel on Climate Change/Technology and Economic Assessment Panel special report

Note by the Secretariat

1. The Seventeenth Meeting of the Parties to the Montreal Protocol adopted decision XVII/19, in which it requested the Ozone Secretariat to organize an experts' workshop in the margins of the twenty-sixth meeting of the Open-ended Working Group to consider issues arising from the special report of the Intergovernmental Panel on Climate Change and the Technology and Economic Assessment Panel on safeguarding the ozone layer and the global climate system and the Technology and Economic Assessment Panel's supplementary report.

2. In the decision, the experts at the workshop were requested to produce a list of practical measures relating to ozone depletion that arise from the reports, indicating their associated ozone-depleting substance cost-effectiveness and taking into account the full costs of such measures, and also to include information on other environmental benefits, including those relating to climate change, that would result from those measures.

3. In accordance with the decision, an experts' workshop on the special report was convened on 7 July 2006 immediately after the twenty-sixth meeting of the Open-ended Working Group.

4. The full report of the workshop (UNEP/OzL.Pro/Workshop.2/2) is attached to the present note for consideration by the Parties.

* UNEP/Ozl.Pro.18/1.

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Annex

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Ozone Secretariat Workshop
on the IPCC/TEAP Special Report
Montreal, 7 July 2006

Report of the Ozone Secretariat Workshop on the IPCC/TEAP Special Report

Introduction

1. The Technology and Economic Assessment Panel (TEAP) and the Intergovernmental Panel on Climate Change (IPCC) developed in 2005 a special report on protecting the ozone layer and the global climate system (the Special Report) as requested by the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer and the United Nations Framework Convention on Climate Change (UNFCCC).

2. At its twenty-fifth meeting, the Open-ended Working Group of the Parties to the Montreal Protocol requested TEAP to prepare a supplementary report explaining clearly the ozone depletion implications of the issues raised in the Special Report.

3. The Seventeenth Meeting of the Parties to the Montreal Protocol considered the TEAP supplementary report and adopted decision XVII/19. In accordance with that decision, the Ozone Secretariat convened an experts' workshop on the IPCC/TEAP special report on 7 July 2006 at the headquarters of the International Civil Aviation Organization in Montreal, Canada, immediately after the twenty-sixth meeting of the Open-ended Working Group.

4. Paragraphs 1 and 3 of decision XVII/19 specified the objectives of the workshop as follows:

> "1. To request the Ozone Secretariat to organize an experts workshop in the margins of the twenty-sixth meeting of the Open-ended Working Group in 2006, to consider issues as described in paragraph 3 of the present decision, arising from the special report of the Intergovernmental Panel on Climate Change and the Technology and Economic Assessment Panel and the Technology and Economic Assessment Panel's supplementary report;"
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> "3. To request the Technology and Economic Assessment Panel to present a summary of the reports at the workshop and that experts then produce a list of practical measures relating to ozone depletion that arise from the reports, indicating their associated ozone-depleting substances cost effectiveness and taking into account the full

costs of such measures. The list should also contain information on other environmental benefits, including those relating to climate change, that would result from these measures;"

5. The agenda of the workshop was as follows:

1. Opening of the workshop
2. Presentations on the IPCC/TEAP Special Report on Safeguarding the Ozone Layer and the Global Climate System and the supplemental report thereto prepared by TEAP for consideration by the Seventeenth Meeting of the Parties to the Montreal Protocol.
3. Development of a list of practical measures relating to ozone depletion arising from the report.
4. Consideration of the ozone-depleting substances cost effectiveness of measures arising from the report, taking into account their full costs and the other environmental benefits that would result from those measures, including those related to climate change.
5. Conclusions and closure of the workshop.

6. The workshop was attended by 199 experts from the following 116 Parties : Afghanistan, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Comoros, Costa Rica, Cote d'Ivoire, Croatia, Cuba, Czech Republic, Dominican Republic, Ecuador, Egypt, Estonia, European Community, Fiji, Finland, France, Gabon, Germany, Ghana, Guatemala, Guinea, Guinea-Bissau, Haiti, Hungary, India, Indonesia, Iran (Islamic Republic of), Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Lebanon, Malaysia, Mali, Mauritius, Mexico, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Papua New Guinea, Peru, Philippines, Poland, Qatar, Republic of Korea, Republic of Moldova, Russian Federation, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent & Grenadines, Senegal, Serbia and Montenegro, Slovenia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Thailand, The Former Yugoslav Republic of Macedonia, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, United States of America, Uruguay, Uzbekistan, Viet Nam, Zambia and Zimbabwe.

7. Representatives of TEAP also attended the workshop as advisors. Representatives of the following United Nations entities, organizations and specialized agencies attended the workshop as resource persons: United Nations Development Programme, United Nations Environment Programme Division of Technology, Industry and Economics, United Nations Framework Convention on Climate Change, United Nations Industrial Development Organization, World Bank, Secretariat of the Multilateral Fund for the Implementation of the Montreal Protocol and the Scientific Assessment Panel.

8. A full list of participants is contained in annex II to the present report.

9. The workshop was chaired by Ms. Marcia Levaggi (Argentina).

I. Opening of the Workshop

A. Statement by the Executive Secretary

10. The workshop was opened by Mr. Marco Gonzalez, Executive Secretary of the Ozone Secretariat, who recalled the meeting's mandate as set out in decision XVII/19. Observing that decision XVII/19 had been carefully negotiated and drafted by the Parties in Dakar, he expressed the hoped that the workshop participants would not spend time on questions of interpretation of the wording in the decision. He thanked six Parties that had provided written inputs for the list of measures, namely, El Salvador, the European Community, Guyana, Mexico, the United States of America and Uganda, and noted that a compilation of those inputs had been circulated the day before the workshop at the twenty-sixth meeting of the Open-ended Working Group of the Parties to the Montreal Protocol. He also thanked the TEAP Co-Chairs and members for their hard work on the reports and their advice and service during the workshop.

B. Statement by the Chair

11. The Chair thanked the participants and made some remarks on the agenda and organization of work. She noted that agenda items 3 and 4 would be taken up together on the basis of the list of submitted measures distributed by the Secretariat. She also reminded the participants that the task of producing a list of practical measures had to be completed in just one day, which meant that work would have to proceed with utmost efficiency.

III. Presentations on the IPCC/TEAP Special Report on Safeguarding the Ozone Layer and the Global Climate System and the supplemental report thereto prepared by TEAP for consideration by the Seventeenth Meeting of the Parties to the Montreal Protocol (agenda item 2)

A. Presentation on the IPCC-TEAP Special Report

12. At the invitation of the Chair of the Workshop, TEAP Co-Chair Mr. Lambert Kuijpers provided a summary of the IPCC/TEAP Special Report.

13. Mr. Kuijpers began with an overview of past and present atmospheric concentrations of chlorofluorocarobns (CFCs), hydrochlorofluorocarbons (HCFCs) and hydroflurocarbons (HFCs) and of trends in halocarbon emissions into the atmosphere, and then went on to examine sources of emissions, explaining the importance of banks. He stated that a significant portion of CFC, HCFC and HFC emissions came from their respective banks and noted that the amount of HFCs and HCFCs in banks was increasing, while the amount of CFCs in banks was decreasing. He also pointed out that there were no control obligations under the Montreal Protocol or the Kyoto Protocol to the United Nations Framework Convention on Climate Change to restrict CFC and HCFC emissions. He specified that, although the foam bank was larger, it accounted for a smaller proportion of emissions because foams released greenhouse gases at a relatively slower and lower rate than did refrigeration equipment. Refrigerant banks, though smaller than foam banks, accounted for a larger proportion of emissions due to the greater probability of leakage from refrigeration equipment.

14. Following a description of the development of banks and emissions by sector and by substance group, Mr. Kuijpers presented projections of future emission reduction trends. Under a business-as-usual (BAU) scenario, it was estimated that CFC emissions would diminish by about 80 per cent in 2015 when compared to 2002 (on the basis of carbon dioxide equivalents). The primary reason for that reduction would be the phase-out of CFC-containing equipment. Under a mitigation scenario, in which best practices were assumed for use, recovery and destruction globally, the estimated reduction would be increased to about 86 per cent in 2015, compared to 2002. Meanwhile, HCFC emissions in 2015 were forecast to be at least double the CFC emissions in 2015 under the BAU scenario. In that light, Parties might wish to consider how, under the Montreal Protocol, HCFC mitigation measures could reduce emissions. Early HCFC production controls would certainly also contribute.

15. He noted that the Special Report had identified a number of options for achieving a significant reduction in CFC and HCFC emissions by 2015: containment (i.e., reduced, low leakage); recovery, recycling and destruction; and use of not-in-kind technologies or substitutes, with a preference for those with low global warming potential (GWP). To the extent possible, those options had been analyzed using life-cycle climate performance and life-cycle assessment methods.

16. In terms of the reduction of greenhouse gas emissions from ozone-depleting substance replacements, the Special Report covered the refrigeration and air conditioning sector, foams, medical aerosol products, fire protection, non-medical aerosol products, solvents and HFC-23 by-product emissions. The gases covered by the Special Report were CFCs, HCFCs and halons, as well as those HFCs and perfluorocarbons (PFCs) replacing ozone-depleting substances, with the emphasis on the latter. The Special Report did not cover HFCs and PFCs in applications not replacing ozone-depleting substances, or methyl bromide.

17. Conversion to low GWP alternatives had arisen as a principal measure for reducing the climate impact of emissions for all applications in the refrigeration and air conditioning sector, i.e., domestic refrigeration, vending and beverage dispensing, commercial refrigeration, food processing and large refrigeration systems, transport refrigeration, stationary air conditioning and heat pumps and mobile air

conditioning. Early replacement of old equipment with more energy -efficient models, recovery of refrigerants at service and at end of life, reduction of refrigerant charges and reduction of refrigerant leakage were further emission-reducing measures highlighted in the Special Report.

18. In the foam sector, greenhouse gas emissions from ozone-depleting substance replacement could be reduced through the adoption of life cycle climate performance analysis for selecting among insulation types (leading to a preference towards hydrocarbon foams in many applications) and through recovery of blowing agents at end of life. In the medical aerosol product sector, a complete transition from CFC to HFC metered-dose inhalers and a subsequent transition from HFC metered -dose inhalers to dry powder inhalers or to some other not -in-kind alternative not dependent on propellants was the way forward to reduce greenhouse gas emissions. Emissions from the fire protection sector could be reduced by using agents with no impact on climate change, to the extent possible, and by managing banks of all fire-protection materials carefully and responsibly. Finally, the application of low GWP compounds satisfying environmental health and safety criteria and the application of improved containment systems were measures that could be used to reduce greenhouse gas emissions from the solvent sector.

19. With respect to current and future supply of ozone-depleting substance replacements, the Special Report identified the Montreal Protocol as the major driver for HFC and PFC demand, as it had been instrumental in introducing a variety of CFC replacements. Consequently, CFC emissions had fallen significantly over the 1990–2000 period, while HCFC and HFC emissions had grown. Demand for HCFC was expected to grow significantly during the 2002-2015 period, particularly in Article 5 countries. Furthermore, the existing CFC bank was still more than one million tonnes and constituted a significant source of potential future emissions. By-product emissions of HFC-23 were also expected to rise globally by 60 per cent by 2015 under a BAU scenario.

20. The Special Report estimated total direct emissions at about 2.5 GT[1] of carbon dioxide equivalents per year, which was similar to the estimate based on atmospheric measurements. Chemical-specific observations, however, indicated higher emissions than the calculated estimates for individual substances from banks, particularly for CFC-11, HCFC-141b and HCFC-142b. With respect to emission estimates, the Special Report set forth qualitatively sound conclusions, but a great deal more work beyond the scope of the Special Report would be required to provide accurate quantitative conclusions, in particular for the above-mentioned chemicals.

B. Presentation on the Technology and Economic Assessment Panel's Supplementary Report

21. Following Mr. Kuijpers's presentation on the Special Report, Mr. Paul Ashford made a presentation on the TEAP supplementary report on ozone-related aspects of the issues raised in the Special Report. In doing so, he also cited a number of other relevant reports.

22. Mr. Ashford's presentation drew on five primary sources. The first source was the supplementary report itself, which had been presented at the Seventeenth Meeting of the Parties. That report, which had focused on the ozone-related aspects of the information in the IPCC/TEAP Special Report, did not examine the possible impact of future ozone-depleting substance consumption measures, but rather looked at the ozone-related impacts of the list of proposed emission reduction measures set out in the IPCC/TEAP report. It therefore did not look at all of the possible measures available under the Montreal Protocol for reducing ozone-depleting substance emissions. Nonetheless, it did consider ozone-depleting substance emission reductions (expressed in ODP-tonnes) under both a business-as-usual scenario and a mitigation scenario. While the emission reductions for those substances were expected to be significant between 2002 and 2015, there was not a big difference between reductions predicted for 2015 under the two scenarios. Emissions from foams were expected to be small in relation to the quantity of blowing agent in the banks. In contrast, the ozone layer impact of emissions of halons used in fire protection was expected to be significant, partially due to the high ozone-depleting potential of the halons in question. Emissions of refrigerants would also be significant in the period from 2002 to 2015 but would experience significant reductions over that period as the base of CFC-containing equipment dwindled, which would lead to a reduction in emissions from approximately 150,000 ODP-tonnes in 2002 to less than 50,000 ODP-tonnes in 2015. The supplementary report also presented the data on anticipated emission reductions by type of ozone-depleting substance. In addition, it addressed the differences between the Special Report and the

[1] GT = 10^9 tonnes (one thousand million tonnes)

Scientific Assessment Panel's report with regard to the methodologies used to establish emission projections and to predict dates for ozone-layer recovery.

23. In considering this issue further, Mr. Ashford noted that the Scientific Assessment Panel Report, published in 2003, had made ozone-depleting substance emission projections based on atmospheric concentrations. This had led to an assessment of ozone hole recovery in 2044. However, the assessment of banks established by the bottom-up method in the supplementary report indicated a later recovery, in 2046–2048, with the possibility of recovery two years earlier if banks were managed carefully. Although discrepancies remained between the bank estimates derived from atmospheric concentrations and those derived by bottom-up methods, the Scientific Assessment Panel had elected to adopt the IPCC/TEAP Report bank estimates as its starting point for the 2006 science assessment currently in progress. Work was continuing on issues such as the impact of uncertainties in atmospheric lifetimes as well as in mixing ratios and other transport phenomena. Mr. Ashford noted that these factors had been covered in recent papers scheduled for publication by members of the Scientific Assessment Panel and that the Task Force on Emission Discrepancies (following Decision XVII/19) would also be addressing those sensitivities. Finally, it was noted that transport phenomena into the lower Antarctic stratosphere were at present assumed to be slower than originally thought (the age of air in the lower stratosphere being older than elsewhere), leading to the observation that the ozone hole (in the 1980's) started at lower concentrations than expected and recovery will also occur at lower concentrations than originally thought. By association, (delayed) emissions from banks could remain significant factors in the recovery of the Antarctic ozone hole.

24. For its part, the TEAP HCFC Task Force Report of 2003 had addressed the production and consumption of HCFCs and their ozone implications and had briefly mentioned climate change implications, including those associated with HFC-23 production (and emissions) as a by-product of HCFC-22 production. It predicted an increase in the demand for HCFCs to between 350,000 and 400,000 tonnes in 2015, but those predictions were being adjusted to values in the 500,000–600,000 tonnes range, and, in some quarters, to more than 700,000 tonnes. The demand was expected to be mainly for HCFC-22 in stationary air conditioning and refrigeration applications. There would be continuing use of HCFC-141b in polyurethane foams and solvent uses, however, as well as growth in HCFC-142b use for extruded polystyrene board applications. In summary, the main demand-driving sectors in countries operating under paragraph 1 of Article 5 of the Montreal Protocol would be air conditioning, commercial refrigeration and foams.

25. According to the 2005 TEAP Foams End-of-Life Report, which dealt primarily with ozone-depleting substances, emissions could be reduced through blowing agent recovery from appliances. That practice was widespread in Japan and the European Community and its technical feasibility had been demonstrated. Its cost-effectiveness had also been verified and, although more costly than other forms of emission mitigation, it was clearly commercially practical. With regard to foams in buildings, emissions over the 2002–2015 period were particularly low because emissions from those foams were only released significantly when the buildings containing them were demolished – a process likely only to take place after 2015. The economics of building insulation foam recovery were still being examined in an attempt to evaluate opportunities for that activity.

26. Finally, the report of the Meeting of Experts on the Collection and Disposal of non-reusable and unwanted ozone-depleting substances in Article 5 countries (Collection and Disposal Workshop), held in March 2006, had also focused on banks and on emission issues. The report of that workshop assessed the "specific effort" required to collect and dispose of various ozone-depleting substances. Refrigerants were given a low "specific effort" rating if they were localized and concentrated and a medium rating if they were widely dispersed. A similar rule applied to halons, with the additional factor of size in fixed systems. Since foam blowing agents were more difficult to extract, they were given a medium "specific effort" rating even if they were localized, and a high "specific effort" rating if they were dispersed. This classification had made it possible for Multilateral Fund efforts to focus on low "specific effort" recovery projects. Mr. Ashford further explained that the Ozone Secretariat had used the term "practicality" to prepare examples within the blank tables circulated to Parties in order to solicit proposals for the list. TEAP, however, had prepared summary tables on the submissions and had decided, based on the successful experience of the Collection and Disposal Workshop, to change the term "practicality" to "specific effort" in the heading of the summary tables to facilitate the discussions at the current workshop. Similarly, the term "cost effectiveness" had been converted to "cost" to overcome some confusion with submissions.

III. Development of a list of practical measures relating to ozone depletion arising from the report (agenda item 3) and consideration of the ozone-depleting substances cost effectiveness of such measures, taking into account their full costs and the other environmental benefits that would result from those measures, including those related to climate change (agenda item 4)

27. Following a presentation by TEAP, at the invitation of the Chair, a representative of the Secretariat explained that the list of measures distributed prior to the meeting was a compilation of all the Parties' submissions, exactly as received by the Secretariat, based on the framework tables, with examples, that had been prepared by the Secretariat to facilitate the Workshop. With the help of TEAP the submitted proposals had been categorized by use sector and sorted into groups of duplicated or otherwise similar measures such as those related to recovery of ozone-depleting substances in refrigerators, conversion/retirement of equipment, leakage reduction, and so on. A total of 64 submitted proposals under the seven use sectors of ozone depleting substances had thus been categorized into 31 distinct measures. She noted that TEAP had carried out further work to produce summary tables for each sector, listing distinct measures and summarizing relevant information such as on cost effectiveness, practicality, and environmental benefits that were contained in the submissions.

28. At the request of the Chair, the TEAP representatives, Mr. Paul Ashford, Mr. Lambert Kuijpers and Mr. Daniel Verdonik, presented by way of example the two summary tables for the domestic refrigeration sector. The first table showed which Parties had made submissions against the five identified measures in the domestic refrigeration sector. The second summary table was a list of the five distinct measures, accompanied by information on ozone-depleting substance relevance, significance, degree of effort, cost and environmental benefit in terms of climate change and other environmental aspects. The TEAP representative described the logic and method used in summarizing the submissions. It was explained that some of the submissions actually formed relevant steps or parts of identifiable measures but did not represent measures in their own right. References were made to the relevant parts of the Special Report as necessary to make the links between the submissions, measures and relevant information within the Special Report.

29. A short general discussion ensued regarding how the workshop participants should proceed with the task of listing the practical measures as required by decision XVII/19.

30. One participant commented that some of the practical measures submitted by the Parties were not consistent with the requirement that they should "arise from" the IPCC/TEAP Special Report and TEAP Supplement Report even though they might be excellent, practical ideas for domestic implementation. Another participant said that the workshop should not reject such submissions since they were all valuable and inspired by the reports; he suggested that the workshop should focus on distinct measures arising from summaries of submissions prepared by TEAP and their relevance in terms of ozone-depleting substance reduction and practicality. Another participant emphasized that the important objective was to consider all relevant measures that might mitigate emissions of ozone-depleting substances and that the phrase "arise from" did not necessarily mean "specifically stated in the report". Rather, a non-restrictive understanding of the meaning of "arise from" would be desirable. A few participants also stated that some of the submitted proposals, not strictly arising from the reports, were of key concern especially to Article 5 countries. Hence they should be retained on the list but possibly with an appropriate identifier that they were not expressly mentioned in the reports. A number of participants suggested creating two lists; one with measures arising from the reports and another with measures that were not specifically mentioned in the reports but were inspired by them.

31. One participant commented that International Standards Organization standards such as the ISO 9000 and 14000 series should be taken into consideration under the various measures being considered. Those standards would help ensure responsible manufacture and handling of refrigerators through end of life including destruction, recovery and recycling, from both quality and environmental management perspectives.

32. At the suggestion of the Chair, there was consensus that the TEAP summary tables for the other sectors should be presented and that working groups should then be established to examine the issues in more detail. It was agreed that the working groups would use the TEAP summary tables as the basis for the discussion to produce the final lists of measures for the workshop report and to use the long list of submissions distributed earlier as a reference. It was also agreed that the headings in the TEAP summary tables should be changed to be consistent with the original submissions and that the original list would be annexed to the final report of the workshop.

33. The TEAP representatives then proceeded to present the respective summary tables for commercial refrigeration, transport refrigeration, stationary air conditioning, mobile air conditioning, foams and fire protection.

34. Following the presentation, two working groups were established. Group I was chaired by an expert from Brazil, Mr. Paulo Azevedo, and dealt with four sectors: domestic refrigeration, commercial refrigeration, transport refrigeration and stationary air-conditioning and heat pumps. Group II was chaired by an expert from Denmark, Mr. Mikkel Sorensen, and dealt with three sectors: mobile air conditioning, foams and fire protection.

35. The Chair of each group reported in Plenary on the outcome of the groups' deliberations. Each group presented final lists of distinct measures and associated information for each of the sectors. Furthermore each group reported that the full compilation of the submissions by the Parties had also been discussed and a few, mostly editorial, changes had been made. The workshop participants agreed on the list of practical measures set out in the summary tables below. The compilation of the submissions, as corrected, is also attached to the present report as annex I.

Table 1: Domestic refrigeration

		ODS relevance	*Significance (ODP-tonnes)*	*Practicality*	*Cost effective*	*Env benefits (GWP)*	*Env considerations (Other)*
1	Recover ODS @ E-o-L	Yes	107k 340k	M/H L/M	M/H L/M	H H	Steel recycling option
2	Conversion /Early retirement	Yes	L	M/H	M/H	L	Energy efficiency
3	Leakage reduction (New/existing equipment)	Yes	L	L/M	L/M	L	None
4	Phase-out of ODS in new equipment	Yes	L	M/H	M/H	M	None
			L	M/H	M/H	L	
5	Elimination of ODS "flushing"	Yes	Unkn	M/H	Unkn	Unkn	None

L=low; M=medium; H=high; E-o-L=end of life; Unkn=unknown

Table 2: Commercial refrigeration

		ODS relevance	*Significance (ODP-tonnes)*	*Practicality*	*Cost effective*	*Env benefits (GWP)*	*Env considerations (Other)*
6	Leakage reduction (existing equipment)	Yes	70k/yr	L/M/ H	M/ Variable	M/H	Energy efficiency
7	Early retirement (revolving fund)	Yes	M	M/H	M/H	M/H	Energy efficiency
8	Earlier phase-out of HCFCs (new equipment)	Yes	H	M/H	Variable	Depends on replace ment	Energy efficiency
9	Reduced charge by using indirect systems	Yes	H	M	M	L/M	Variable
9a	Reduced charge by other means	Yes	H	M	M	L/M	Variable

		ODS relevance	*Significance (ODP-tonnes)*	*Practicality*	*Cost effective*	*Env benefits (GWP)*	*Env considerations (Other)*
10	Recover ODS in different types of commercial refrigeration equipment @ E-o-L	Yes	M/H	M	Variable	M/H	Steel recycling option
10 a	Elimination of ODS 'flushing'	Yes	Unkn	M/H	Unkn	Unkn	None

L=low; M=medium; H=high; E-o-L=end of life; Unkn=unknown

Table 3: Transport refrigeration

		ODS relevance	*Significance (ODP tonnes)*	*Practicality*	*Cost effective*	*Env benefits (GWP)*	*Env considerations (Other)*
11	Reduce leakage from existing equipment	Yes	M	M/H	M/H	L/M	Energy efficiency
12	Encourage move from [CFCs and] HCFCs	Yes	L	H	H	L/M	Energy efficiency

L=low; M=medium; H=high; E-o-L=end of life; Unkn=unknown

Table 4: Stationary air-conditioning and heat pumps

		ODS relevance	*Significance (ODP tonnes)*	*Practicality*	*Cost effective*	*Env benefits (GWP)*	*Env considerations (Other)*
13	Reduction of charge size	Yes	H	L /M	Unk	M/H	Energy Efficiency
14	Recovery & recycling at E-o-L	Yes	M/H	M	M	M/H	Steel recycling option
15	Reduce leakage rates (existing equipment)	Yes	M/H	M/H	M/H	M/H	None
16	Early retirement (revolving fund)	Yes	M	M	M	M	Energy efficiency
17	Earlier phase-out of HCFC (new equipment)	Yes	H	H	M	Variable	Energy efficiency

L=low; M=medium; H=high; E-o-L=end of life; Unkn=unknown

Table 5: Mobile air conditioning (MAC)

		ODS relevance	*Significance (ODP tonnes)*	*Practicality*	*Cost effective*	*Env benefits (GWP)*	*Env considerations (Other)*
18	Recovery at service and at E-o-L	Yes	Variable	M/H	M/H	M/H	Energy efficiency
19	Improved technological containment	Yes	M/H	M/H	M/H	M/H	Energy efficiency
20	Standard practices for service emission	Yes	M/H	M	M/H	M	Energy efficiency
21	Earlier phase-out of MAC CFCs by import bans	Yes	L/M	M	M/H	M	Fuel efficiency & lower emissions

L=low; M=medium; H=high; E-o-L=end of life; Unkn=unknown

Table 6: Foams

		ODS relevance	*Significance (ODP tonnes)*	*Practicality*	*Cost effective*	*Env Benefits (GWP)*	*Env Considerations (Other)*
22	Steel faced panels E-o-L treatment	Yes	350k 11k	M/H	M	M/H	Steel recycling option
23	Restrict ODS in One Component Foam	Yes	Low	M/H	Uncert	M/H	Energy efficiency
24	Earlier phase-out of HCFCs	Yes	Variable	L/M	Variable	M	Energy efficiency
25	Reduce 1st yr emissions	Yes	L/M	Variable	Variable	M	Energy efficiency
26	Building design improvements	Yes	L/M	M/H	Variable	Variable	Steel recycling option
27	Extend E-o-L treatment to all appliances	Yes	460k 23k	M/H	M	M/H	Steel recycling option

L=low; M=medium; H=high; E-o-L=end of life; Unkn=unknown

Table 7: Fire protection

		ODS relevance	*Significance (ODP tonnes)*	*Practicality*	*Cost effectiv*	*Env benefits (GWP)*	*Env considerations (Other)*
28	Limited emissions from all banks	Yes	H	M/H	M/H	L/M	None
29	Early transition in fixed systems	Yes	M/H	L	M	L	None
30	Early transition in portables	Yes	L	M/H	M/H	L	None
31	Proper E-o-L management for all halocarbon containing extinguishers	Yes	H	M/H	M/H	L	None

L=low; M=medium; H=high; E-o-L=end of life; Unk=unknown

36. During the Group I deliberations, one participant stated that comprehensive life-cycle management of refrigerants could significantly reduce unnecessary emissions and improve efficiency of equipment across all refrigeration and air conditioning sub-sectors. A variety of approaches could be considered including application of responsible use practices, “no venting” and recycling regulations, recovery equipment optimization, service technician training, deposit/rebate programmes, and destruction incentives.

37. Another participant commented on conversion of in-use domestic appliances, saying that conversion from CFC-12 to HFC-134a was technically and economically questionable, while conversion to hydrocarbon blend was technically easy, often resulting in energy efficiency gains, and was also cost effective under Article 5 countries’ conditions (low handling costs). He further commented that conversion or early retirement of equipment could reduce leakages and emissions before end-of-life of equipment, thus resulting in more efficient refrigerant management. Another participant stated that the comment regarding conversion of domestic appliances to hydrocarbon refrigerants was an opinion and that such conversion might not be practical or legal in some countries such as the United States of America.

38. Following the reports from the Chairs of the working groups, participants made general comments on the Workshop’s deliberations and outcome. Several participants thought that the workshop resulted in a very useful exchange of views and experiences on the various measures. It was also clear that the situation, needs and constraints in different countries meant that measures and their relevance and feasibility would vary from country to country as well. It was suggested that further inputs to the list of measures could be requested from other Parties before the Eighteenth Meeting of the Parties in an attempt to make the list of measures even more comprehensive. Another participant emphasized that as the agreed list of measures was the final product of the Workshop, it should not be

subject to change; instead, the list should be presented to the Eighteenth Meeting of the Parties for further consideration. Any future actions were for the Meeting of the Parties to decide.

39. Another participant said that the time had come to stop talking and to start implementing the measures, which had now been clearly identified in the agreed list of measures. Another participant stated that creative ideas had come forth in the workshop and that clear linkages between ozone-depleting substances and climate change existed. While estimates of future production and emissions of HCFCs were staggering, implementation of some of the measures would greatly help to reduce HCFCs not only for ozone benefits but also in terms of significant reductions in carbon equivalent emissions. She appealed for urgent action to reduce the impacts of climate change.

IV. Closure of the workshop

40. The workshop was adjourned at 4.46 p.m.

Annex I

Compilation of the submitted list of measures arising from the IPCC/TEAP Special Report

Proposed measure (from IPCC/TEAP SROC & TEAP supplementary report)	*ODS relevance*	*Significance*	*Practicality*	*Cost effectiveness*	*Other environmental benefits/impacts*	*Proponent*	
Domestic refrigeration							
Recover ODS contained in domestic refrigerators and freezers at end of life. [SROC §4.2.8 pp 237]	Yes – Banks of both CFCs & HCFCs are present in domestic appliances.	High – Banks of ODS in appliances as refrigerants were estimated at 107,000 tonnes and as blowing agents at 320,000 tonnes in 2002.	Low/Medium/High effort – Several approaches have been demonstrated globally. Refrigerant is generally easier to recapture than blowing agent. Most easily practiced around large conurbations. Collection from remote regions is challenging.	Low/Medium – Costs vary according to approach, with refrigerant recovery being the easiest. Any blowing agent removal will be medium cost. Processing a refrigerator will typically cost $10–15 per unit although this includes an offset for the re-sale of other recycled components (e.g., steel).	High - CFC-11 and CFC-12 have significant GWP and volumes of both refrigerant and blowing agent are also substantial. A deliberate strategy to isolate appliances in the waste stream also assists other recycling programmes. Care needs to be taken to monitor the impact of transportation logistics.	Example Uganda	1
Recover ODS contained in domestic refrigerators and freezers at end of life.	Yes – Banks of both CFCs & HCFCs are present in domestic appliances.	High – in 2002 banks of ODS in appliances as refrigerants were estimated at 107,000 ODP-tonnes, which represented about 1/3 of the whole refrigeration sector (totalled 336,000 ODP-tonnes in 2002).	Low/Medium/High effort - Several approaches have been demonstrated globally. Refrigerant is generally easier to recapture than blowing agent. Most easily practiced around large conurbations. Collection from remote regions is challenging. In some Parties there is already a mandatory requirement to recover electronic equipment, e.g., in EU (the WEEE directive).	Low/Medium – Costs vary according to approach, with refrigerant recovery being the easiest. Any blowing agent removal will be medium cost. Processing a refrigerator will typically cost $10–15 per unit although this includes an offset for the re-sale of other recycled components (e.g., steel).	High - CFC-11 and CFC-12 have significant GWP and volumes of both refrigerant and blowing agent are also substantial. A deliberate strategy to isolate appliances in the waste stream also assists other recycling programmes. Care needs to be taken to monitor the impact of transportation logistics.	EC	1
Designate a warehouse where the general public can lodge their old refrigerators and freezers. The refrigerants could be extracted and	Yes – even trainee technicians can recover CFC gases.	High – it represents another closure to the use of CFCs	Medium/High – Finding a suitable place to maintain and secure can prove difficult.	High – costs of transporting the equipment to the facility may be the responsibility of the owner, which can discourage contributions.	High – this form of "clean-up campaign" can raise public awareness of the Montreal Protocol's objectives.	Guyana	1

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
recycled.							
Recover ODS contained in domestic refrigerators and freezers at end of life. [SROC §4.2.8 p 237]	Yes – Banks of CFCs, HCFCs, and HFCs are present in domestic refrigerators (in refrigerant and foam). (Table 4.1 p 232)	High – Banks of CFC refrigerants from appliances were estimated at 107,000 tonnes in 2002, which represents 19% of total CFC banks and 4% of total refrigerant banks; banks of CFC blowing agents in appliances are also large (discussed below). To prevent emissions of these banks, end-of-life recovery is critical, since it is at appliance disposal stage when ODS foam blowing agent and the remaining refrigerant charge (typically 50%) can be released. (Table 4.1 p 232)	Medium - Several approaches have been demonstrated globally. Refrigerant is easier to recapture than blowing agent. Most easily practiced around population centers. Collection from remote regions is challenging.	Low – Costs vary according to approach. SROC notes that the small refrigerant charge size of domestic appliances makes recovery uneconomical. Any blowing agent removal will be high/medium cost and will require significant manual labor (p 343). Although recovery of blowing agent may reach 250-325g per unit, the cost of recapture and destruction at $30-60 per kg of blowing agent make it uneconomical but not prohibitive (pg 343). However, the recovery of refrigerant and foams provides an opportunity for the recovery/recycling of other materials as well (e.g., aluminum, steel), which may offset these costs.	High - CFC-11 and CFC-12 have significant GWP and the volumes of both refrigerant and blowing agent contained in old equipment still in use are substantial. Isolating appliances in the waste stream can also assist other recycling programs. Impact of transportation in reclaiming or destroying the refrigerant and foams, as well as recycling of other refrigerator components, should be accounted for.	USA	1
Recover blowing agents from refrigeration equipment at end of life.	Yes – Emissions of both CFC-11 and HCFC-141b as well as HFC-134a can be prevented by such measures.	Medium/Large – Current estimates of blowing agent banks in products within this sector are approx. 350,000-450,000 tonnes of CFC-11 and 100,000 – 150,000 tonnes of HCFC-141b.	Medium/High effort – Technologies are well established for recovery of foams from domestic appliances. However, geographic spread will make some units difficult to reach.	Medium - Any blowing agent removal will be medium cost. Processing a refrigerator will typically cost $10-15 per unit, although this includes an offset for the re-sale of other recycled components (e.g., steel).	High - CFC-11 has a significant GWP. A deliberate strategy to isolate appliances in the waste stream also assists other recycling programmes. Care needs to be taken to monitor the impact of transportation logistics. If early retirement of appliances is considered, there could be additional energy efficiency benefits.	EC	1
Situation of rigid foam used for refrigerator insulation systems	Since 2001, refrigeration insulation systems have been	This change was highly significant, since it solved the problem of cfc blowing agents by using non-CFC	Rigid foams, be it for the refrigeration sector or other sectors, no longer use CFC-11 blowing agents; 100%	The cost effectiveness of manufacturing cfc-free foams is very low, since the process uses a blowing agent that does not	Since 2000, there are few atmospheric emissions of CFC as a blowing agent or cleaning agent for refrigerators in El	El Salvador	1

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
and other insulation systems	retrofitted;: the blowing agent was changed from CFC-11, which has an ODP of 1.00, to HCFC-141, with an ODP of 0.05 or less, thus providing 80% control of the ODP. There is the added possibility that the HFC family will yield a blowing agent that will not harm the ozone layer.	blowing agents.	retrofitting has taken place and technicians have managed to handle this technology very well.	harm the ozone layer, giving a very low, almost zero, conversion rate.	Salvador, because the sector has been virtually 100% retrofitted.		
Manufacture refrigerators using HFC-134 as refrigerant and HCFC-141 as blowing agent; in Article 5 countries, technology retrofitting has taken place in factories. Use nitrogen as a cleaning agent for refrigerators, first replacing CFC-11, then replacing HCFC-141.	There is a bank of HFC-134a refrigerators in Article 5 and non-Article 5 countries in a number of factories with retrofitted technology.	By looking at the import statistics of several countries, it can be observed that quantities of HFC-134a have increased over the last 5 years from less than 10 metric tonnes to over 220 metric tonnes, making it necessary to take this strategy into account, since there will be more HFC-134a than CFC-12 by the end of 2010.	It is easier to acquire a new refrigerator with HFC-134a, since that is the market alternative. There is already a batch of these in each country, with a new blowing agent and refrigerant. How long can recycled CFC-12 be used? Until after 2010?	The cost effectiveness of manufacturing a new refrigerator would be the same or lower than with the former technology, since the cost of investment would be multiplied by an ODP factor of 0.00.	The odp factor of CFC-12 is 1.0, compared to zero for HFC-134a; the GWP of CFC-12 is 7000 to 8000 times greater than the GWP of HFC-134a, which is between 2000 and 4000, which implies that reducing CFC-12 and replacing it with HFC-134a would reduce the impact on the ozone layer and lessen climate change. The same would occur by replacing CFC-11 with HCFC-141, since the ozone depleting potential would be reduced from 0.055 to 0.00.	El Salvador	2 And 5
Recover ODS contained in domestic refrigerators and freezers during useful life.	Yes, CFC and HFC banks are present in domestic refrigerators.	High.-in fact, it has been calculated that, worldwide, there are 107,000 tonnes of CFC and 320,000 tonnes of CFC. How long will these quantities last for all countries?	It has been demonstrated that CFC recapture is more practicable than cleaning agent recovery. It is impossible or very difficult to recover the blowing agent.	Cost effectiveness comes in at the time of manufacturing the refrigerator, as it is applied to recovered CFC.	Impact on the environment, preservation of the ozone layer, and climate change, of course, because the recovery-recycling of CFC increases benefits for the environment	El Salvador	2

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
Create a revolving fund to finance the change of old equipment for new refrigerators.	High.- With this measure the recovery of CFC and HCFC will be increased exponentially.	High.- The recovery of refrigerant gas in combination with the destruction of old equipment will reduce the necessity of CFC as refrigerant.	High.- with this revolving fund with low interest rate, the financing of new equipment will increase year by year.	Low.- The cost of recovery of refrigerant is variable, but on the other hand it represents a benefit to the recoverer. Also, destruction of some components of refrigerators is an additional benefit. The financial mechanism should include a fee for destruction of the refrigerant gas and the foam recovered.	Creation of a recovery culture, and recovery of HFCs, with a high global warming impact	Mexico	2
Fund establishment of equipment destruction programme through a recovery fee, preceded by a seed fund to initiate the programme.	High.- With this measure the ozone depletion problem will be completely eliminated, at least with respect to CFCs.	High.- With the destruction of CFCs the problem of managing recovered CFCs is reduced to a minimum.	Medium- The difficulty is to implement a fee for establishinng the destruction programme.	Medium.- The owners of old equipment should pay for the destruction. This could be an disincentive to the programme.		Mexico	2
Stress leak control and recovery of HFC-134a and CFC-12 in refrigerator maintenance.	The relevance is that we would end up with a demand for a smaller quantity of both CFC-12 and HFC-134a for domestic refrigerator maintenance.	After 2010, it is more likely that there will be more HFC-134a than recycled CFC-12 and LPG available. In the medium term, CFC-12 refrigerators will tend to disappear, since recycled refrigerant will be scarcer.	How effective will the CFC-12 recovery and recycling process be, compared to the quantity of HFC-134a, after 2010, to guarantee that CFC-12 needs are met?	The cost-effectiveness of manufacturing CFC-12 domestic refrigerators is \$10–\$15 per kilogram; which is the same as for HFC-134a refrigerators, compared to LPG refrigerators, which will be less than \$1.00 per kilogram, since they will use the same parts as CFC-12 refrigerators.	The flammability of LPG and cyclopentane blowing agent refrigerators imply that countries will have to increase safety standards in servicing workshops.	El Salvador	3
Reduce leakage of refrigerant from new and in-use units. [SROC §4.2.6 p 235]	Yes – But only where ODS are permissible as refrigerants and are still being used. New equipment uses HFC-134a or HC-600a, but many	Low – Charge sizes and leak rates are low; CFC emissions from appliances were estimated at 8,000 tonnes in 2002, representing only 1.6% of total refrigerant emissions,	Low – Leak rates from new and existing equipment are already low. Moreover, reducing leak rates in millions of in-use refrigerators would require home owners to have their units serviced to ensure	Low- The cost to inspect and service existing refrigerators in millions of homes is substantial. (p 235)	Low – Reductions in emissions of both ODS (which have significant GWP) and HFC-134a—however small—will have a positive impact on climate change.	USA	3

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
	units still in use rely on CFC-12. (p 231)	much of which may have been emitted at end of life, not during use. (Table 4.1 p 232)	minimum leakage, even if the equipment seems to be operating well (p 237)				
Use liquid blends of propane-butane (LPG) in reprigerators.	Relevant, since there will be a shift to manufacturing refrigerators without R-12 or R-134, 100% ozone-layer and climate friendly.	R-12 refrigerators are retrofitted directly to LPG without major changes to their systems.				El Salvador	4
Require conversion of in-use domestic appliances to non-ODS alternatives or require retirement or replacement of units when servicing is required. [SROC §4.2.5 p 234-235]	Yes – A significant number of appliances still in use rely on CFCs. (p 235)	Low – Replacement of CFC-12 units can lead to significant emission reductions *if* the refrigerant is recovered and properly destroyed. In-use leakage rates from domestic refrigeration equipment do not tend to be high.	Low – SROC notes that the limited capital resources in developing countries leads to labor-intensive servicing of units compared to retirement/replacement with new non-ODS units (p 235)	Low - Developing countries may not have the resources to purchase new units. Moreover, the technical feasibility of retrofitting CFC-12 units to HFC-134a is questionable (material incompatibility and decreased appliance functioning) and the costs of such retrofits are unknown.	Low/Medium - There will be an increased number of units entering the waste stream that will need to be properly recycled to achieve environmental benefits (p 235). However, if all waste refrigerant, foam, and other materials are properly recycled/destroyed, ODS and GHG benefits may be significant. Replacement units will use HFC-134a which has a high GWP, or HC-600a. (p 231). However, energy efficiency gains (refrigerators may be 3x more efficient) may significantly reduce greenhouse emissions.	USA	2
Reduce availability of CFC-11 & CFC-12 dependent refrigerators & freezers on the market.	Yes – There will be less need for the use of virgin CFCs in case of leakage and repairs.		Medium effort – assists in the transition rate to cleaner technologies.	Low/medium – replacement refrigerant gases reduce the profit margin of technicians.	High – reduction in CFC-11 & 12 technologies will reduce GWP. Assists in maintaining compliance.	Guyana	4
Promote environment friendly refrigerators &	Zero use of ODS in Refrigeration sector	High – It represents another closure to the use of CFCs.	Replacement & new technologies	Medium/high – reduced consumer costs	High – Shows advancement of technology for countries.	Guyana	4

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
freezers that do not require CFCs.							
Commercial refrigeration (includes retail food equipment, food processing/cold storage, industrial refrigeration)							
Reduce leakage of refrigerant from existing systems. [SROC §4.3.6 – pp243]	Yes – but only where HCFCs are permissible as refrigerants	High – Use phase emissions from commercial refrigeration systems can represent up to 60% of total lifetime emissions.	Low/Medium – Some measures are related to changes in practice, although others will require some investment.	Medium – Refrigerant emission abatement measures have a cost range of $20-280 per tCO_2-eq.	Medium/High – Leakage reduction measures will have benefits for all refrigerants and in particular for those with high GWP.	Example Uganda	6
Reduce leakage of refrigerant from existing systems.	Yes – but only where HCFCs are permissible as refrigerants	High – Use phase emissions from commercial refrigeration systems can represent up to 60% of total lifetime emissions.	Low/Medium – Some measures are related to changes in practice, although others will require some investment.	Medium – Refrigerant emission abatement measures have a cost range of $20-280 per tCO_2-eq.	Medium/High – Leakage reduction measures will have benefits for all refrigerants and in particular for those with high GWP.	EC	6
Reduce leakage of refrigerant from existing systems. [SROC §4.3.6 – pp243]	Yes – Many types of commercial refrigeration equipment containing ODS have high leakage rates. (pp 240-241)	High – Commercial refrigeration comprises 40% of total global annual refrigerant emissions. Specifically, in 2002, commercial and industrial refrigeration equipment was responsible for 43% of global CFC refrigerant emissions (62,000 out of 144,000 tonnes/yr) and 56% of HCFC refrigerant emissions (131,000 out of 236,000 tonnes/yr). (Table 4.1 p 232)	Medium/High – Technician training, increased frequency and comprehensiveness of leak inspection activities and investment in leak detection technologies/repair materials will be required. However, costs borne by equipment owners will be offset by refrigerant cost savings. Industry efforts and government regulations may also be required. (p 243)	Variable – Refrigerant emission abatement measures have a cost range of $10-300 per tCO_2-eq (p 245). Overall, for certain systems cost-effectiveness will be high and for those where technical barriers are significant, cost effectiveness will be low.	High – Leakage reduction measures will have high benefits, particularly for equipment with high-ODP/GWP refrigerant. In addition, leak reduction may improve system efficiency, resulting in lower indirect emissions associated with energy consumption, as well as improve product (e.g., food) quality. (pp 245-247)	USA	6
Create a revolving fund to finance the change of old equipment for new refrigerators	High.- With this measure the recovery of CFC and HCFC will be increased exponentially.	High.- The recovery of refrigerant gas in combination with the destruction of old equipment will reduce the necessity of CFCs as	High.- with a revolving fund with a low interest rate, the financing of new equipment will be increased year by year.	Low.- The cost of recovery of refrigerant is variable, but on the other hand it represents a benefit to the recoverer, and destruction of some components of refrigerators	Creation of a recovery culture, and also some HFCs will be recovered, with a high impact on the reduction of global warming.	Mexico	7

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
		refrigerant.		will yield an additional benefit. The financial mechanism should include a fee for destruction of the refrigerant gas and the foam recovered.			
Use ammonia & HCFCs in commercial operations	Yes – until the phase out of the HCFCs begin	Medium – due to number of applications	Medium/high – New investments will install new technologies.	High – low maintenance & operational expenses	Medium/high – reduced ODS emissions & GWP gases	Guyana	8
Early transition to non-HCFC alternatives	Yes – HCFCs are still widely used in commercial refrigeration outside Europe.	High – The use of HCFCs is expected to be substantial in developing countries before phase-out in 2040. Earlier transition to alternative technology will greatly diminish future stocks and HCFC emissions.	High – Stand-alone equipment is the dominant form of commercial refrigeration in developing countries. HFC equipment is used already and its use is expected to increase in the future. Other technologies, (e.g., HCs and CO_2) are being evaluated.	Low/medium – Alternative technologies are more expensive than ODS technology right now but further development is expected to reduce the cost.	High – HCFCs have a high GWP and reducing their emissions will have a positive effect on the climate change. The total impact depends, however, on alternative technologies chosen. There should be careful consideration of maximizing energy efficiency and choosing refrigerants with a low GWP value.	EC	8
Earlier phase-out of HCFCs in new equipment. [SROC §4.3.3.1 p 241]	Yes – The majority of new commercial refrigeration equipment produced outside of Europe and U.S. contains HCFCs.	High – Future HCFC consumption in new commercial refrigeration equipment is expected to be substantial before phase-out in developing countries in 2040. By phasing out new HCFC equipment early, future stocks and subsequent emissions of HCFCs will be greatly curtailed—as will the servicing demand for that equipment.	High – Stand-alone equipment is the dominant form of commercial refrigeration in developing countries. HFC stand-alone equipment is available on the market and HC and CO_2 technologies are being evaluated. (pp 239, 241-242)	Medium/High - The capital costs of equipment using alternatives is greater than that containing ODS; however, an earlier phaseout could create new market forces, effectively reducing the cost premium. (p 244)	Medium/High - Care needs to be given to selecting alternatives that maximize energy efficiency. Where high GWP refrigerants are used, actions to minimize leakage and maximize end-of-life recovery are important to prevent direct emissions of GHGs. New energy -efficient equipment can reduce energy consumption by 10-20% (p 243).	USA	8
Reduce charge size by promoting the use of indirect	Yes – Where CFCs or HCFCs are permissible as	High – Indirect systems can reduce refrigerant charge by up to 90% and bring annual	Medium - Indirect systems have not significantly penetrated the market yet,	Medium – the capital costs associated with an indirect system may be 10-25% higher	Low/Medium – Care is needed in selecting alternatives that have low GWP and/or minimize	USA	9

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
commercial refrigeration systems. [SROC §4.3.4.2.2 p 242]	refrigerants in new equipment The use of indirect systems can limit the charge size and leak rates of HFC systems (thereby lowering GHG emissions). (Table 4.11 p 246)	leakage rates down to about 5% (from about ≥ 15%). Moreover, these systems can rely on primary refrigerants with low or zero ODP/GWP. (Table 4.11 p 246, p 245)	except in some European countries. They entail higher capital and operating costs. (pp 242, 244)	than the costs of a direct system, with annual energy costs being about 10% more. (p 244, Table 4.11 p 246)	emissions. Where natural refrigerants (i.e., CO_2, HCs, or ammonia) are used, safety measures are needed to minimize leakage and limit human and environmental health risks. Care is needed to design and operate indirect systems to negate or minimize energy efficiency penalties, which were seen in early designs, and to ensure that total equivalent warming impact of refrigerant plus energy is reduced.		
Recover ODS contained in stand-alone equipment at end of life	Yes – Banks of both CFCs & HCFCs are present in domestic appliances.	Low/Medium – Banks of ODS in stand-alone equipment as refrigerants were probably already below 40,000 tonnes in 2002. There is no specific data on banks of ODS blowing agents, although it is estimated that total banks in "other appliances" (which also includes water heaters) amounted to 48,000 tonnes.	Low/Medium/High effort - Several approaches have been demonstrated globally. Refrigerant is generally easier to recover than blowing agent. Recovery is most easily practiced around large conurbations. Collection from remote regions is challenging. Size variation in stand-alone equipment may also work against mechanized recovery of blowing agent.	Low/Medium – Costs vary according to approach with refrigerant recovery being the easiest. Any blowing agent removal will be medium cost. Processing a refrigerator will be above that for domestic refrigerators because of size variations.Again net costs will include an offset for the re-sale of other recycled components (e.g., steel).	Medium - CFC-11 and CFC-12 have significant GWP and volumes of both refrigerant and blowing agent are also substantial. A deliberate strategy to isolate appliances in the waste stream also assists other recycling programmes. Care needs to be taken to monitor the impact of transportation logistics.	EC	1 0
Recover ODS contained in commercial refrigeration equipment at end of life. [SROC §4.4.5 p 249]	Yes – Banks of CFCs and HCFCs are present in commercial refrigeration equipment. (Table 4.1 p 232)	High – A significant amount of ODS refrigerant is banked in commercial equipment, much of which will be intact at time of equipment disposal. Existing banks of CFC refrigerants in 2002 in commercial and industrial refrigeration were estimated at 221,000 tonnes,	Medium – Many countries have adopted recovery vacuum requirements of 0.3 or 0.6 atm, resulting in a recovery rate of 92–97% of total refrigerant charge—if in fact recovery is practiced, and practiced properly. Ensuring compliance with recovery laws is difficult unless economic incentives support	Variable – Will depend mostly on the economic value of the refrigerant recovered. For higher-valued refrigerants, recovery of large banks at end of life and reuse or reselling will be cost-effective. Additionally, recovered refrigerants may be used in other systems after chemical production has ceased, thereby	High – If recovery at end of life is performed on all equipment, HFCs will be recovered and reclaimed/destroyed, as well as ODS. This will ensure that GHG emissions are avoided. (p 249)	USA	1 0

Proposed measure *(from IPCC/TEAP SROC & TEAP supplementary report)*	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
		representing 39% of total CFC banks (8% of total refrigerant banks); HCFC banks were estimated at 458,000 tonnes, representing 30% of HCFC banks (17% of total refrigerant banks). Recovery at end of life is critical to avoiding venting much of the bank. (Table 4.1 p 232)	such activities. Additionally, adequate infrastructure is also required (e.g., recovery equipment, reclamation facilities). (p 249)	allowing existing equipment to be replaced when it makes economic sense. Added costs would need to be considered for destruction.			
Use HCFC and HFC in commercial refrigeration equipment, such as certain refrigerators, cold rooms, freezers, as an alternative, since, by including the two groups of refrigerants, HCFC and HFC, all refrigeration systems are covered, from the near future through to 2040, and as we will not reach the ceiling (basic level of HCFC) until 2016, availability is guaranteed.	Both for HCFC and HFC, there is no reduction control until 2015–2016, which is why these refrigerants will be used for refrigeration technology in the medium term; during this time, HCFC will gradually be replaced by HFC.	Countries' dependency on refrigerants for refrigerators and blowing agents is moving toward both hfc and HCFC; since the ODP of HCFC is 0.055 to 0.01; since the ODP of HFC is zero, it represents 20 times less damage than CFC.	The practicality of using HFC, as with HCFC, tells us that the servicing workshops that handle these refrigerants will have to be highly technical, but we have 10 years in which to train technicians and certify them in order to have workshops with the required capacity by 2015.	Cost-effectiveness cannot be calculated yet, since the refrigerator retrofitting step still gives enough time to train and certify refrigeration technicians and build the capacity of servicing workshops.	By dominating the refrigeration system market with HCFC and HFC, with maintenance technicians and equipment conversion to these systems, we guarantee HCFC with an ODP of 0.05 to 0.01 and HFC with an ODP of zero, virtually solving the problem of protecting the ozone layer, and a GWP lower than 4000, for both HFC and HCFC, will leave us with the goal of fine-tuning technology that will create zero global warming damage by the mid-21st Century or before using simple chemical refrigerants, such as CO2, NH3 and others.	El Salvador	10
Transport refrigeration							

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
Reduce leakage rates of existing equipment, particularly in larger vessels.	Yes – CFCs and HCFCs are used.	Medium – Virtually all of the 35,000 plus merchant ships worldwide larger than 500 gross tonnes have on-board refrigeration systems, the majority of which use HCFC-22 as refrigerant. Estimates of annual leakage rates are 15–20% of the system charge (2/3 of the systems are direct systems with up to 5 tonnes of refrigerant per system).	Medium – The likelihood of leaks is greater due to vibrations, sudden shocks, risk of collisions with other objects, etc. Frequent leak checks and repairs will be needed.	Medium – For larger vessels early detection and repair of leaks may be cost effective as it saves refrigerants used and ensures better functioning of refrigeration equipment.	Medium – Reducing HCFC-22 emissions will also help mitigate climate change.	EC	1 1
Reduce leakage rates from existing equipment. [SROC §4.6.1 p 256]	Yes – CFCs, HCFCs, and HFCs are in use. (p 256)	Medium – Leakage from this equipment represents a relatively low percentage of overall refrigeration/AC emissions. In 2002, refrigerant emissions from transport refrigeration represented less than 1% of CFC emissions (1,000 out of 144,00 tonnes/yr), less than 1% of HCFC emissions (1,000 out of 236,000 tonnes/yr) and only 3% of HFC emissions (3,000 out of 100,000 tonnes/yr). However, some transport applications have particularly high leakage rates. Specifically, refrigerated transport vehicles and fishing vessels are estimated to leak	Low/Medium – Equipment is more susceptible to vibrations, sudden shocks and other incidents that may cause equipment to leak more than stationary equipment. Frequent leak inspection and/or repair activities will be required. Industry efforts and government regulations may also be required. (p 256)	Low/Medium – Emissions from this end use do not represent a significant share of sector emissions (with most applications having small charge sizes). However, for the larger applications with higher leakage rates, time and money spent on repairing leaks and applying leak control technologies may be cost-effective.	Low/Medium – Direct GHG emissions from this end use are a significant contributor to the climate impact of transport refrigeration; however, emissions from the transport refrigeration end-use are very low relative to other end uses.	USA	1 1

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
		15-20% of system charge annually. Road transport units and refrigerated railway transport leak even more—about 20-25% annually. Therefore, targeted leak reduction may be worthwhile. (p 256-257)					
Encourage transition away from HCFCs. [SROC §4.6.1 p 256]	Yes – HCFCs are still widely used in sea transport & fishing and some intermodal transport. HFCs are often used as alternative refrigerants in other sectors such as road and rail transport. (Table 4.15 p 260)	Low – Banks of HCFCs in this end use were estimated at 4,000 tonnes (only 1% of total 2002 bank). However, 25% of total banks in transport refrigeration in 2002 were HCFCs. For new equipment in many transport refrigeration sub-sectors, the transition away from HCFCs is almost complete. (Table 4.15 p 260)	High – This sector has almost entirely transitioned away from ODS; hence, remaining phase-out would be relatively easy to implement. (pp 257–259)	Low – Most new equipment already contains non-ODS refrigerants; thus, alternative technologies are already competing strongly in the market.	Low/Medium – Where natural refrigerants (i.e., CO2, HCs, or ammonia) are used to lower GWP and climate impact, safety measures must be taken to minimize leakage and limit potential human and environmental health risks. In addition, energy efficiency must be taken into account when selecting alternatives; increased energy requirements of alternatives may increase GHG emissions from fuel usage.	USA	12
Stationary air conditioning and heat pumps							
Reduce charge size. [SROC §5.1.2 p 273] [SROC §5.2.3.1 p 283]	Yes – ODS are still widely used in stationary equipment. 90% of unitary air conditioners produced use HCFC-22. HFCs are also used in some new equipment. (p 271)	High – Reducing equipment charge size will translate into reduced leakage of refrigerant from future stationary A/C equipment. Because the use of stationary A/C equipment is so widespread, and because charge sizes can be high, the environmental impact of such a change would be significant. In 2002, refrigerant contained in stationary A/C equipment represented 15% of total	Low/Medium – Charge sizes, particularly in domestic A/C, are already quite low. Furthermore, in most cases for unitary equipment, energy efficiency is achieved with the use of larger heat exchangers requiring more refrigerant. However, additional R&D may provide an opportunity to reduce the charges of large equipment such as chillers and may provide ways to reduce unitary equipment charge sizes without reducing energy efficiency. (pp 273, 283-284)	Unknown	Medium/High – Reducing charge size may also help limit emissions of high-GWP refrigerants. Banks of HFCs in stationary A/C in 2002 were estimated at 81,000 tonnes, which represented 16% of total HFC banks (3% of total refrigerant banks). Therefore, reducing charge size would lower HFC banks in future, compared to a business as usual scenario. (Table 4.1 p 232)	USA	13

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
		CFC refrigerant banks (84,000 tonnes) and 68% of total HCFC refrigerant banks (1,028,000 tonnes). Reducing charge size would lower future banks compared to business as usual. (Table 4.1 p 232)					
Recover refrigerant at end of life.	Yes – Banks of ODS are substantial and will otherwise reach the waste stream until all ODS-containing equipment is decommissioned.	Medium/High – In 2002 the banks of HCFCs in A/C equipment were estimated to be in excess of 1 million tonnes. For CFCs the figure is approximately 84,000 tonnes.	Low/Medium/High effort - Several approaches have been demonstrated globally. Refrigerant is generally easier to recover than blowing agent and is most easily practiced around large conurbations. Collection from remote regions is challenging. Size variation in A/C equipment may also work against mechanized recovery of blowing agent.	Medium – Amounts of refrigerant per unit are relatively large, particularly for chillers. However, manual recovery is necessary and the geographic location of some units may make recovery challenging. Specific abatement costs dealing with existing banks can range from 3 to 170 US$ Mt CO_2-eq.	Medium /High - CFC-12 and HCFC-22 have significant GWP. Bearing in mind the quantities involved, the impact on greenhouse gas emissions could be substantial.	EC	1 4
Proper recovery and recycling of refrigerant at equipment end of life. [SROC §5.1.3.1 pp 274-275]	Yes – For equipment using CFCs, HCFCs, and HFCs.	High – Given the large number of unitary units in use, and the high charge size for some other equipment types (e.g., chillers), refrigerant emissions prevented at disposal can be significant. (pp 273, 275)	Medium – Recovery and reuse of refrigerant is economical from large equipment, although potentially not for smaller systems. Industry standards and/or government incentives or regulations may be required, as well as increased technician training and infrastructure (e.g., recovery equipment, reclamation facilities). Ensuring recovery from small equipment where it is not economical may be difficult, even if regulations are in	Medium – Technician training and infrastructure will require expenditures. Regulations and industry standards will need to be established. (p 275)	High - For equipment using HFCs, refrigerant recovery will reduce direct emissions of GHGs.	USA	1 4

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
			place. (p 275)				
Reduce leakage rates from existing stationary A/C equipment. [SROC §5.2.3.1 – pp283]	Yes – HCFC-22 is still in widespread use within unitary air conditioners. CFCs are also still in use in 50% of large-scale centrifugal chillers globally.	Medium/High – As with commercial refrigeration, leakage from A/C equipment can represent a substantial proportion of life-time impact. In 2002, the banks of HCFCs in A/C equipment were estimated to be in excess of 1 million tonnes. For CFCs the figure is approximately 84,000 tonnes. Reduction in leakage will not change the size of the banks but will change the demand for servicing.	Low/Medium effort – Measures would include the introduction and enforcement of improved maintenance practices. Because of the amounts available in larger equipment, on-site recycling can be encouraged.	Low/Medium – Costs should be limited to training inputs and minor expenditure in other engineered leakage reduction measures.	Medium /High - CFC-12 and HCFC-22 have significant GWP. Bearing in mind the quantities involved, the impact on greenhouse gas emissions could be substantial.	Example Uganda	1 5
Reduce leakage rates from existing stationary A/C equipment.	Yes – HCFC-22 still in widespread use within unitary air conditioners. CFCs also still in use in 50% of large scale centrifugal chillers globally.	Medium/High – As with commercial refrigeration, leakage from A/C equipment can represent a substantial proportion of life-time impact. In 2002 the banks of HCFCs in A/C equipment were estimated to be in excess of 1 million tonnes. For CFCs the figure is approximately 84,000 tonnes. Reduction in leakage will not change the size of the banks but will change the demand for servicing.	Low/Medium effort – Measures would include the introduction and enforcement of improved maintenance practices. Because of the amounts available in larger equipment, on-site recycling can be encouraged.	Low/Medium – Costs should be limited to training inputs and minor expenditure in other engineered leakage reduction measures.	Medium /High - CFC-12 and HCFC-22 have significant GWP. Bearing in mind the quantities involved, the impact on GHG emissions could be substantial.	EC	1 5
Regular and timely maintenance checks.	Yes – Reduced consumption of virgin ODS	High	Medium/high – Recycling options to be implemented	Medium – The use of existing technology will appeal to users.	Medium/high – Reduced dependence on HCFCs & GWP	Guyana	1 5

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
Reduce leakage rates from existing stationary A/C equipment. [SROC §5.2.3.1 – p 283]	Yes – Stationary equipment containing ODS refrigerant is widespread. For example, CFCs are still in use in 50% of large-scale centrifugal chillers globally, while the use of HCFC-22 is widespread in unitary air conditioners. In 2002, HCFC banks in A/C equipment were estimated to be in excess of 1 million tonnes; for CFCs, banks are approximately 84,000 tonnes. HFCs are also used in A/C equipment, with banks estimated at 81,000 tonnes. (Table 4.1 p 232)	Medium/High – Leakage from A/C equipment can represent a substantial proportion of lifetime impact. In 2002, 15% of the CFC refrigerant banked in stationary A/C equipment (13,000 tonnes) and 9% of the HCFC refrigerant was emitted. The environmental impact of repairing leaks will be most significant in equipment with large charge sizes and high leak rates. (Table 4.1 p 232)	Medium/High – Measures would include technician training, increased frequency/comprehensiveness of leak inspections and investment in leak control/reduction technologies. (p 275)	Medium/High – Costs should be limited to training inputs and minor expenditures in leak inspection activities and other engineered leakage reduction measures. Efforts should focus on those end uses with high charge sizes and large leak rates. (pp 274-275)	Medium/High - Bearing in mind the quantities involved, a reduction in leak rates from these equipment types would also decrease emissions of GHG alternatives. In 2002, emissions of HFCs from stationary A/C were estimated at 6,000 tonnes. This number can be expected to increase with the transition away from ODS. (Table 4.1 p 232)	USA	15
Fund establishment of equipment destruction programme through a recovery fee, preceded by a seed fund to initiate the programme.	High.- With this measure the ozone depletion problem will be completely solved, at least with respect to CFCs.	High.- With the destruction of CFCs the problem of manage recovered CFCs is reduced to a minimum.	Medium.- The difficulty is to implement the fund for destruction through a fee.	Medium.- The owners of old equipment should pay for the destruction, and it could be an disincentive to the programme.		Mexico	16
Phase-out HCFC in new equipment earlier.	Yes – Since 90% of air conditioners are produced to use	Medium/High – Future cumulative HCFC consumption in new	Low – Technologies are already available to assist this transition and the only barriers	Medium – Technology already exists to address this issue and any costs will be related to the	Low/Medium – Care needs to be given to selecting alternatives which maximize energy	Example Uganda	17

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
[SROC §5.2.3.2 – pp284-285]	HCFC-22, there is substantial value in earlier transition to new refrigerants.	stationary A/C equipment is expected to be substantial before phase-out in developing countries in 2040.	anticipated will be those of cost.	higher investment costs (capital and/or revenue) associated with alternative technologies. There should be economies of scale if the transition is universal.	efficiency. Where high GWP refrigerants are required to achieve this, actions to minimize leakage and maximize end-of-life recovery are important.		
Early transition to non HCFC alternatives.	Yes – It is estimated that more than 90% of the installed base of stationary A/C equipment currently use HCFC-22, and an estimated 368 million air-cooled A/Cs and heat pumps are installed worldwide.	High – The use of HCFCs is expected to be substantial in developing countries before phase-out in 2040. Earlier transition to alternative technology will reduce future stocks of HCFCs.	High – alternative technology already exists and HFC blends and hydrocarbons are being used.	Medium/low – Alternative technology is already available but its cost is still higher than with ODS. Energy efficiency and operational costs vary depending on the technology chosen and local requirements.	High – HCFCs have a high GWP and reducing their emissions will have a positive effect on climate change. The total impact depends, however, on the alternative technology chosen. There should be careful consideration of maximizing energy efficiency and choosing refrigerants with a low GWP value.	EC	17
Phase-out HCFCs in new equipment earlier. [SROC §5.1.3.2 pp 275-276] [SROC §5.2.3.2 – pp 284-285]	Yes – 90% of A/C units are produced to use HCFC-22. (pp 271, 274)	High – Future HCFC consumption in new stationary A/C equipment is expected to be substantial before phase-out in developing countries in 2040. Reducing future stocks of HCFCs will also reduce servicing demand for decades.	High – Technologies are already available to assist this transition in the US and the only barriers anticipated will be those of cost. (pp 274-276, 284-285) Technical challenges could be greater in developing countries because of equipment and training constraints.	Medium/High –Equipment using alternative refrigerants is widely available, although it is typically associated with higher capital and, in some cases, electricity costs. There should be economies of scale if the transition is universal, as it would decrease the cost premium. (pp 275, 284)	Low/Medium – HFC refrigerants can be used responsibly and achieve greater energy efficiency and thereby reduce indirect GHG emissions from energy generation. Care is needed in selecting alternatives that maximize energy efficiency. Where high GWP refrigerants are used, actions to minimize leakage and maximize end-of-life recovery are important to prevent direct emissions of GHGs.	USA	17
Mobile air conditioning (MAC)							
Recover refrigerants contained in existing vehicles. [SROC §6.4.1.2	Limited – Old systems are likely to be leaky and most CFC-12 will already have been released. There is some	Low/Medium – In 2002, the bank of CFC-12 globally was estimated at 149,000 tonnes but is expected to have reduced fairly rapidly since then as	Low/Medium effort – Technology is relatively straightforward, although logistics can be a problem because of the fragmented and geographically widespread	Low/Medium - Cost of recovery equipment is modest and should also have been already encouraged under various refrigeration management plans.	Medium - CFC-12 has a significant GWP. However, replacements may also have some direct impact. The efficiency of air conditioning equipment will influence the	Example, EC	18

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
pp304]	on-going servicing requirement which is usually met from recycled material.	vehicles have been replaced.	ownership of automobiles.		charge required and potential emissions from a system during its lifetime.		
(Personnel transportation) Recover refrigerant from abandoned cars.	Low	Low – Fewer vehicles use CFCs.	Low – There are a small number of vehicles over a large area; it would also be dependent on resource availability.	Low – due to wide distribution of units	Low/medium – due to operational demands	Guyana	1 8
Recover refrigerants contained in existing vehicles during service and at vehicle end of life. [SROC §6.4.1.2 p 304]	Yes – CFC-12 MVACs are still in widespread use in developing countries and may continue to be manufactured in new systems until 2008. HFC-134a is used in most newer MVACs,and its market penetration will increase in developing countries as CFC-12 is phased out. Recovery of refrigerant at service and disposal is critical to reducing ODS & GHG emissions.	High – Although MVACs have a small charge size, their large numbers translate into high emissions unless refrigerant is recovered during service and disposal events.	Medium/High – MVAC refrigerant recovery programmes have already been implemented in many developing countries. Technology is relatively straightforward, although the logistics of recovery can be a challenge because of the large number of dispersed service stations. Do-it-yourselfers cannot easily be targeted or monitored.	Medium/High - Costs of technician training and recovery equipment are modest and have already been promoted under various refrigeration management plans.	Medium/High - CFC-12 has a significant GWP and its replacement—HFC-134a—also has a high GWP. Therefore, recovering these refrigerants is critical to minimizing emissions of GHGs, not just ODS.	USA	1 8
Improve containment of refrigerants.	Yes – CFC-12 MACs are still widely used and will be produced in developing countries until 2008. In one study (SROC p. 300), CFC-12	Medium/high – Via improved containment avoided emissions could be significant, particularly in developing countries where the use of MACs is increasing.	High – MAC technology is being improved as MAC use becomes more common in motor vehicles. Training of servicing personnel is required and could be done at a moderate cost, partly with	Medium/high – Costs associated with improved HFC-134a systems are $24–36 per functional unit. Other technologies under development are CO_2 (costs $48–180 per functional unit)	High – Improved containment will reduce direct emissions of ODS and GHGs and thus help mitigate the climate change.	EC	1 9

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
	emissions were approximately 105 tonnes in 1990 and are expected to be around 5192 tonnes in 2015. Leak checks and repairs could decrease emissions of refrigerants.		the help of MAC manufacturers. In some developing countries, phase-out of CFC-12 has permitted the implementation of good practices.	and HFC-152 (costs $48 per functional unit).			
Improved containment of refrigerant [SROC §6.4.1 p 304]	Yes – Improved refrigerant containment could decrease emissions of both CFC-12 and HFC-134a, depending on which refrigerant manufacturers in developing countries are using (full transition from CFC-12 is not required until 2008, although most production now involves HFC-134a). (p 297)	Medium/High – If leakage rates were reduced through improved containment, avoided emissions could be significant—especially in the future, as the number of MVACs in developing countries continues to grow. In 2003 alone, 63,000 tonnes of CFC-12 and 74,000 tonnes of HFC-134a were emitted from MVACs. [SROC §6.2.2 p 300]	High – Improved HFC-134a systems are under development and expected to be commercialized in the near future.	Medium/High – Capital costs associated with improved HFC-134a systems is roughly $40 per system. (p 306)	Medium – Improving containment will reduce direct emissions of GHGs (as well as ODS, if applied to CFC-12 systems). Improved HFC-134a systems are also expected to be more energy efficient, reducing gasoline use to operate the system and resulting GHG emissions.	USA	19
Standardsand programmes to reduce service-related emissions (recovery, recharge, leak detection, and leak repair). [SROC §6.4.1 p 304]	Yes – Improved servicing would reduce emissions of CFC-12 and HFC-134a.	Medium/High – Although MVACs have a small charge size, their large numbers translate into high emissions, some of which occur during service. Service-related emissions can result in the release of 5–15% of the original MVAC charge—or much more if performed by unskilled technicians (i.e.,	Low/Medium – A standardized certification method would need to be developed for checking the leak tightness of each MVAC component after it is installed. While training and technology is straightforward, getting participation from a large number of small, geographically-dispersed service stations may be a	Medium/High – Cost of recovery equipment is modest and should also have been already encouraged under various refrigeration management plans. Additional costs are associated with training programs to ensure best practices for recovery, as well as leak detection and repair.	Medium – CFC-12 has a high ODP and GWP, and its replacement, HFC-134a, has a high GWP.	USA	20

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
		do-it-yourselfers).	challenge. Further, ensuring compliance with agreed standards could be difficult.				
In El Salvador, only vehicles made before 1994 are likely to contain CFC-12, since, under a Salvadoran transportation law aimed at reducing vehicle exhaust emissions that was passed in 2001, no vehicles older than 1994 can be imported. It has also been stipulated since then that no vehicles over seven years old can be imports, and the vehicles imported this year are the first that have air conditioning systems that come from the factory carrying HFC-134a.	This regulation is important since, in the first decade of the 21st century, vehicles from the 20th century no longer enter the country and those that have air conditioning (not all of them have it) only use HFC-134a refrigerant. The probability of finding a vehicle model older than 1994 with CFC-12-based air conditioning is very low, which means that the mobile air conditioning (MAC) sub-sector only creates demand for HFC-134a refrigerants, which do not damage the ozone layer and create little greenhouse effect, far less than CFC.	This change in demand, which was generated by the 1994 regulation, is very important (high significance) for achieving the reduction of CFC-12-based MAC systems in El salvador. if this were done in several countries, the situation globally would move away from the trend of changing MAC systems with R-134 to R-12.	Workshops in El Salvador may have to build capacity with regard to this new technology so that MACs will function properly and leakage will be controled.	The cost effectiveness of retrofitting is very low, since the majority of imported vehicles, which, in El Salvador, is 100%, are not manufactured by us. The MAC systems of most vehicles have already been retrofitted, so this cost does no have an impact on the vehicle within the country.	The environmental impact of this measure is that, after 2010, the ozone layer will suffer very little damage, since the emissions from the MAC sector will be very low throughout the 21st century.	El Salvador	21

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
			Foams				
Recover blowing agents from steel-faced building panels. [SROC §7.5.2 pp 344]	Yes – Both CFC-11 and HCFC-141b have been used in the manufacture of these products.	Medium – In 2000, the bank estimates for CFCs were 350,000 tonnes of CFC-11 and 100,000 tonnes of HCFC-141b. Benefits will not begin to accrue until panels reach the waste-stream in 2015 or thereabouts.	Medium/High effort – Recent trials in Europe have shown that existing refrigerator recycling equipment can be used to process panels. Logisitics for recovery from sites would need to be managed.	Medium – Where reasonable volumes of panels are in one place (e.g., a medium/large building), the logistics cost should be tolerable. Since the foam:metal ratio will be higher, the recovery efficiency of the plant could be affected.	Medium/High – CFC-11 has a significant GWP. The recycling of steel is also an additional environmental advantage.	Example	22
Recover blowing agents from steel-faced building panels. [SROC §7.5.2 p 344]	Yes – Both CFC-11 and HCFC-141b have been used in the manufacture of these products.	Medium – In 2000, PU panel bank estimates for CFCs were 350,000 tonnes of CFC-11 and 100,000 tonnes of HCFC-141b; however, benefits will not begin to accrue until panels reach the waste stream around 2015 [SROC §4.4 of the Technical Summary p 66]	Low/Medium – Recent trials in Europe have shown that existing refrigerator recycling equipment can be used to process panels. Logistics for recovery from each site would need to be managed.	Medium – Cost effective where large volumes of panels are in one place (e.g., a medium/large building). Since the foam/metal ratio will be higher, the recovery efficiency of the plant could be affected.	Medium/High – CFC-11 has a significant GWP. The recycling of steel is also an additional environmental advantage.	USA	22
Restrict the use of ODS in one-component foams (OCF). [SROC §7.1.2.1 p 320]	Some – HCFC-22 is one of the blowing agents used in the OCF market. These foams are widely used in the building industry as gap fillers around doors and windows as well as in plumbing applications. This is a highly emissive application. (p 322)	Low – The amount of ODS still used in producing OCF is small.	Medium/High – There are numerous non-ODS propellants used for OCF.	Uncertain	High –OCF restriction is one of many actions that can reduce energy requirements for buildings and can have a significant impact on GHG emissions associated with reduced energy generation.	USA	23
Phase out HCFCs earlier; encourage use of alternative blowing agents or not-in-kind	Yes – CFCs and especially HCFCs are still used in developing countries. Some HCFCs are still	Variable – Consumption of HCFCs in 2002 was 128,000 tonnes and is projected to be 50,000 tonnes in 2015.	Medium/High – Alternatives with zero ODP and low GWP have been widely adopted in several sub-sectors. Most industrial CFC conversions	Variable – Insulation value of alternatives may offset direct emission reductions. As long as HCFCs are available, HCs and HFCs will only be used in	High – The use of blowing agents with reduced (or zero) GWP could have a significant impact on emissions of GHGs, assuming no significant energy	USA	24

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
technologies. [SROC §7.5 pp 326-327; 341-342]	used in developed countries, but phase-outs are already scheduled and in place.	Lower insulation value of alternatives may offset any direct emission reductions.	financed by the Multilateral Fund can use equipment that supports non-HCFC technologies such as CO_2 and hydrocarbons. Further technological development will be required. However, this is not realistic until after 2010. In addition, not-in-kind technologies have limited feasibility depending on sub-sector. (p 324)	developing countries if the additional costs can be passed on. Specific abatement costs of each blowing agent are variable by sector – the emission abatement cost associated with major polyurethane foam and extruded polystyrene is $25–85 per tCO_2-eq and $6–12 per tCO_2-eq, respectively.	penalty. The reduction of HFC consumption can result in cumulative emissions reduction of 31,775 tonnes, 225,950 tonnes, and 352,350 tonnes by 2015, 2050, and 2100, respectively. (pp 317-318)		
Reduce emissions during foam production and installation. [SROC §7.5.1 p 342]	Yes – Consumption of HCFC blowing agent amounted to 128,000 tonnes in 2002 and is projected to amount to 50,000 in 2015. (p 317)	Medium – Measures of this kind are not expected to achieve a saving better than 20% on average.	Variable from process to process. It may be possible to reduce production losses in the extruded-polystyrene sector to between 17.5% and 20%. Practices that minimize process waste from block-foam measures can be introduced. However, SROC notes that emissions savings are unlikely to exceed 20%. (p 342)	Variable	Variable. As long as alternatives are chosen with GWP lower than that of HCFCs, there will be positive climate impacts associated with minimizing emissions of blowing agents.	USA	25
Improve product and building design. [SROC §7.5.1 p 342]	Yes – Consumption of HCFC blowing agent amounted to 128,000 tonnes in 2002 and is projected to amount to 50,000 in 2015. (p 317)	Low – Losses in use are low as a proportion of total blowing agent loading and changes in technology are unlikely to have a major impact.	Low – In-use losses represent only a small portion of the emissions associated with the use of ODS in foams.	Variable – Depends on the cost of altering product and building design.	Low – Due to the small amount of in-use losses, few environmental benefits can be expected.	USA	26
Extend end-of-life management measures to all appliances. [SROC §7.5.2 pp	Yes – Significant banks of ODS exist in appliance foam. In 2000 bank estimates were 460,000 tonnes of CFCs, 209,100	Potentially High – Implementing European practices for decommissioning domestic refrigerators around the world could have a	High – It is anticipated that by 2010, all domestic refrigerators worldwide could be properly decommissioned.	Medium/High – The emission abatement costs associated with recovering and destroying foam from appliances are estimated to range from $30–60 per kg of blowing agent.	High – Minimizing direct emissions of ODS and GHGs from foams could have significant climate impact. The energy requirements associated with decommissioning and	USA	27

Proposed measure *(from IPCC/TEAP SROC & TEAP supplementary report)*	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
343-344]	tonnes of HCFCs, and 1,150 tonnes of HFCs. [SROC §4.4 of the Technical Summary p 66]	significant impact on emissions of HCFCs.			recycling domestic refrigerator components will need to be considered.		
Halons							
Adopt appropriate management techniques to limit emissions from all banks of fire protection agent (halon, HCFC, HFC and other). [SROC § 9.4 pp 375-376]	Yes – Both halons and, to a lesser extent, HCFCs are still used in fire protection equipment. Good practices in bank management offer longevity of use for key applications and avoid the need for re-manufacture.	Low/Medium – Halons are now only in use within about 4% of current fire protection equipment. However, banks exist on the order of 39,000 tonnes for Halon 1301 and 83,000 tonnes for Halon 1211, while for HCFCs there are 3,600 tonnes in fixed systems and 2,700 tonnes in portable systems. The high ODP of halons makes them still an important target for emission prevention.	Low/Medium effort – Strategies have already been developed in many countries and enforcement through either regulation or voluntary agreement (supported by necessary standards) has been effective. The challenge remains the widespread use of fire protection equipment – particularly in the form of portable systems.	Low/Medium – Costs should be limited to training inputs and minor expenditure in other engineered leakage reduction measures. Arguably, the cost of developing suitable codes of practice and regulation should also be considered. However, it is now possible to borrow from several existing and successful schemes.	Low – Emission reduction measures are always welcome when limiting pollution. However, there is evidence to suggest that halons can act as significant "global coolers" [Figure TS-6]. The GWP of HCFC-123 (used in portable equipment) is also relatively low. However, a reduction in emission of HCFC-22 (used significantly in fixed systems) could make a valuable contribution to climate protection. Fire prevention in itself, of course, is an act of environmental protection.	Example	2 8
Adopt appropriate management techniques to limit emissions from all banks of fire protection agent (halon, HCFC, HFC and other). [SROC §9.4 pp 375-376]	Yes – Halons, HCFCs, and HFCs are used in fire protection equipment. Good practices in bank management offer longevity of use for key applications and avoid the need for re-manufacture. (p 363)	High – Halons are now only needed in about 4% of new installations that formerly used halon, but banks are estimated at 39,000 tonnes for Halon 1301 and 83,000 tonnes for Halon 1211. For HCFCs, banks are estimated to be 3,600 tonnes in fixed systems and 1,300 tonnes in portable systems. Proper management is needed to ensure that these banks are not unintentionally emitted.	Medium/High – Strategies have already been developed in many countries and enforcement through either regulation or voluntary agreement (supported by necessary standards) has been effective. However, because the use of fire protection equipment, particularly portable systems, is so widespread, it is difficult to ensure full observance with recommended practices. (p 375)	Medium/High – Costs should be limited to training inputs and minor expenditures in leak inspection activities and engineered leakage reduction measures. The cost of developing, adopting, and implementing existing codes of practice and appropriate regulations should also be considered. However, it is now possible to borrow from several existing and successful schemes. SROC notes that there is an economic incentive	Low – Emission reduction measures are always welcome and reduction in emission of halocarbons (used significantly in fixed systems) could make a valuable contribution to climate protection. Fire prevention in itself, of course, is an act of environmental protection.	USA	2 8

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
		Emissions for 2005 were estimated by HTOC (2003) to be 1,900 tonnes and 16,000 tonnes of Halon 1301 and Halon 1211, respectively, although discharges are included in these estimates (not just leakage). (pp 364, 367-368)		to properly recover halon alternatives. (pp 375-376)			
Transition to use of non-halon alternatives for new fixed systems. [SROC §9.2.1-9.2.2 pp 369-370]	Yes – halons have high ODP and are still used in fire protection systems. HCFCs are used in limited applications.	Medium/High – Although halon consumption all but ceased in developing countries in 2004, recycled halon is still available for use in new systems, for many of which viable halon alternatives are available. As of 1999, only 4% of the former halon market required halon in new systems. (pp 364, 367)	High – There are a variety of alternatives, including clean agents (e.g., HFC-227ea) and not-in-kind technologies, each of which is suited to different applications. In developed countries, new systems and not-in-kind alternatives have replaced about half the applications that historically used halons. (pp 370-373)	High – Halon alternatives are available for most fixed-system applications, with the exception of some specialty uses (e.g., aviation, military, etc.), though capital costs may be higher. Over time, halon costs will increase and render the alternatives more competitive. (pp 371-373)	Low – Halocarbon alternatives may have negative environmental impacts; HCFCs are ODSs and GHG and HFCs are GHGs. However, other not-in-kind technologies (i.e., water-based, total flooding, dry-chemical and aerosol systems), as well as inert gas, create no direct emissions of ODSs or GHGs. (p 370)	USA	29
Transition to use of non-halon alternatives for new portable extinguishers. [SROC §9.3 p 373]	Yes – Halons have high ODPs. HCFCs and HFCs are used as alternatives. (p 369)	Medium – Halon consumption ceased in developing countries in 2004, so the manufacture of halon in new portable extinguishers should be low or non-existent. The re-fill of existing extinguishers continues to occur.	High – With a few exceptions (e.g., for use in military), non-halon alternatives are available for streaming applications. Options include “in-kind” alternatives (e.g., halocarbon), water and dry chemical. (pp 374-375)	Medium/High – Some halon alternatives may be less expensive than halon. Alternatives are already available so costs associated with continued research and development are not high.	Low – Halocarbon alternatives may have negative environmental impacts; HCFCs are ODSs and GHGs and HFCs are GHGs. However, other not-in-kind replacements (i.e., water, dry-chemical) create no direct emissions of ODS or GHGs. (p 370)	USA	30
The fire extinguisher sector was retrofitted in El Salvador over 10 years ago.	In the 21st century, no atmospheric there have been no emissions of halon, one of the types of ODS that is most harmful to the ozone layer.	High significance, since the sector has been 100% retrofitted.	The practicality of retrofitting this sector and managing the refilling of extinguisher systems is very high, since the businesses that manage this activity are very efficient and highly professional.	During the retrofitting process, the extinguishers were retrofitted in factories in El Salvador and imported, so the cost effectiveness of reducing damage to the atmosphere is very high.	High environmental impact because, in El Salvador, as in many Article 5 countries, the systems have been 100% retrofitted, meaning that halons, the ODS that is most harmful for the ozone layer, will have been reduced by almost 100%.	El Salvador	30

Proposed measure ***(from IPCC/TEAP SROC & TEAP supplementary report)***	***ODS relevance***	***Significance***	***Practicality***	***Cost effectiveness***	***Other environmental benefits/impacts***	***Proponent***	
Proper handling of end-of-life equipment	Yes – Halons and HCFCs as well as HFCs are used in fixed systems and portable fire extinguishers.	High – Emissions are likely to occur at this stage without sufficient knowledge and skills to handle ODS as well as appropriate equipment. A considerable amount of ODS is still in systems and equipment which are near the end of their service life.	Medium/high – Recovery should be performed by a trained technician with proper equipment. Reclamation and/or destruction require special facilities.	High – Halon's positive market value provides a financial incentive to minimize emissions.	High – Recovery of substances with high ODP and GWP prevent their emissions and thus their impact on ozone depletion and climate change.	EC	3 1
Handle fixed systems and extinguishers at end of life properly. [SROC §9.4.3 p 375]	Yes – Halons, HCFCs, and HFCs are used in fixed systems and portable extinguishers. (p 363)	High – Considerable amounts of halon are still present in existing systems; if halon is not recovered from these systems and properly reclaimed or destroyed, ODS emissions will be very significant. Moreover, banks of HCFC and HFC will continue to increase as halon is phased out, and it is critical that remaining agent not be vented at end of life. (pp 363-364, 367)	Medium/High – Because only properly trained technicians tend to deal with total flooding systems, proper end-of-life treatment of such systems can be monitored and controlled. However, ensuring proper recovery/treatment of extinguishing agent at the end of life of portable extinguishers may be more difficult.	High – The existence of a halon market and the high market value of halons provides a financial incentive for properly recovering and recycling halons at end of life. Similarly, HCFC and HFC replacements are also being recovered and recycled due to their market values. (p 376)	High – Recovering high ODP/GWP agents will prevent emissions of ODS and GHGs.	USA	3 1

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