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THE 1994 SCIENCE, ENVIRONMENTAL EFFECTS, AND TECHNOLOGY AND ECONOMIC ASSESSMENTS

Synthesis Report*

Addendum

March 1995 synthesis report

* Prepared at the request of the United Nations Environment Programme, on behalf of the Parties to the Montreal Protocol.

MARCH 1995 SYNTHESIS REPORT

Summary

This synthesis report examines the scientific, technical and economic implications of a range of scenarios of possible action that could be considered by the Parties to the Montreal Protocol. The report states that, from the scientific perspective of reducing the risks of future ozone depletion, key steps that the Parties may want to consider include:

(a) Ensuring full compliance with the Montreal Protocol as amended at Copenhagen;

(b) Actions to reduce production and consumption of methyl bromide in non-Article 5 countries;

(c) Actions to collect and destroy existing chlorofluorocarbon (CFC) and halon stocks;

(d) Actions to limit future growth in hydrocholorofluorocarbon (HCFC) and methyl bromide use in Article 5 countries.

Other actions considered in this report that have substantially less impact in reducing risks of future ozone depletion include: accelerating the phase-out of HCFCs and reducing the size of the HCFC cap.

From a technical and economic perspective, this report concludes that:

(a) Compliance with the Protocol as amended at Copenhagen is technically and economically feasible if Article 5 countries and countries with economies in transition have access and adequate financing;

(b) Although it is technically feasible (though costly) to destroy halon and CFCs, recycling of existing stocks for essential uses and maintenance of equipment is required to implement the phase-out in accordance with the Protocol;

(c) Reductions of up to 90% in the use of methyl bromide are technically and economically feasible for non-Article 5 countries;

(d) Limits to future growth in HCFC and methyl bromide use in Article 5 countries are technically and economically feasible;

(e) Reducing the size of the HCFC cap is technically but perhaps not economically feasible in every non-Article 5 country. It is difficult to estimate the economic consequences;

(f) It is technically but perhaps not economically feasible to completely phase out HCFCs by 2015 because HCFCs will be necessary to service equipment with a useful lifetime beyond 2015.

I. INTRODUCTION

1. The Montreal Protocol on Substances that Deplete the Ozone Layer states in Article 6 that: "the Parties shall assess the control measures ... on the basis of available scientific, environmental, technical, and economic information." To provide the mechanisms whereby these assessments are

conducted, the Protocol further states that: "the Parties shall convene appropriate panels of experts ..." and "... the panels will report their conclusions ... to the Parties".

2. The 1994 assessment reports were prepared by a total of more than 700 of the world's leading experts from 46 countries (see UNEP/OzL.Pro/WG.1/11/3, paragraph 3). Full assessment reports are available from the Ozone Secretariat.

3. There are only a limited number of approaches to lowering stratospheric chlorine and bromine abundances beyond those already adopted by the Parties to the Protocol. In 1994, four approaches identified by the Science Assessment Panel (SAP) were evaluated by the Technology and Economic Assessment Panel (TEAP) and its Technical Options Committees (TOCs) (for details, see UNEP/OzL.Pro/WG.1/11/3, paragraph ES.15).

4. At their Sixth Meeting, the Parties to the Montreal Protocol by decision VI/13 requested further scientific elaboration of different scenarios for possible future emissions of hydrochlorofluorocarbons (HCFCs) and methyl bromide. They also requested TEAP to evaluate the technical and economic feasibility of more stringent controls for these substances. SAP examined a wide range of scenarios and conducted sensitivity analysis to identify which possible control measures would significantly reduce chlorine and bromine loading in the stratosphere. TEAP examined 15 scenarios that cover a broad range of possible actions.

5. This document is a synthesis of these separate assessments. It is based on the 1994 scientific assessment of ozone depletion and the 1994 technology and economic assessment report (including the reports of the seven TOCs plus additional work of TEAP and its TOCs).

6. Prior to discussing these options, it should be noted that failure to adhere to the international agreements as they currently stand will delay recovery of the ozone layer. If there were to be additional production of chlorofluorocarbons (CFCs) at 20% of 1992 levels for each year through 2002 and ramped to zero by 2005 (beyond that allowed for countries operating under Article 5 of the Montreal Protocol), then the integrated effective future chlorine loading above the 1980 level is predicted to be 9% more over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.

II. APPROACHES TO LOWERING METHYL BROMIDE AND HCFC ABUNDANCE THAT ARE TECHNICALLY AND ECONOMICALLY FEASIBLE

A. Further control of methyl bromide

7. According to the scientific assessment, if emissions of methyl bromide from agricultural, structural, and industrial activities were to be eliminated in the year 2001, then the integrated effective future chlorine loading above the 1980 level (which is related to the cumulative future loss of ozone) is predicted to be 13% less over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.

8. Controls under the current Protocol freeze methyl bromide consumption by January 1995 at 1991 levels in non-Article 5 countries. It is the consensus of TEAP and its 1994 MBTOC that further controls beyond the currently established control levels are technically feasible, though the judgement of the magnitude of technically feasible reductions in specified years varied widely among some Committee members. TEAP believes that additional controls on methyl bromide would be more cost-effective than additional controls on other controlled substances per tonne weighted by ozone-depleting potential (ODP). Furthermore, TEAP believes that the challenges faced by users of methyl bromide in implementing alternatives and substitutes, while substantial, are no greater than those already overcome by users of the other ozone-depleting substances (ODSs).

9. Five methyl bromide scenarios are presented in this report, two relating to non-Article 5 country consumption and three relating to Article 5 country consumption. All scenarios assume that there will be exemption from control for pre-shipment and quarantine uses of methyl bromide or some essential use process replacing this global exemption at the same level of consumption as currently used for pre-shipment and quarantine.

10. For the cases presented below, SAP calculated the resulting change in the total integrated equivalent effective stratospheric chlorine (EESC) loading that would occur. Chapter 13 of the "Scientific assessment of ozone depletion: 1994" shows that the integrated EESC is related to the total integrated amount of stratospheric ozone depletion. Therefore, for the cases presented below, the percentages relate to decreases (or increases) in the amount of total ozone depletion that would occur from 1980-2050 for the various control choices. The baseline to which these changes refer is the Copenhagen Controls for HCFCs for non-Article 5 Parties, Copenhagen Controls for HCFCs extended to Article 5 Parties with a ten-year grace period and a freeze on methyl bromide emissions at 1994 levels by both Article 5 and non-Article 5 Parties. The percentage change in EESC can be used to compare the advantage of each control scenario relative to the assumed baseline. (These percentage changes in EESC should not be confused with changes in ozone depletion in any given year.)

B. Methyl bromide scenarios

1. Methyl bromide non-Article 5 Party scenarios

(a) Methy bromide early-action scenario for non-Article 5 Parties

25% reduction by 1998, 50% reduction by 2001 in non-Article 5 Parties consumption

11. **SAP**: For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 4.1 to 5.7% decrease in the integrated EESC loading and hence total ozone depletion. (The range of values reflects different assumptions about the relative effectiveness of bromine compared to chlorine in ozone depletion.)

12. **TEAP:** The 1994 MBTOC estimated that by using known technology it is technically possible for non-Article 5 Parties to significantly reduce usage of methyl bromide. Estimates of the magnitude of the reduction and its time scale varied widely amongst 1994 MBTOC members. Opinions ranged from a reduction of 50% feasible by 1998, to decreases of only a few per cent by 2001.

13. Most of the 1994 MBTOC members accepted that a 25% reduction in use and emissions by 1998 and a 50% reduction by 2001 is technically feasible for non-Article 5 countries through choice of available alternatives, alternatives now at an advanced stage of development, and through improved application practices including recycling and better containment.

14. In some cases, ministries and other competent agencies will need to expedite registration of alternatives and substitutes, if reductions in methyl bromide use are to be achieved without interruption to particular areas of trade or crop production currently dependent on the chemical. International cooperation could speed these necessary efforts. Such cooperation is already effective for the phase-out of CFC, halon, 1,1,1-trichloroethane and carbon tetrachloride.

(b) Methyl bromide 2001 phase-out scenario for non-Article 5 Parties

Phase-out by 2001 in non-Article 5 Parties

15. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 7.8 to 10.9% decrease in the integrated EESC loading and hence total ozone depletion.

16. **TEAP:** While alternatives are available for the majority of current uses, the 1994 MBTOC did not identify technically feasible alternatives, either currently available or at an advanced stage of development, for less than 10% of 1991 methyl bromide use.

17. Among the 10% of current uses without alternatives or substitutes, there are many processes which would be recognized as quarantine or pre-shipment uses under the Protocol, according to the definitions in decision IV/11 of

the Fourth Meeting of the Parties to the Montreal Protocol. There are additional, specific, uses that are necessary as a result of local pest circumstances. Given the time required for adequate field tests, commercial development, and regulatory approval of alternatives and substitutes, 2001 appears to be the earliest technically and economically feasible date to schedule phase-out reductions beyond 50%.

18. A minority of MBTOC members estimate that it is technically feasible to phase out all methyl bromide uses by 2001, while another small minority of the Committee estimates that reductions of only a few per cent are possible by 2001.

2. Methyl bromide Article 5 Party scenarios

19. Developing countries currently use about 18% of the methyl bromide produced globally for agricultural and related uses. The main uses are for soil fumigation (about 70% of total) and disinfestation of durables (about 20%). Any schedule for reduction in methyl bromide use in Article 5 countries will need to take into account their special circumstances.

(a) Methyl bromide no-controls option for Article 5 Parties

Retain no controls and assume continuing growth in use at the current rate of about 7% per year.

20. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a >700% increase in the integrated EESC loading and hence total ozone depletion.

(b) Methyl bromide freeze scenario for Article 5 Parties

Freeze in 1996 at 1996 levels for Article 5 Parties

21. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 0.3 to 0.4% increase in the integrated EESC loading and hence total ozone depletion. (Note that the increase is relative to the assumed baseline of a 1994 freeze.)[1]

22. **TEAP:** For the most part, the same technologies that provide alternatives and substitutes to methyl bromide in developed countries are also technically suitable in developing countries. Therefore, it is

[1] The issues in setting methly bromide base years, grace periods, and exemptions for Article 5 countries are discussed in the 1994 TEAP report (pp. 47-48) in response to decision V/19 of the Fifth Meeting of the Parties.

technically feasible to halt the increase in use in Article 5 countries provided that technology, financing, and infrastructure are available.

23. A 1996 deadline for implementing such a freeze may well be administratively impossible in many Article 5 countries. This will be particularly so in those countries where consumption is rapidly expanding and there will be inadequate information on which to establish appropriate baselines, together with severe disruption to planned crop expansion until alternatives are established.

(c) Methyl bromide freeze and phase-out scenario for Article 5 Parties

Freeze at 1996 levels and phase-out by 2011 (2001 with ten-year lag)

24. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 1.3 to 1.8% decrease in the integrated EESC loading and hence total ozone depletion.

25. **TEAP:** If non-Article 5 Parties phase-out methyl bromide use by 2001, it is anticipated that a wide variety of substitutes and alternatives will have been commercialized by that time. In principle, ten years is sufficient time for Article 5 Parties to implement these same technologies provided there is access to new technology, infrastructure development, and financing. However, there may be some pest situations which are unique to Article 5 countries and therefore may not be solved by the research efforts of non-Article 5 countries. Uses for these potential applications could be approved under an essential use process.

(d) Methyl bromide early-action scenario for Article 5 Parties

Freeze at 1996 levels, 25% reduction by 2008, 50% reduction by 2011

26. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 0.5 to 0.7% decrease in the integrated EESC loading and hence total ozone depletion.

27. **TEAP:** This scenario is more economically feasible to implement in Article 5 countries than a complete phase-out (see discussion of the "freeze and phase-out" scenario). A 50% allowance would accommodate unusual pest situations and difficulties of building infrastructure.

C. Reductions in the HCFC cap and acceleration of the phase-out schedule

28. SAP calculated that if emissions of HCFCs were to be totally eliminated by the year 2004, then the integrated effective future chlorine loading above the 1980 level is predicted to be 5% less over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.

29. HCFCs remain critical for meeting the near-term CFC phase-out goals. Without additional controls, it is conceivable that Parties could use HCFCs

for applications where they are not technically necessary. However, there is little evidence of unnecessary HCFC use and many Parties have prohibited specific unnecessary uses. Therefore, there may be relatively little environmental advantage in further restrictions. TEAP and its TOCs were unable to evaluate the economic consequences to particular Parties. HCFCs are less important for new equipment available in the medium and long-term.

30. In considering further HCFC controls, the Parties may wish to bear in mind that:

(a) Numerous non-HCFC alternatives to CFCs, halons, 1,1,1-trichloroethane and carbon tetrachloride present their own environmental and human health risks. If HCFCs are not available, users may select more toxic chemicals, potent greenhouse gases such as perfluorinated compounds, or substitutes that are not energy efficient or do not have demonstrated long-term reliability.

(b) Some companies which demonstrated environmental leadership - with the encouragement of the Protocol, national governments, and non-governmental organizations - commercialized the supply and use of selected HCFC technologies long before they were proven or practical. Parties may wish to consider the advantages of halting final HCFC production after a time that allows reasonable recovery of the investment costs.

D. HCFC scenarios

1. HCFC non-Article 5 Party scenarios

31. The current formula prescribing the HCFC production cap in non-Article 5 Parties is 3.1% of the ODP-weighted CFC production in 1989 plus the 1989 HCFC production level. The phase-out schedule is: freeze at cap level in 1996, 35% reduction by 2004, 65% by 2010, 90% by 2015, 99.5% by 2020, and 100% by 2030.

(a) HCFC lowered-cap scenario for non-Article 5 Parties

Reduce HCFC cap in non-Article 5 countries from 3.1% to 2.5% of 1989 CFC use plus 1989 HCFC production

32. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 0.9% decrease in the integrated EESC loading and hence total ozone depletion.

33. **TEAP:** It is technically but perhaps not economically feasible in every non-Article 5 country to reduce the cap. The amount of reduction may vary significantly among non-Article 5 countries. It is difficult, however, to estimate the economic consequence at this time. Parties may wish to consider the alternative of further strengthening resolutions not to use HCFC where it is not necessary for CFC replacement.

34. The potential economic consequence of too little HCFC use to replace

important CFC uses is an increase in costs, abandonment of valuable installed HCFC-based equipment creating an incentive for some users to continue CFC use until a more permanent solution is found, and possible selection of chemicals that are hazardous to workers or environmentally less acceptable. In addition, HCFC shortages may result in an undesirable increase in existing illegal CFC imports.

(b) HCFC accelerated-final-step scenario for non-Article 5 Parties

Retain HCFC cap in non-Article 5 countries at 3.1%; accelerate HCFC phase-out on the following schedule: 35% by 2004 (unchanged); 65% by 2010 (unchanged); 100% by 2015 (accelerated)

35. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 0.3% decrease in the integrated EESC loading and hence total ozone depletion.

36. **TEAP:** It is technically but perhaps not economically feasible to completely phase-out by 2015 because HCFC will still be necessary to service HCFC-based refrigeration and air-conditioning equipment with a useful lifetime beyond 2015.

(c) HCFC accelerated-step and reduced-cap scenario for non-Article 5 Parties

Reduce HCFC cap in non-Article 5 Parties from 3.1% to 2.5% of reference level and accelerate HCFC phase-out to 2015: 35% by 2004; 65% by 2010; 100% by 2015

37. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 1.1% decrease in the integrated EESC loading and hence total ozone depletion.

38. **TEAP:** It is technically feasible to reduce the cap, but the amount of reduction may vary significantly among non-Article 5 Parties. It is not economically feasible to phase-out by 2015 for the reasons stated above.

2. HCFC Article 5 Party scenarios

39. If Article 5 countries are adequately funded and technically assisted, HCFC use could be limited and then eliminated more quickly in these countries. Article 5 Parties still enjoy the benefit of the grace period which is allowing a choice based on a wider selection of alternatives and with more complete information than was available when enterprises in developed countries faced more rapid phase-out. In many cases developing countries can avoid investments in HCFC technology that was at one time considered to be the best choice but has now been, or will soon be rendered unnecessary by newer and more environmentally acceptable technologies.

(a) HCFC grace-period, baseline scenario for Article 5 Parties

Phase-out with ten-year lag from current non-Article 5 Party schedule (with a 1998 base level; 3.1% cap): freeze by 2006 at 1998 levels, 35% reduction by 2014, 65% by 2020, 90% by 2025, 99.5% by 2030, and 100% by 2040

40. **SAP:** This is the baseline scenario.

41. **TEAP:** With adequate financing, it is technically feasible to phase-out HCFC production 10 years after the current schedule for non-Article 5 countries. The total cost of phase-out will be considerably less if Article 5 countries minimize HCFC production and consumption by avoiding HCFCs when other alternatives and substitutes are available. Because investment in HCFC refrigeration and air-conditioning equipment will become unnecessary by 2010, it will be possible to phase-out as early as 2035.

(b) HCFC no-controls scenario for Article 5 Parties

Retain no controls and assume continuing growth in use at the current rate of about 7% per year

42. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 208% increase in the integrated EESC loading and hence total ozone depletion.

43. **TEAP:** Without controls, it is likely that Article 5 countries would increase HCFC use as substitutes for controlled ODSs and in some applications where use of HCFCs is not technically necessary but where HCFCs have a cost advantage. This use would eventually decline when other substances are commercialized and implemented in non-Article 5 countries and the HCFCs become obsolete and unwanted, and particularly if some individual countries were to restrict imports of products made with or containing HCFCs.

(c) HCFC freeze scenario for Article 5 Parties

Freeze use at 1998 levels

44. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 0.05% decrease in the integrated EESC loading and hence total ozone depletion.

45. **TEAP**: It is not technically or economically feasible to freeze HCFC production at 1998 levels for Article 5 countries because HCFC refrigeration, air-conditioning, and insulating foam uses are expected to increase at least until 2000 and new substitutes for these uses will not be fully commercialized and globally available in adequate quantities at that time. During this period it is technically and economically feasible to minimize HCFC production by emphasizing available alternatives such as hydrocarbons and HFCs.

(d) HCFC grace-period/low-cap scenario for Article 5 Parties

Phase-out with ten-year lag from non-Article 5 Party schedule but with 2.5% cap (with 1998 base level), freeze by 2006 at 1998 levels, 35% reduction by 2014, 65% by 2020, 90% by 2025, 99.5% by 2030, and 100% by 2040

46. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 0.13% decrease in the integrated EESC loading and hence total ozone depletion.

47. **TEAP:** It is technically and economically feasible and ultimately more economic to limit production with a 2.5% cap because adequate HCFC supplies would be available for necessary uses but the limit would discourage dumping of obsolete equipment in Article 5 countries and would discourage over-marketing of HCFCs for unnecessary emissive uses such as solvent cleaning, aerosol products, and non-insulating foams.

(e) HCFC accelerated-final-step/grace-period/high-cap scenario for Article 5 Parties

Retain HCFC cap in non-Article 5 Parties at 3.1%; accelerate HCFC phase-out on the following schedule: 35% by 2014, 65% by 2020, and 100% by 2025

48. **SAP:** For this case, the methods of the 1994 scientific assessment of ozone depletion yield a 0.02% decrease in the integrated EESC loading and hence total ozone depletion.

49. **TEAP**: It is technically and economically feasible to reduce production for Article 5 countries to 65% of base-year production by 2020 but it is not economically feasible to phase out entirely by 2025 because it is expected that economically valuable refrigeration and air-conditioning equipment existing at that time will still require small amounts of HCFC until at least 2035. No more than 5% of base-year production is necessary after 2025.
