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REPORT ON EMISSION REDUCTIONS AND PHASE-OUT OF CTC (DECISION 55/45)

1. In decision 55/45, taken at its 55th Meeting, the Executive Committee requested the Secretariat to provide a report to the 58th Meeting of the Executive Committee on emission reductions and phase-out of CTC in Article 5 and non-Article 5 countries. The report was to take into account the information to be provided by the Technology and Economic Assessment Panel (TEAP) in response to decision XVIII/10 of the Eighteenth Meeting of the Parties. The TEAP provided an verbal report to the Twentieth Meeting of the Parties concluding that the rapid decrease in model-estimated bottom-up emissions (i.e. based on information from industry and Article 7 data) is significantly lower than emissions derived from atmospheric measurements for the range of scientifically determined atmospheric lifetimes. The report provided by TEAP speculated that the decrease in emissions from controlled uses seems to be compensated by a rapidly growing new source. It pointed out that more work needs to be done, providing the example of the need to explore high growth products such as HCFC-22 and its consequences for CTC co-production when producing feedstock for HCFC-22.

2. After discussions with several experts as well as proponents of decision 55/45 of the Executive Committee, the Secretariat interpreted the mandate of the Executive Committee to be to seek a better understanding of emissions, possible limits of reporting, accuracy of predictions and modelling, and other issues which might play a role in the consolidation of the results from atmospheric measurements and of emissions data derived from reported levels of consumption. The resulting report is entitled “Emissions of CTC in Article 5 and non-Article 5 countries” and is provided as an Annex to the present document.

3. To fulfil this mandate the Secretariat initiated exchanges and discussions with the co-chairs of TEAP, the chair of the Chemicals Technical Options Committee, members of the Science Assessment Panel (SAP) and relevant experts and stakeholders in the scientific and industrial communities. These activities included a telephone conference with scientific experts associated with the SAP, the commissioning of a study on production and industrial emissions of CTC, and a two-day workshop on industrial emissions. A web-site for document and information exchange within the scientific community was also established.

4. Within the same time frame the Secretariat also prepared an updated report for the 57^{th} Meeting of the Executive Committee on the progress made in reducing emissions of controlled substances from process-agent uses as required by decision XVII/6 of the Parties. This report was subsequently transmitted for consideration at the 29th Meeting of the Open-ended Working Group (document UNEP/OzL.Pro.WG.1/29/4). The main findings of the report to the OEWG have been incorporated into the present report.

5. The approach taken to fulfilling the mandate in decision 55/45 was to seek information from relevant experts on the comprehensiveness and accuracy or otherwise of data and on recent developments in both atmospheric science and in the chemical industry, with specific reference to the possibility of sources for yet-unrecognised or underestimated emissions. The resulting report consequently summarises information about the status of atmospheric science in regard to CTC, the likeliness for natural sources of CTC and the probability of significant emissions of industrially produced CTC beyond the information currently available. In order to do so, data reported under Article 7 was examined as well as issues arising from CTC uses not controlled under the Montreal Protocol, compared to controlled (solvent and process agent) use.

6. CTC occupies a unique place in the management regime for ozone depleting substance adopted under the Montreal Protocol, since the majority of CTC produced has always been used as a feedstock, i.e. a non-controlled use. This non-controlled use will continue in significant quantities well beyond the phase-out date for CTC in 2010. A somewhat similar situation can be expected for HCFC-22 in the future, making an investigation into the causes for the data discrepancies even more relevant.

7. Atmospheric data on CTC concentrations can be transformed into emission estimates using a model that takes into account the atmospheric lifetime of CTC, previous emissions, and atmospheric science. Recent scientific studies have given rise to different, and in some cases significantly higher, regional emissions estimates than those contained in the 2006 SAP report. These new estimates are consistent with the global total in the SAP report, but are substantially in excess of both reported and estimated industrial emissions at national and global levels. Additional regional data collection and analysis would assist in increasing the level of certainty about the accuracy and completeness of regional and global emissions estimates from atmospheric measurements.

8. Nonetheless, there was a consensus among the scientific experts consulted by the Secretariat about the relative accuracy of the scientific model and the absence of significant natural sources of CTC. The implication from the scientific perspective is that emissions additional to those arising from controlled uses reported under Article 7 of the Protocol would most probably be related to as-yet uncategorised uses or losses in chemical processes.

9. Despite a high level of uncertainty about the completeness of CTC data reported under Article 7 of the Montreal Protocol in earlier years, recent production and consumption data when combined with un-published information on feedstock quantities is broadly consistent with information from industry sources and the data on production, feedstock and consumption show clear convergence.

10. The report at Annex I strived to look at all co- and by-production of CTC which might amount to a significant scale. While there cannot be absolute certainty, it seems likely that all major sources of CTC production or by-production and emissions have been taken into account in this exercise. It would be surprising if those which might have been overlooked would amount to more than 1per cent of the difference between the various emission estimates as presented by TEAP.

11. CTC has an intrinsic minimum value arising from the value of the chlorine it contains. Provided certain quantities of CTC are available annually, destruction facilities that process a variety of chlorinated hydrocarbons into hydrochloride acid can be financially viable, although not very profitable and somewhat capital intensive.

12. The use of chloroform as feedstock for HCFC-22 production is presently the most significant cause for CTC co-production; this co-production can be minimised, but not reduced to zero. However, it should be noted that in 2007 CTC was intentionally produced globally for feedstock applications beyond the minimum co-production from chloroform production. This suggests that for the year 2007 and earlier years, intentional release of large quantities of CTC would have been economically not meaningful. It should be noted that in the future, further increases in HCFC-22 production might change this situation.

13. An initial assessment has been made of transport and storage losses, which in total are significant. Because of the dispersed nature of these losses, investments in reducing them yield a much lower return than the destruction described in the previous paragraph. The initial, order-of-magnitude estimate for such emissions is 7,500 ODP tonnes globally per year. A closer investigation of such losses and ways to address them could be an integral part of a more extensive, systematic study of CTC emissions.

14. Given the definitions of feedstock and process agents arising from relevant decisions of the Parties, it appears possible that some uses of CTC classified as feedstock may have a process agent component. This component could give rise to emissions which are not *de-minimis* and which could be significant. Additionally, the quantity of CTC consumed in controlled uses as a process agent (other controlled uses are now reduced to insignificant levels) is typically determined by deducting the feedstock amount from the total level of production. This might lead to a significant error in the determination of consumption for controlled use arising from only minor errors in recording of the base production or the feedstock data. The introduction of licensing systems for all CTC production, with appropriate enforcement, as already introduced in a number of countries, might reduce this uncertainty.

15. Possible emissions from industrial waste could not be quantified at this stage. Anecdotal evidence pointed to ad-hoc disposal of wastes containing chlorine by many industries for over half a century until even less than 20 years ago. Emissions from these sites might have some significance, but would require additional investigation.

16. Based on the above investigations, and even when using CTC emissions estimates at the top of the relevant uncertainty range, an explanation for the discrepancy between atmospheric and industrial use data that assumed to result from previously unreported industrial emissions remains elusive.

17. Further investigation of the overall data discrepancy will require, on the one hand, a more detailed and systematic assessment of losses or unintended emissions from all industrial sources and, concurrently, development and implementation of a programme for the collection and analysis of additional data on concentrations of CTC in the lower atmosphere. The North American region is of particular interest given the apparent discrepancies in regional emissions estimates in different atmospheric studies as well as between those and industry-based estimates. In addition, North America has the potential for accurate data collection because of the capacity for monitoring of emissions.

18. Should the Executive Committee wish the Fund Secretariat to undertake further work on this matter, activities related to the quantification of losses including site visits in key Article 5 countries, further investigation of the economics of feedstock use and destruction, establishment and constant updating of an emission model from industry data, and support in information exchange among the different entities involved may be needed. Such activities would require separate funding for the Secretariat.

Recommendation

19. The Executive Committee might wish to:

(a) Note the report on emissions of CTC in Article 5 and non-Article 5 countries contained in Annex I to document UNEP/OzL.Pro/ExCom/58/50;

(b) To draw the report to the attention of relevant bodies, in particular the Scientific Assessment Panel and the Technology and Economic Assessment Panel;

(c) Consider whether it wishes to:

(i) Request the Secretariat to continue its work towards a resolution of the discrepancy between estimates of CTC emissions arising from atmospheric data and those arising from reported Article 7 data and industry estimates;

(ii) Approve a total funding of US $100,000 for that purpose for the years 2009 and 2010; and

(iii) Establish a small steering group of four members to be convened via telephone and e-mail to decide on the specific activities to be undertaken by the Secretariat; and

(d) Request a report on the activities undertaken and results achieved for the 61st Meeting of the Executive Committee.

Annex I

Emissions of CTC in Article 5 and non-Article 5 countries

I. Introduction

Mandate

1. In decision 55/45, taken at its 55th Meeting, the Executive Committee requested the Secretariat to provide a report to the 58th Meeting of the Executive Committee on emission reductions and phase-out of CTC in Article 5 and non-Article 5 countries. The report was to be in accordance with all relevant decisions of both the Meetings of the Parties and the Executive Committee and was to take into account the information to be provided by TEAP in response to decision XVIII/10 of the Eighteenth Meeting of the Parties, as well as any decisions taken at the Twentieth Meeting on additional process agent uses. This paper has been prepared in response to the request in decision 55/45.

2. At the Twentieth Meeting of the Parties the TEAP presented an update of the findings of the TEAP 2008 task force on CTC emissions in which it concluded that:

(a) The rapid decrease in model-estimated bottom-up emissions is significantly lower than emissions derived from atmospheric measurements for the range of scientifically determined atmospheric lifetimes;

(b) The decrease in emissions from controlled uses seems to be compensated by a rapidly growing new source; and

(c) More work needs to be done, i.e., explore high growth products such as HCFC-22, which may require co-production of CTC with chloroform.

3. The information provided in the TEAP update indicated that the discrepancy or ‘gap’ between the scientific assessment of emissions and those able to be predicted through quantities reported as being used and emitted exceeds 40,000 ODP tonnes per year. With this in mind, the primary focus of this report and the work on which it is based has been to delineate, understand and, where possible, corroborate the information from which the “top-down” (i.e. atmospheric scientific based) and “bottom-up” (i.e. use based) assessments were derived. Efforts were also made to identify any data discrepancies, omissions or other additional factors that might lead to major readjustment of one or both of the emissions estimates. Finally the report seeks to outline options for further study, with a view to making an effective contribution to resolving the CTC emissions discrepancy at the earliest opportunity.

4. At the 57th Meeting the Secretariat presented the draft of a report to the 29th Meeting of the Open Ended Working Group (OEWG) on the progress made in reducing emissions of controlled substances from process-agent uses for the period 2007–2008 (Document UNEP/OzL.Pro/ExCom/57/Inf.2). The current report makes use of the information provided in the draft OEWG report but does not cover the same ground or reproduce the information in detail.

General approach

5. There are three main data sets containing primary information relevant to CTC emissions. They are: measurements of CTC concentrations in the atmosphere, largely in the lower atmosphere (troposphere) with some supporting measurements in the upper atmosphere (lower stratosphere); reports on national CTC consumption provided under Article 7 of the Montreal Protocol, and; reports of

industrial production and use, available from industry sources and also contained in project data provided to the Secretariat by countries and implementing agencies.

6. Atmospheric data was not compiled directly by the Secretariat, since the interpretation of such data is highly specialized. Rather, discussions were held with a limited number of relevant scientific experts to provide insights into the comprehensiveness or otherwise of data coverage, the reliability of its conversion into emissions estimates, including the issue of atmospheric lifetime, and the existence of gaps or additional information that would have a bearing on emissions estimates.

7. A brief assessment of data reported under Article 7 of the Protocol was conducted by the Secretariat. The assessment included a review of the definitions of production, consumption, feedstock, process agent use and the relevant reporting conventions as well as an analysis of the consistency or otherwise of the year-by-year data in respect to its usefulness as a sole basis for CTC emission estimates.

8. An industrial production study was commissioned by the Secretariat to update the primary data available on CTC production and use, as well as the estimate of emissions from all industrial sources. The study took into account the information in the draft of the report "Global assessment of CTC phase-out in the chlor-alkali sector" presented to the 55th Meeting of the Executive Committee. The study also examined consumption and production data resulting from reports by countries under Article 7.

9. The information from the above data sets was discussed with relevant experts in an international teleconference with atmospheric scientists held on 2 June 2009 and in a two-day expert meeting with industry experts held in the Secretariat offices on 10 and 11 June 2009. As an additional tool, a website was established for document exchange among participants of the teleconference. Participants in each conference and their affiliations are presented in Annexes A and B. Emphasis was placed on identifying factors that could potentially give rise to significant errors in estimates of either atmospheric or industrial emissions and to identifying measures that could be taken to fill in any gaps in data coverage, resolve mismatches or to re-examine relevant assumptions in emissions calculations, with a view to quantifying opportunities and costs for further work.

II. Data sets

Atmospheric data

10. The atmospheric concentration of CTC is measured at heights varying from the stratosphere (occasionally) to near ground level (quasi-continuously). Lower level (tropospheric) measurements are available from both fixed measuring stations and from the once-off sampling of air at specific locations or along specific transport routes (for example railways). Tropospheric and stratospheric data is strongly interlinked and both data sets were integrated into the findings of the 2006 Scientific Assessment Panel (SAP) in their “Scientific Assessment of Ozone Depletion: 2006” report, in which it was estimated that global emissions of CTC in 2004 totalled some 70,000 metric tonnes (77,000 ODP tonnes).

11. Estimates of emissions such as those provided by the SAP are calculated from atmospheric CTC concentrations, based on, among other things, the estimated atmospheric lifetime of CTC. The atmospheric experts canvassed by the Secretariat were not aware of any new data that might suggest changing the CTC atmospheric lifetime from the current 26 years, taking into account the significant uncertainty in this lifetime (15-30 years), while noting that atmospheric lifetimes will be revisited in the 2010 SAP report. Presently, there is no indication that this will lead to a revision of the atmospheric lifetime.

12. Tropospheric measurements can provide an indication of the location of emissions by region, provided a sufficiently comprehensive set of measurements is available. Measurements, either sporadic or quasi-continuous, have been made in many but not all the major global regions.

13. A recent analysis of atmospheric data has provided regional emissions estimates averaged for 1996-2004 (Xiao and Prinn, 2008) as indicated in the following table :

Table 1 - Regional emissions estimates averaged for 1996-2004

Region	Emission estimates (tonnes/yr) (from atmospheric measurements)
South East Asia and China	39,000±6000 (±15%)
North America	20,000±3000 (±15%)
Europe	8,500±4000 (±45%)
North West & South Asia	7,500±3500 (±50%)
Australia	2,500±1000 (40%)
Africa	2000±1000 (±50%)
South America	500±250 (±50%)
Global	80,000±8,000 (10%)

14. According to these estimates, emissions in the European Union (EU) and North America are decreasing, those in Asia are increasing and the global sum is steady. Indications from once-off measurements taken across the Russian Federation in East-West direction on the approximate latitude of Moscow suggest there are relatively few emissions in that region (around 1,600 tonnes per annum); it is unknown if there was sufficient coverage to include possible emissions from the chloro-chemical manufacture sites concentrated mostly in the south of the country.

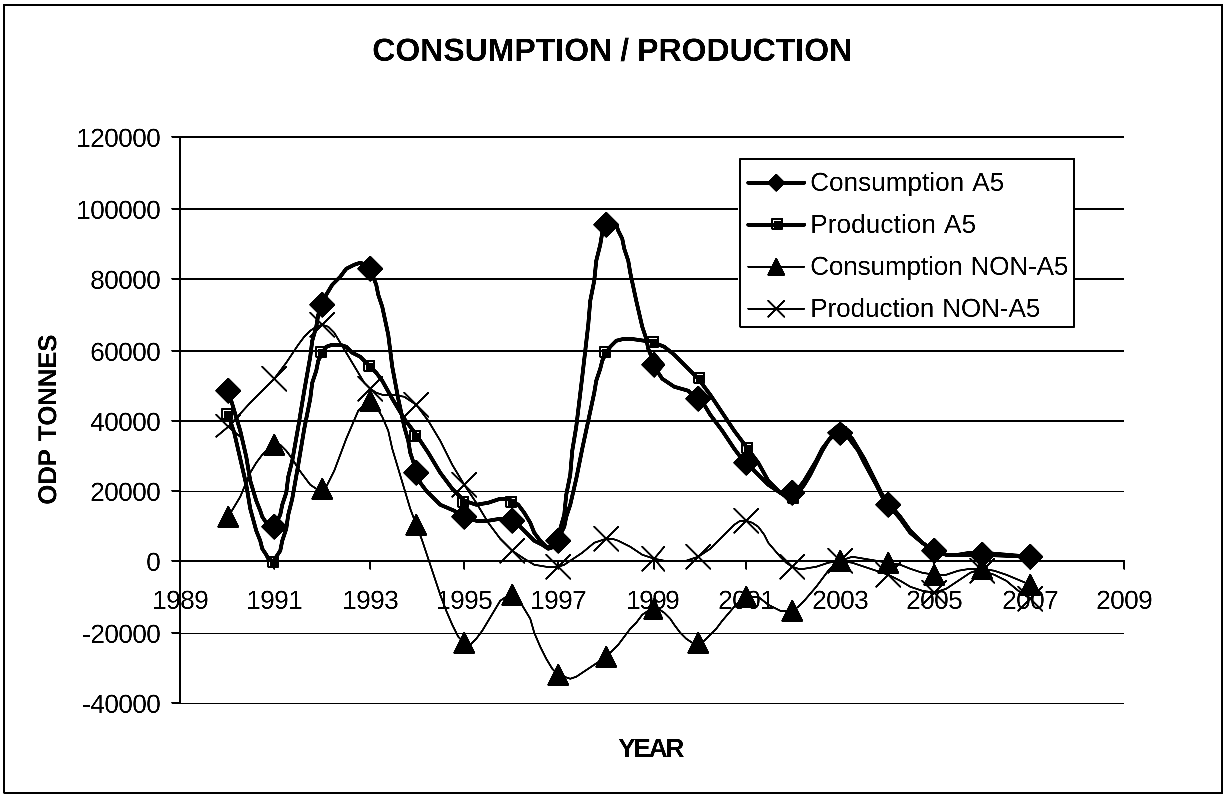
15. The estimates and information provided in the above paragraphs essentially emanated from the international telephone conference with atmospheric science experts convened by the Secretariat on 2 June 2009. During this telephone conference, a number of additional issues were discussed. In regard to the adequacy of global coverage, it was indicated that there is little tropospheric data available for the Indian sub-continent region. An existing measurement site in the Maldives may be able to assist and a joint Australian/India programme on the east coast of India (at Cape Rama) could potentially undertake a measuring programme. Given the currently estimated levels of emissions for South East Asia and China additional measurements would be valuable in reducing the level of uncertainty of estimates. Existing atmospheric monitoring stations in Japan, the Republic of Korea and China are well placed and may be sources of data to improve the precision and accuracy of these estimates. Measurements in the Russian Federation were taken in the context of two studies conducted on the trans-Siberian railway. Equipment for sporadic measurements (flasks) and for semi-continuous measurements cost around US $10,000 and US $50,000 - 400,000 respectively.

Article 7 data

16. Under Article 7 of the Protocol, Parties have been obliged to report annually on their production and consumption of CTC since the entry into force of the London Amendment in August 1992. The figures required to be reported are those corresponding to the Protocol definitions of production and consumption and do not necessarily represent total production of CTC in a country or total use in that country. One of the most significant factors influencing data accuracy has been the reporting of, and accounting for, feedstock, which is not a controlled use but which has always been the major use of CTC in industry worldwide. To assist in clarifying the necessary reporting methodology and to reduce reporting errors the Parties approved data reporting forms with corresponding explanatory notes at their Ninth Meeting in 1997 (decision IX/28).

17. Additionally, and with particular relevance to CTC reporting, in decision X/14 the Parties introduced process agents as controlled substances. Subsequent decisions extended the definitions of individual process agent applications and thus transferred the use of CTC for those applications from an uncontrolled (feedstock) use to a controlled use, thus further complicating the objective of accurate and meaningful reporting, and the comparison of submissions from different years. The graph 1 hereunder presents the reported production and consumption data in Article 5 and non-Article 5 countries respectively between 1990 and 2007.

Graph 1 - Reported production and consumption between 1990 and 2007



18. Whereas production figures for Article 5 countries largely correspond to the consumption figures since 2002, for non-Article 5 the discrepancy between the two remains. Non-Article 5 countries also show negative figures both for production and consumption in 2004-2007. This is specifically the case for several EC member-states; the European Commission informed the Fund Secretariat that this is due to the fact that most uses have been phased out already and recovery and destruction is taking place on a large scale. Despite the figures for some countries (both Article 5 and non-Article 5) indicating possible reporting issues, the overall, global Article 7 production and consumption data indicates a clear trend towards complete phase-out in 2010.

19. In regard to emissions, it can be inferred that consumption of CTC as defined in the Protocol is equivalent to emissions into the atmosphere. However, this is not absolutely correct, and the error is not insignificant for CTC given the high quantities used in total (in particular as feedstock) and the low quantities consumed. Consumption in non-Article 5 countries essentially ceased in 1996. Consumption in Article 5 countries is either for open solvent use, which is short-term emissive save for small amounts in waste streams that might be incinerated, or use as a process agent, It has been commonly understood that any make-up quantities, that is, consumption, in process agent uses in Article 5 countries is equivalent to the quantities emitted.

Industrial production and use data

20. It goes without saying that CTC cannot be emitted unless it is first produced. Most of the CTC produced is used as a chemical intermediate – a feedstock – in the manufacture of other chemicals and apart from inadvertent losses is totally consumed. CTC is produced inescapably in all chemical plants that process chloromethanes ($CCLH_3$, CCL_2H_2, CCL_3H, CCL_4 = CTC). While the operating conditions can be varied to minimize CTC, the minimum level of CTC is in the order of 8per cent of the amount of chloroform, CCL_3H, produced in the process and the maximum around 12 per cent; some plants, in particular in India, tend towards the higher rate of CTC co-production.

21. Currently much of the methyl chloride production is for silicone manufacture and methylene chloride is used in pharmaceuticals and as a paint stripper. However the main use for chloromethanes is the production of chloroform which itself is the feedstock for the production of HCFC-22. HCFC-22 is not only used as refrigerant in air conditioning applications, but also as an important feedstock for the production of polytetrafluoroethylene (PTFE). The mass balance between HCFC-22 and chloroform as the feedstock is approximately 1:1.47, which leads to a co-production of some 0.12 to 0.15 metric tonnes of CTC for each metric tonne of HCFC-22 produced. Table 2 below provides the reported Article 7 data for HCFC-22 production for feedstock uses and controlled uses in the last three years, divided between non-Article 5 countries and Article 5 countries. It should be noted that there were strong suggestions related to global data on chloroform production that the global HCFC-22 production figures should be not higher than about 720,000 metric tonnes, i.e. more than 20 per cent lower than they are according to Article 7 data; this would lead to a proportional reduction in minimum CTC co-production.

Table 2 - HCFC-22 production and minimum co-production of CTC from production of chloroform for HCFC-22 feedstock use

Year	HCFC-22 production							Calculated minimum CTC co-production [metric tonnes]
	Non-Article 5 countries		Article 5 countries		Global			
	Production for non-feedstock [metric tonnes]	Production for feedstock [metric tonnes]	Production for non-feedstock [metric tonnes]	Production for feedstock [metric tonnes]	Production for non-feedstock [metric tonnes]	Production for feedstock [metric tonnes]	Total production [metric tonnes]	
2005	231,606	228,437	271,964	78,343	503,570	306,780	810,350	95,297
2006	148,209	265,749	313,434	91,311	461,643	357,060	818,703	96,279
2007	186,193	268,937	361,795	109,534	547,988	378,471	926,459	108,952

22. This would indicate that in 2007, as a minimum 109,000 metric tonnes (119,800 ODP tonnes) of CTC would have been co-produced. The trend of continuously increasing HCFC-22 production as demonstrated above might slow in future years, and a one-time reduction effect due to the phase-out from some refrigerant use in 2010 in some regions might be experienced; but it seems unlikely that the general growth trend will reverse in the next five years. It can be assumed that increases in the production for feedstock will compensate any possible near-future reductions in production for consumption as refrigerants. The associated CTC production will have to be absorbed by the different feedstock applications or destroyed, leaving HCl as a valuable end-product of the destruction.

23. CTC can also be co-produced in plants that manufacture perchlorethylene. However operating conditions in these plants can typically be varied so that excess CTC is recycled into the process. This occurs today in most plants as a means of consuming CTC, including the CTC co-produced with chloroform for HCFC 22 manufacture, except in those cases where CTC is specifically required as a feedstock. Consequently, the production of perchlorethylene can both serve as a source as well as as a sink of CTC, depending on the operation conditions. While a zero production of CTC or use as feedstock

for this application might not be as economical as producing CTC as a side product and using it for feedstock, it is more economical than emitting the CTC or even destroying it.

24. The findings of the report on industrial production of CTC indicate that for the years 2006 to 2008, total average global CTC production was approximately 206,800 ODP tonnes (188,000 metric tonnes) per year, most of which is being consumed as a feedstock for production of non-ODS chemicals, including chloroform as indicated above. To discrepancies between industry and Article 7 data see below paragraph 30. The industry data was segregated by main uses as indicated in the Table 3 below.

Table 3 - Industry data regarding CTC production and use for feedstock applications

ODP tonnes 000's	Average production 2006-2008	To PCE	To HFCs	To CFCs	To specialty chemicals (incl. DVAC)	To destruction	To process agent/solvent	To export
Non-article 5	132	26.4	40.7	5.5	6.6	28.6	7.7	16.5
Article 5	74.8	13.2	2.2	7.7	48.4	1.1	8.8	-5.5
Total	206.8	39.6	42.9	13.2	55	29.7	16.5	11

25. The significant use in Article 5 countries for specialty chemicals includes an estimated 15,000-16,000 ODP tonnes in India as a feedstock for DVAC. Most of the remaining quantity is used in China for conversion to methyl chloride and, starting only very recently but increasing rapidly, for production of DVAC in China. The overall market for CTC is changing rapidly in India and China, driven by the reduction of CTC use for CFC feedstock, the new production of DVAC being the most obvious example. Consequently, this three year averaged breakdown cannot be taken as an indicator of historic use levels and can be expected to continue to change in future years. The quantities exported do not necessarily imply emissive uses. Most exports are in bulk for feedstock use in countries other than the country of manufacture.

26. Turning to CTC as a by-product in waste streams, by far the largest and most significant source of CTC occurs in vinyl production plants. Total global production of vinyl chloride monomer (VCM) was around 37 million tonnes in 2008. The production process yields around 2.5 per cent of by-products of which CTC may be assumed to be about 5 per cent. This gives a theoretical estimate of around 37,000 metric tonnes of CTC by-product annually. However, in virtually all producing regions vinyl plants incorporate an incineration unit that destroys all wastes including the CTC contained therein; such plants recover the chlorine from the CTC and other chlorinated substances in the waste stream as hydrochloric acid for re-use in the production process. It is believed that the incineration is generating a surplus in revenue as compared to e.g. emission due to the inherent value of the chlorine, provided sufficient quantities are being incinerated.

27. As indicated in paragraph 22 above, the minimum co-production of CTC when producing chloroform for HCFC-22 production was 109,000 metric tonnes (119,800 ODP tonnes). It should be noted that as per paragraph 24 the amount of CTC used as feedstock is in comparison significantly larger, at 160,000 metric tonnes of CTC, than the minimum production. If one discounts the use of CTC as feedstock for CFC production, the remaining feedstock application in 2007 was 147,400 metric tonnes of CTC. This is still a reasonable difference to the minimum co-production of CTC, although this difference might shrink in the future depending on trends in HCFC-22 production for controlled and non-controlled uses.

28. CTC also has the potential to be produced as a by-product arising from the use of chloroform as process agent in the production of chlorine. However the likely total volume of chloroform is expected not to exceed 1000 tonnes annually giving rise to no more than 11 per cent or 110 tonnes of CTC, most or all of which is incinerated.

29. By-production of CTC might also take place in a number of chlorination processes. As the most likely candidates, the chlorination of methane, ethane, propane and butane was considered. The discussion during the expert meeting looked into a number of processes in addition to the production of chloromethanes, polyvinylchloride and perchlorethylene discussed separately. It is assumed, although not certain, that the major processes which might lead to a significant by-production of CTC are included in the following list:

(a) For ethane: The only, but very significant, candidates in this group appear to be perchlorethylene and Ethylene Dichloride, which is a feedstock for the production of Polyvinylchloride, PVC. Both are discussed separately.

(b) For propane: There seem to be two processes with propane derivatives which might involve the by-production of CTC:

(i) Propylene oxide is an organic compound which is produced on a large scale industrially, its major application being its use for the production of polyether polyols for use in making polyurethane plastics; the production of this chemical is globally estimated to be in the order of 7.5 to 8 million tonnes, of which potentially 40 per cent are produced through the chlorohydrin route where a possible by-production of CTC might occur; however, quantities produced and emitted were assumed to be insignificant and some known cases of waste stream analysis confirm this.

(ii) Epichlorohydrin is an organochlorine compound and an epoxide. It is a highly reactive compound and is used in the production of glycerol, plastics, and elastomers, with a production volume in the order of 1,300,000 tonnes annually. Epichlorohydrin is historically manufactured from allyl chloride, and might have a by-production of CTC leading to 3-4 per cent of CTC in the waste stream. While the percentage of CTC by-production is relatively high, the main producers identified to be in Western Europe, Japan, Taiwan and the United States incinerate it for chlorine recovery. This might lead to a by-production of about 1000 metric tonnes per year, which is assumed to be incinerated almost completely.

(c) From butane: 2-chloro-1,3-butadiene is the monomer for the production of the polymer polychloroprene, a type of synthetic rubber. Polychloroprene is better known to the public as Chloroprene, the trade name given by DuPont. In 2008, approximately 400,000 tonnes were produced, mainly in USA and Japan. It is not believed that the possible by-production of CTC leads to any significant emissions.

Correlation between Article 7 and industrial data sets

30. The degree of correlation between atmospheric and Article 7 as well as industrial data is currently low and, indeed, is the reason for preparation of this report. Given the appearance that inconsistencies exist between CTC production and consumption quantities reported under Article 7, the level of correlation between Article 7 data and industrial use data is of particular interest. As can be seen from the Table 4 below, aggregated Article 7 data appears fairly consistent in itself when data for feedstock use is added to Protocol production data. However, as mentioned in paragraph 18 above, the production data from Western Europe appears to suggest a lower production than is actually the case; this is due to the large amount of destruction undertaken in particular in the EC. The industry data is remarkably consistent with Article 7 data taking into account the mentioned high level of destruction in Western Europe; it should be noted that at the time of preparation of the industry study, feedstock data reported under

Article 7 had not been available. This assists in establishing the validity of the total production figures from both data sets.

Table 4 - CTC production (ODP tonnes), comparison of industry data (total production) and Article 7 data (including production for feedstock, excluding destruction)

Country	2005		2006		2007	
By article	Industry	Article 7 (incl. feedstock)	Industry	Article 7 (incl. feedstock)	Industry	Article 7 (incl. feedstock)
Non-article 5	132,000	88,939	130,900	95,651	123,200	90,817
Article 5	73,150	71,501	75,350	65,605	67,650	60,563
Total	**205,150**	**160,440**	**206,250**	**161,256**	**190,850**	**151,380**
By region	Industry	Article 7 (incl. feedstock)	Industry	Article 7 (incl. feedstock)	Industry	Article 7 (incl. feedstock)
Western Europe	62,700	8,943	58,300	16,763	49,500	13,455
Eastern Europe	3,300	1,262	3,300	2,145	4,400	1,372
North America	55,000	61,897	60,500	60,135	60,500	63,266
Asia	84,150	88,338	84,150	82,213	76,450	73,287
Total	**205,150**	**160,440**	**206,250**	**161,256**	**190,850**	**151,380**

III. Emissions

Emissive uses

31. By definition, there are no longer any emissive uses of CTC in non-Article 5 countries. There are two minor exceptions. Firstly, essential uses, for which only very minor exemptions were approved by the Fifteenth Meeting of the Parties. Secondly, there are de-minimis emissions from applications that constitute process agent use in non-Article 5 countries, but for which emission control technologies have reduced CTC emissions to levels consistent with those identified in Table B of decision X/14 of the Parties as indicated below. According to the following Table 5, the maximum amount of CTC emitted by all non-Article 5 countries is not to exceed some 243 ODP tonnes per year.

Table 5 - Emission limits for process agent uses as per decision X/14

Country/region	Make-up or consumption*	Maximum emissions*
European Community	1,000	17
United States of America	2,300	181
Canada	13	0
Japan	300	5
Hungary	15	0
Poland	68	0.5
Russian Federation	800	17
Australia	0	0
Czech Republic	0	0
Estonia	0	0
Lithuania	0	0
Slovakia	0	0

Country/region	Make-up or consumption*	Maximum emissions*
New Zealand	0	0
Norway	0	0
Iceland	0	0
Switzerland	5	0.4
Total	4,501	220.9 (4.9%)

*All figures are in metric tonnes per year

32. The total non-Article 5 emissions limit is the sum of national emissions limits provided by governments in the context of formulation and adoption of decision X/14 in 1998. No information is available as to its technical basis and whether or not it has since been verified or updated at a national level. However using the broad estimate in the industry study of the total of process agent uses in non-Article 5 countries, namely 7,700 ODP tonnes, and the average percentage emissions loss of 4.9 per cent indicated in Table B, total losses from process agent uses in non-Article 5 countries averaged for the years 2006-2008 would be some 377 ODP tonnes. While this is 55 per cent greater than the total in Table B, it remains insignificant in the context of the overall data discrepancy.

33. According to Article 7 data, total consumption in non-Article 5 countries, as defined under the Protocol, has been negative since 2004. This is largely because of the reporting of substantial negative consumption by the European Union, which may result from challenges in determining the impact of internal trade and the reporting of exports.

34. In Article 5 countries CTC use as a cleaning solvent has almost ceased. Sector plans in China and India, the major users, that address solvent use are nearing the end of implementation. Under the sector plan for China solvent use ended in 2006. Residual solvent use is estimated at less than 467 ODP tonnes in 2008 in India. For the years 2009 and beyond, these uses have to be covered from the total remaining CTC quantities in stockpiles and the allowed 2009 production, totalling 442 ODP tonnes (402 metric tonnes), of which about 50 metric tonnes are expected to be used as process agents in 2009.

35. The major remaining emissive use of CTC in Article 5 countries is as a process agent. On the basis of current Article 7 data, the total reported CTC consumption for process agent and all other controlled uses in Article 5 countries in 2007 (excluding the Republic of Korea) was 1,129.7 ODP tonnes. Ninety seven point five per cent of this consumption was reported in a total of four countries, namely India (707.3 ODP tonnes), China (265.1 ODP tonnes), Mexico (79.1 ODP tonnes) and Brazil (50.3 ODP tonnes). China has reported to the Executive Committee additional use of 1,230.46 ODP tonnes of CTC in 2008 in process agent applications listed in decision XIX/15 of the Nineteenth Meeting of the Parties and those newly identified applications not currently classified as process agents in relevant decisions of the Parties.

36. While Article 7 consumption data provides a useful insight into general trends, it may not fully reflect the use of CTC for process agent applications. In particular it will not include use in applications that might be viewed by many technical experts as a process agent use rather than a feedstock, which is not a controlled use. Such information would only need to be reported as Article 7 data subsequent to a decision of the Meeting of the Parties defining specific uses as process agent use, i.e. as controlled use. Some applications are understood to involve CTC as both a feedstock and process agent, thus the categorisation of such uses can be a matter of debate between technical experts. By far the largest application in this category is the production of DV acid chloride (DVAC) which, after extensive consideration was not categorised by the TEAP as a process agent use. Current CTC consumption for this use is understood to be of the order of some 16,000 ODP tonnes per annum, mostly in India, with new production facilities coming on-stream in China..

37. Additionally, Article 7 data in previous years may not have included the consumption of CTC in the years in question for process agent applications that are addressed under approved sector plans, since approval of the plans included agreement that the current consumption prior to individual plant conversions was consistent with the provisions of decision X/14 and thus could be considered as a feedstock use and not included in Article 7 data. This is relevant to any examination of previous years' data but will no longer be a consideration in 2010 when consumption under the sector plans in India and China will have reached agreed residual levels.

38. Given the above, the most reliable estimates for emissive use quantities in the major Article 5 country users, namely China and India, are those provided in the industry study, namely 5,500 ODP tonnes per year in China and 3,300 ODP tonnes per year in India, being average figures for the period 2006-2008.

Unintended emissions

39. No production process is totally without losses. Losses to a greater or lesser extent will occur at the production, storage, transhipment, delivery and subsequent use stages as well as in maintenance and cleaning of the production equipment and disposal of residues. While the use of best industry practice can minimise such losses, not all plants conform to best practice standards all the time. There are usually large differences in loss levels between old and new plants. The Secretariat endeavoured in its workshop with industry experts to provide some assessment of the order of magnitude of unintended emissions as follows.

40. Losses of up to 3-5 per cent can occur in the production process in chloromethanes plants. However the losses would not all be CTC. CFC production plants were also said to have similar losses but due to their lower boiling points the losses were more likely to have been CFC-11 and CFC-12, rather than CTC, which would have been recycled within the plant. Losses also occur when plants are shut down for annual maintenance. The magnitude of the losses depends on management practices. Indications from audits of closed CFC production facilities are that construction standards for small, old plants were poor and the sites on which they were built showed evidence of saturation with chemicals, which could be expected to continue to produce emissions to the atmosphere. In general, recent plants in both Article 5 and non-Article 5 countries are much larger, and typically both better designed and better managed, bearing in mind that losses represent economic inefficiencies which reduce competitiveness.

41. Immediately following production, emissions will occur at the site of bulk storage. It is not unusual in Article 5 countries for CTC production and storage installations storage tanks to be at atmospheric pressure and vented to the atmosphere. Tanks can have a capacity of between 100 and 5,000 tonnes. The principal avenue for emissions is upon the filling of a tank when the CTC vapour inside will be expelled. There can also be evaporation losses when ambient temperatures are high. The boiling point of CTC is 76.5 degrees Celsius. In many non-Article 5 countries, it would be a requirement to capture vent emissions for re-use or destruction. According to anecdotal information and a verification of losses for India submitted by the World Bank to the Secretariat, that is often not the case in Article 5 countries.

42. International transportation of bulk CTC in 'iso' containers does not give rise to significant losses. However when ship's tanks are used there will be evaporation losses on filling, emptying and cleaning of the tank. Transport by road takes place in either bulk tankers or through the filling and transport of 200 litre drums. Both tankers and drums are typically filled from a bulk production tank through a hose. Losses may occur through displacement of vapour from the tank or drum, tank cleaning and use, and disposal of the drums and the residue in them, and could be up to 1 per cent in filling and 2 per cent for use, cleaning and disposal. Consistent with CTC phase-out, use for small scale applications including small scale feedstock and process agent plants has been decreasing. Future use will be for large

scale feedstock applications where more efficient bulk transport and delivery mechanisms are likely to prevail.

43. Residue disposal and site cleaning continues to be a significant issue. CTC manufacture and use has been occurring for almost 80 years and, according to anecdotal evidence, for much of that time production residues in significant quantities were dumped and/or flushed into sewer systems. Dump sites will still potentially be a source of CTC emissions, although this is unlikely to be at levels consistent with the discrepancy in data. Plant decommissioning can also involve losses but these are once-off occurrences and do not give rise to ongoing emissions other than from ground contamination.

44. In regard to CTC use, all quantities used in non-feedstock applications are fully emitted, on the basis that prior to implementation of Multilateral Fund projects, there was no substantive capture and incineration of CTC or other emissions in Article 5 countries. There is a high probability that feedstock processes in non-Article 5 countries are tightly controlled for both regulatory and economic purposes. In Article 5 countries, with the cessation of CFC production, almost all the remaining CTC feedstock uses in are in applications which have only arisen in the last decade. There was very little feedstock use in China and India other than CFCs prior to the 1990s. In many cases new plants use similar technology and plant design to those built in non-Article 5 countries and would be likely also to be operated with significantly lower losses than those typical of earlier generation plants. The main feedstock applications, namely methyl chloride, perchlorethylene, chloroform, and DV acid chloride (DVAC), have a requirement to be virtually free of CTC residue and are unlikely to be a source of emissions of any significance.

45. In regard to the control of unintended emissions from plants and processes, it is relevant to note that there are clear and increasing economic incentives to minimise CTC and other losses both for its value as a feedstock and for the value of the chlorine contained in the waste stream; however, there are emissions due to inefficiencies and equipment vents.

46. However the value of CTC as a feedstock is dependent on supply and demand. With the demise of CFC production, and rapidly increasing demand for chloroform to produce HCFC-22, oversupply of CTC was in prospect. This has been mitigated through its diversion to the production of perchlorethylene together with methyl chloride and chloroform in China and DVAC in India and now China.. DVAC production is said to now consume some 16,000 ODP tonnes of CTC per year in India. As indicated previously, this has been accepted by the Parties as a feedstock use, and not consumption as a process agent. Notwithstanding, a view remains within parts of the technical community that the production process involves the use of CTC both as a feedstock and as a process agent. If this were to be the case, the production process could potentially result in additional emissions of the process agent component.

<u>Other possible emission sources</u>

47. In the context of the teleconference with atmospheric science experts the Secretariat sought an update on the likelihood of natural sources or sinks of CTC. In regard to terrestrial sources, there was a consensus that a significant number of tests had revealed that CTC was unlikely to be produced from bacteriological activity in soil. Such activity produced low levels of chloroform, rather than CTC. In regard to oceans, measurement programmes had indicated that oceans were more likely to act as a low level sink, thus exacerbating to some extent the data discrepancy. Studies have indicated that volcanic activity contributes only some 3.4 metric tonnes (3.7 ODP tonnes) per annum of CTC to the atmosphere. Preliminary measurements downwind from coal plants indicate that the emissions from such plants contain chlorinated compounds such as chloroform, but no CTC. There appear to be no significant emissions of CTC from modern, capped landfills which collect and use landfill gas.

Destruction

48. As part of this report, the incentives related to destruction of CTC as compared to emissions were investigated in some detail. The cost of emission of CTC is low. One would assume that emissions would take place by adding CTC to surface water, where it would evaporate within a relatively short period of time. However, CTC contains a significant amount of chlorine which would be lost, together with its inherent value. Destruction processes retain a large part of that value by transforming the CTC and other chlorinated hydrocarbons to hydrochloric acid, HCl; this substance can be used as a feedstock in a number of chlorine-related processes. In addition, the destruction will generate heat of a high temperature which would be usable for a variety of purposes in a chemical plant.

49. Such destruction plants require considerable investment, but have moderate relatively low operating cost. The example below is meant to provide an understanding about the financial benefits and drawbacks of destroying CTC; any actual investment decision would take into account a large number of additional issues, such as local legislation, availability of hydrogen allowing more cost effective operation than using natural gas, annual product stream and subsequent use of the HCl and heat generated. According to one source of information, the investment is in the order of US $6.5 million for a plant with a capacity of 10,000 tonnes of CTC per year, generating about 30,000 tonnes of hydrochloric acid (HCl) of 31 per cent concentration. The main costs and main income is provided in Table 6 below. It becomes apparent that it is possible to generate an income stream in the order of US $750,000 per year provided the equipment operates 8000h/year, i.e. with a downtime of 3 per cent, and is very dependent on the value of the high temperature heat generated. The original investment will have a pay-back time of 8.5 years without taking into account annuity and financing cost.

Table 6 - Operational cost of a fictive CTC destruction plant with a capacity of 10,000 t/year feed

	Per tonne of CTC (US $)	For a plant of 10,000 t feed, per year(US $)
Income		
HCl (+)	28.82	288,242
Heating (+)	143.13	1,431,270
Costs		
Operation cost (-)	74.25	742,500
Maintenance (-)	n/a	202,500
Total	**97.70**	**774,512**

50. The above analysis is limited by a number of constraints: the underlying data for both natural gas as well as energy cost is from the year 2007, and one assumption was that CTC constitutes the only chlorine containing feed into the destruction, while in an integrated processing of chloro-hydrocarbons, or production of complex chloro-hydrocarbons, a complex mix of waste chemicals will constitute the feed to a destruction plant. Such a mix will typically have a higher energy yield or lower natural gas consumption, while producing also less hydrochloride acid per tone of throughput. Finally, in particular a mix of waste chemicals will often have toxic by-products, in which case an incineration would be carried out independently of the economics.

51. However, the analysis also makes clear that destruction of only CTC is economically approximately at the break-even point, binding financial resources of the company but reducing any regulatory or public pressure on the company; a meaningful use for the heat generated by the destruction can be assumed in a chemical plant. These economic conditions can be assumed to be the case for

chloromethane production plants, while other plants are likely to have more favourable operating conditions due to the lower need for external fuel.

IV. Analysis

52. Using estimates for production and use from the industry study, the maximum emissions of CTC can be calculated as total estimated CTC production less total feedstock quantities consumed less amounts destroyed by incineration. This produces a total, global figure of some 16,500 ODP tonnes. While this approach is particularly sensitive to under-estimates in production or over-estimates in feedstock use, it is the only approach currently available to form such an estimate. An additional estimate of the possible total inadvertent losses from feedstock applications could be added to this figure. The nature of inadvertent losses was discussed in Section III above on emissions. From that discussion it can be inferred that total losses could be of the order of 5 per cent. For comparison purposes, this level of losses is consistent with the average of the levels advised for process agent uses by non-Article 5 countries in decision X/14, namely 4.9 per cent. Such a percentage would give rise to additional emissions of no more than 7,500 ODP tonnes. Inadvertent losses from transport and use in process agent and solvent applications do not need to be added since these applications are already considered as totally emissive.

53. The sum of emissions for all uses arising from the industry study thus becomes no more than 24,000 ODP tonnes. This is broadly consistent with the information provided by TEAP to the Twentieth Meeting of the Parties, but does little to resolve the fundamental difference between industrial and atmospheric emissions estimates.

Considerations for further investigation

54. The work on this study commenced with a hypothesis that it might be possible to identify major and thus far un-catalogued sources of industry emissions. The existence of such major sources now appears less likely. Given the order of magnitude of total identified CTC production in the period 2006-2008 of some 200,000 ODP tonnes per annum, additional emissions of over 40,000 ODP tonnes per annum would appear to require quantities of CTC in excess of a doubling the currently identified global production. This seems an unrealistic proposition.

55. At the same time, the discussions with atmospheric science experts have discounted natural sources of CTC and have reinforced the level of confidence in the parameters upon which the prediction of CTC emissions levels have been based including the atmospheric lifetime of CTC of some 26 years. Nonetheless, on the basis that in due course a rational explanation for the data discrepancy will emerge, a number of options for working towards a resolution have been identified. These are set out below.

The possibility of new or updated information on atmospheric lifetime arising from the 2010 Science Assessment

56. While the consensus appears to be that the current estimate is broadly accurate, the effect on the data discrepancy of an extended lifetime is significant. The provision of an update in 2010 will either serve to remove one area of uncertainty or, possibly, assist in narrowing the data gap.

Collection of additional data on regional near-ground atmospheric concentrations of CTC

57. Near-ground measurements of CTC concentrations can provide sound data on the regional location of emissions sources. Given the key roles of India and China in the current distribution of CTC use (mainly as a non-ODS feedstock) atmospheric science experts have indicated that additional data from these regions would aid a more accurate assessment of regional emissions levels. In particular, little

data is currently available for the Indian sub-region. Monitoring stations in Japan and the Republic of Korea could potentially be used to gather additional data on the north Asia region. A monitoring station in the Maldives and a joint Australian and Indian project in eastern India could potentially provide data on the Indian sub-region.

58. Funding would be required to support such activities. The necessary equipment for a measurement programme involving the collection of air samples in flasks and remote analysis could be provided for as little as US $10,000, not counting for staff time and other operational costs. A permanent installation for continuous monitoring and analysis of air samples could cost from US $50,000 to US $400,000 under the same understanding.

59. While the details are not available at the time of preparation of this report, it is understood that additional studies on atmospheric CTC concentrations in China have been undertaken by Chinese authorities and overseas organizations. Cooperation with these efforts could be sought.

60. Two studies providing regional emission estimates based on atmospheric measurements were considered in this report. The 2006 report of the SAP[1], and a recent Ph.D. thesis. The work of the SAP reported that "United States emissions […] of CCl_4 have been no longer detectable in the regional studies" for the years 1999 to 2002; however, that report recognised significant differences between the regional emission estimates and a global figure. The thesis has provided a global data set with figures consolidated between regions for the year 2004, but his emission estimates for North America and Australia appear to be inconsistent with, in these cases, relatively well known industrial emissions.

61. The situation of the continental USA is of particular interest because it is protected by oceans on the east and west , and from trans-boundary emissions. Emissions from Canada and Mexico are likely to be virtually zero, and with its large and geographically dispersed population the USA has a relatively comprehensive network of monitoring facilities. In view of these circumstances there might be merit to carefully re-examine existing data regarding North America and, in particular, the USA both in terms of atmospheric data as well as industry reports regarding emissions, and, to the degree available, data from waste disposal sites for chemical waste. The objective for such an undertaking would be to achieve consolidation of a limited data set, providing input into any further data consolidation efforts.

62. The estimate of Australian emissions (2,500 tonnes/yr) is also not supported by independent estimates using the same atmospheric data but another correlation technique, which suggests Australian CTC emissions of less than 250 tonnes/yr.

V. Conclusions

63. Atmospheric data is derived from two independently monitored data sets: ground level (tropospheric) data and high level (stratospheric) data. The measurements are transformed into emission estimates using a model, which takes into account the atmospheric lifetime of CTC, previous emissions, and atmospheric science. As well as global figures, such models can indicate regional and in some circumstances national emission levels where adequate regional data is available. Aggregated regional data in the 2006 SAP report did not correspond with global totals. Separately, more recent studies have given rise to different, and in some cases significantly higher, regional emissions estimates. These estimates approximate global totals, but are substantially in excess of reported industrial emissions and the additional emissions postulated in this report. More regional data collection and analysis would assist in increasing the reliability of regional and global emissions estimates.

[1] See chapter 1.3.1 and, in particular, Table 1-6 of the SAP report

64. Nonetheless, noting the consensus among the scientific experts consulted by the Secretariat about the relative accuracy of atmospheric lifetime calculations and the absence of significant natural sources of CTC, the implication from the scientific perspective is that emissions additional to those arising from controlled uses reported under Article 7 of the Protocol must be related to as-yet uncategorised uses or losses in chemical processes.

65. CTC occupies a unique place in the management regime for ozone depleting substances adopted under the Montreal Protocol, since the majority of CTC produced has always been used as a feedstock, i.e. a non-controlled use; and the non-controlled use will continue in significant quantities well beyond the phase-out date for CTC in 2010. It should be noted that this may also apply to HCFC-22 in even larger absolute (metric) quantities. Consequently, any generic conclusions drawn from this report, or additional related work on CTC, may be relevant to future considerations about management of the use, and phase-out of HCFC-22.

66. CTC production and consumption has been reported under Article 7 of the Montreal Protocol for over 15 years. According to both anecdotal evidence and analysis of reported data, the first years of reporting were associated with a high level of uncertainty, due in part to the interpretation of Protocol definitions, particularly feedstock versus controlled uses, and incomplete knowledge of the industry at a national level. Despite this, the reporting of CTC under Article 7, when combined with un-published information on feedstock quantities, is broadly consistent with information from industry sources, and the data regarding production, feedstock and consumption has shown clear convergence in the recent years.

67. CTC has an intrinsic minimum value arising from the value of the chlorine it contains. Provided certain quantities of CTC are available annually, destruction facilities that process a variety of chlorinated hydrocarbons into hydrochloride acid can be financially viable, although not very profitable and somewhat capital intensive.

68. The use of chloroform as feedstock for HCFC-22 production is presently the most significant cause for CTC co-production; quantitatively significant co-production with other chemicals is directly recycled into the processes or forms part of a mix of multiple chlorinated hydrocarbons which is being destroyed on site. The co-production of CTC can be minimised, but by far not reduced to zero. However, it should be noted that in 2007 CTC was intentionally produced globally for feedstock applications beyond the minimum co-production from chloroform production. This suggests that for the year 2007 and earlier years, intentional release of large quantities of CTC is unlikely. It should be noted that in the future, further increases in HCFC-22 production might change this situation.

69. An initial assessment has been made of transport and storage losses, which in total are significant. Because of the dispersed nature of these losses, investments in reducing them yield a much lower return. The initial, order-of-magnitude estimate for such emissions is 7,500 ODP tonnes globally per year. The emissions are related to mode of transport, levels of integration of production and consumption, regulations and enforcement, as well as the investment culture and expected return on investment in related countries and companies. A closer investigation of such losses and ways to address them should be an integral part of a more extensive, systematic study of CTC emissions.

70. Given the definitions of feedstock and process agents arising from relevant decisions of the Parties, it appears possible that some uses of CTC classified as feedstock may have a process agent component. This component could give rise to emissions which are not de-minimis and which could be significant. Additionally, the quantity of CTC consumed in controlled uses as a process agent (other controlled uses are now reduced to insignificant levels) is typically determined by deducting the feedstock amount from the total level of production. This might lead to a significant error margin in the determination of consumption for controlled use arising from only minor errors in recording of the base

production data. The introduction of licensing systems for all CTC production, with appropriate enforcement, as already introduced in a number of countries, might reduce this uncertainty.

71. Possible emissions from industrial waste could not be quantified at this stage. Anecdotal information pointed to ad-hoc disposal of wastes containing chlorine by many industries for over half a century until as recently as about 20 years ago. Emissions from these sites might have some significance, but would require additional investigation.

72. Based on the above investigations, and even when using CTC emissions estimates at the top of the relevant uncertainty range, an explanation for the discrepancy between atmospheric and industrial use data that is postulated on identification of previously unreported industrial emissions remains elusive.

Annex A

List of participants at the CTC telephone conference with atmospheric experts

Tuesday, 2 June – 9:30 a.m., Montreal time

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Annex B

List of participants at the workshop on global emissions, emission reductions and phase-out of CTC

Wednesday, 10 June – Thursday, 11 June

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