CHANGES IN HCFC CONSUMPTION AND EMISSIONS FROM THE U.S. PROPOSED ADJUSTMENTS FOR ACCELERATING THE HCFC PHASEOUT

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UPDATED: SEPTEMBER 12, 2007

INTRODUCTION

This document is comprised of two attachments:

- **Attachment A** contains the August 2007 version of the report "Changes in HCFC Consumption and Emissions from the U.S. Proposed Adjustments for Accelerating the HCFC Phaseout." Apart from the correction of minor typographical errors, the version of this report included in Attachment A is identical to the report that was submitted to the Ozone Secretariat (available online at: http://ozone.unep.org/Meeting_Documents/mop/19mop/USA-HCFC-Accerelated-phase-proposal.pdf).
- **Attachment B** contains an alternate version of the results on changes in HCFC consumption and emissions based on the U.S. proposed adjustments for accelerating the HCFC phaseout. After the submission of the August 2007 report to the Ozone Secretariat, newer data was identified on the breakout of HCFCs in developing countries by gas and incorporated into the version of the analysis contained in Attachment B. In addition, global warming potential (GWP) values were updated based on the 2007 Report on Scientific Assessment of Ozone Depletion.

In most cases, the differences between the HCFC consumption and emissions reduction results shown in Attachment A and Attachment B are small. Thus, the conclusions of the analysis—regardless of which version of results is considered—remain the same: accelerating the HCFC phaseout according to the U.S. proposal will produce significant benefits for the ozone layer, and small but discernible benefits for the climate system.

ATTACHMENT A:

CHANGES IN HCFC CONSUMPTION AND EMISSIONS FROM THE U.S. PROPOSED ADJUSTMENTS FOR ACCELERATING THE HCFC PHASEOUT

AUGUST 2007 VERSION,
AS SUBMITTED TO THE OZONE SECRETARIAT

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This report provides a streamlined presentation of a preliminary analysis conducted for and submitted to EPA. A series of draft memoranda on this analysis have been made from February through June 2007 under a quick turnaround timeframe. This report has been revised based on input received in response to a Notice of Data Availability (NODA, 72 FR 35230) and request for comment issued on June 27, 2007. The results of this preliminary analysis should be interpreted as rough approximations of the impact of each policy option.

CONTENTS

1. INTRODUCTION

This report presents a preliminary global analysis of the stratospheric ozone and climate impacts associated with the United States proposed adjustments for revising the phaseout schedule for HCFCs under the *Montreal Protocol on Substances that Deplete the Ozone Layer* (the Protocol). The purpose of this report is to evaluate the extent to which different options for changing the phaseout schedule may result in a reduction of HCFC consumption and emissions as well as how such changes may or may not benefit the climate from 2010 to 2040.

Seven options for adopting the elements of the U.S. proposed adjustments independently or jointly are evaluated in this analysis. The methodology for evaluating the options first required projecting consumption baselines for Article 5 (A5) countries—the Protocol's identifying term for developing countries—through 2040 and for non-A5 countries through 2030 under the current HCFC phaseout schedules. Assumptions were then developed to determine:

- Reductions in HCFC consumption weighted by ozone depletion potential (ODP) and weighted by global warming potential (GWP) metric tons;
- The climate impact of transitioning to hydrofluorocarbons (HFCs);
- The climate impact of reducing by-product production and emissions of HFC-23; and
- The climate impact of transitioning to more energy efficient equipment (as driven by the purchase of newer, more energy efficient equipment—not refrigerant choice).

Estimates are presented in both ODP- and direct GWP-weighted consumption and emission changes associated with each of the seven accelerated phaseout options. Given the broad and generally conservative (i.e., to not over-estimate climate and ozone benefits) assumptions employed by the analysis, the results should be interpreted as rough approximations of the impact of each policy option. This analysis would yield greater environmental benefits under each policy option if "best case" assumptions were applied; for example, if HCFCs were assumed to be replaced strictly with zero or low GWP alternatives, and if greater energy efficiency improvements were assumed to be made.

The general conclusion of the analysis is that an accelerated HCFC phaseout schedule could significantly decrease ODP-weighted consumption and emissions and also have a small climate protection benefit. An accelerated HCFC phaseout in A5 countries will yield greater environmental benefits than will an accelerated HCFC phaseout in non-A5 countries, given that developed countries have already begun to phase out HCFCs; thus, the net reduction in their consumption will be smaller. Nonetheless, benefits associated with an accelerated phaseout also will be important for developed countries. It is important to note that this analysis did not consider the expected costs associated with these proposals. While this analysis was based on the U.S. proposed adjustments, generally, the findings are applicable to the proposed HCFC adjustments submitted by other Parties.

2. LIMITATIONS OF THE ANALYSIS

The analysis in this report is preliminary. This analysis is based on broad assumptions that have been applied to developed and developing countries without further disaggregation by country; consequently, the results of this analysis should be interpreted as rough approximations of the impact of each policy option. For example, the U.S.-based rule of thumb assumption used to determine the climate impact of the transition from HCFCs to HFC-based alternatives could be improved by developing and applying regional assumptions. Furthermore, the 'emission-to-consumption' ratios may not capture total impact. The analysis could be strengthened by calculating emissions from a bank rather than from annual consumption of HCFCs; however, this effort would require more sophisticated analysis and modeling than was performed for this analysis. Nonetheless, these ratios are considered generally representative of a mature, but not yet declining, market, and as such, assumed to be a reasonable rule of thumb.

In addition, even though HCFC-142b has a high ODP of 0.065, it is analyzed as part of the low ODP group of HCFCs under the "Worst First" approach (included in Options 4 and 7). The percentage of total HCFC consumption associated with HCFC-142b in developing countries is currently unknown. As a result, HCFC-142b is grouped in the "other HCFCs" category even though it is understood that this category is intended to represent low ODP HCFCs under Options 4 and 7. While consideration should be given to this limitation when interpreting the results, because HCFC-142b is used in relatively lower volumes, its inclusion in the "other HCFCs" is not expected to significantly impact results. Nonetheless, further analysis could address this and other broader limitations to provide a fuller picture of the net impact of accelerated HCFC phaseout in A5 and non-A5 countries. Furthermore, to the extent that additional information has since been made available regarding HCFC consumption by gas, further refinements to the assumptions applied to disaggregate reported and projected HCFC consumption by gas for A5 countries would provide more precise estimates by option.

This analysis was developed with the identifiable set of assumptions. Therefore, certain considerations that imply greater or less benefits associated with adopting any of these policy options could be made when reviewing the results. For example, the analysis currently uses 2% as a HFC-23/HCFC-22 ratio for assessing the climate impact of reducing the production of HFC-23, a high-GWP byproduct of HCFC-22. A higher ratio, such as 3%, would yield slightly greater climate benefits from an earlier HCFC-22 phaseout; results based on this assumption are presented in Annex D. If the analysis were run with 1% it would result in slightly less benefits. Similarly, other scenarios that show larger ozone and climate benefits are plausible, such as allowing Clean Development Mechanism (CDM) credits for HFC-23 byproduct emissions from a growing HCFC-22 production base, likely leading to much higher HCFC-22 emissions in the baseline. Another consideration is the possibility that A5 countries may adopt energy efficient equipment as a result of the engineering investment made in response to an earlier phaseout (i.e., engineering that would not have occurred in the absence of an accelerated phaseout and which would yield benefits throughout the timeline of the analysis); this potential trend has not been quantified. Similarly, a "best case" scenario assuming that HCFCs are replaced entirely with zero or low GWP alternatives has not been investigated and those results are not presented. The results of the current analysis reflect the adoption of a current suite of available alternatives for HCFCs. If the analysis were to consider a different suite of refrigerants, such as those under development, the results would vary. The analysis in this report is preliminary; further refinements would provide more precise estimates by option.

3. DESCRIPTION OF OPTIONS EVALUATED

Under the current HCFC controls established by the Protocol, A5 countries must freeze consumption at 2015 levels in 2016 and completely phase out HCFCs in 2040. Non-A5 countries must reduce HCFC consumption by 65%, 90%, and 99.5% of baseline levels in 2010, 2015, and 2020, respectively, and must completely phase out HCFCs by 2030. Seven options for adopting the elements of the U.S. proposed adjustments independently (i.e., Options 1 – 4) or jointly (i.e., Options 5 – 7) are evaluated in this analysis, as described below.

- **Option 1: Establish Interim Reductions for Article 5 Countries.** Option 1 establishes interim steps in the cap on HCFC consumption in 2020 (65% reduction from baseline) and 2025 (90% reduction from baseline) for A5 countries.
- **Option 2: Set Article 5 Baseline Five Years Earlier.** Option 2 requires that the A5 countries' baselines be established based on their level of consumption in 2010, rather than on the level of consumption in 2015.
- **Option 3: Accelerate Non-Article 5 and Article 5 Phaseout by 10 Years.** Option 3 accelerates the complete HCFC phaseout by 10 years for both A5 and non-A5 countries. For A5 countries, this moves the 100% phaseout date from 2040 to 2030; for Non-A5 countries, this moves the 100% phaseout date from 2030 to 2020.[1]
- **Option 4: Modify Phase out Schedule to use a 'Worst First' Approach.** Under Option 4, A5 and non-A5 countries follow the Montreal Protocol consumption phaseout schedule, but additional step-downs for higher ODP HCFCs are also employed. For A5 countries, starting in 2020, annual consumption of higher ODP gases (i.e., HCFC-22, HCFC-141b, and HCFC-142b) on an ODP-weighted basis must not exceed 25% of baseline and by 2025, annual consumption of these gases cannot exceed 5% of baseline. For non-A5 countries, these step-downs occur 10 years earlier, starting in 2010, annual consumption of higher ODP gases must not exceed 25% of baseline and by 2015, annual consumption of these gases cannot exceed 5% of baseline.
- **Option 5: Establish Interim Reductions for Article 5 Countries AND Set Article 5 Baseline Five Years Earlier.** Option 5 combines Options 1 and 2 of this analysis. Under Option 5, the A5 countries' baseline is established based on the level of consumption in 2010 (rather than on the level of consumption in 2015), and interim steps are established in the HCFC consumption cap for A5 countries in 2020 (65% reduction from baseline) and 2025 (90% reduction from baseline).
- **Option 6: Set Article 5 Baseline 5 Years Earlier AND Accelerate Non-Article 5 and Article 5 Phaseout by 10 Years.** Option 6 combines Options 2 and 3 of this analysis. Under Option 6, the A5 countries' baseline is set based on the level of consumption in 2010 (rather than on the level of consumption in 2015), and the complete HCFC phaseout is accelerated by 10 years for both A5 and non-A5 countries.
- **Option 7: Maximum HCFC Consumption and Emissions Reduction.** Option 7 combines Options 1, 2, 3, and 4 of this analysis. For A5 countries, the baseline is first established based on the level of consumption in 2010 (rather than in 2015). Then, starting in 2020, total annual consumption of HCFCs must not exceed 35% of that baseline, and annual consumption of higher ODP HCFCs (i.e., HCFC-22, HCFC-141b, and HCFC-142b) must also not exceed 25% of baseline. Starting in 2025, total annual consumption of HCFCs must not exceed 10% of baseline, and annual consumption of higher ODP HCFCs cannot exceed 5% of baseline. In addition, the complete HCFC phaseout is accelerated by 10 years (from 2040 to 2030). For non-A5 countries, in addition to the existing phase-down steps required by the Montreal Protocol, starting in 2010, annual consumption of higher ODP gases must not exceed 25% of baseline and by 2015, annual consumption of these gases cannot exceed 5% of baseline. In addition, the complete HCFC phaseout is accelerated by 10 years (from 2030 to 2020).

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[1] EPA regulations at Section 82.16(f) interpret "100 percent phaseout" to provide for continued exemptions for: (1) production for a use that results in transformation or destruction, for export to A5 countries, or for exemptions stipulated under the

4. METHODOLOGY

This section presents the methodology used to calculate the stratospheric ozone and climate impacts associated with each of the options. Section 4.1 describes the approach used to project a consumption baseline through 2040 for A5 countries and through 2030 for non-A5 countries under the current HCFC phaseout schedules.

Sections 4.2 through 4.5 describe the methodology used to calculate the ozone and climate impacts associated with: (1) reductions in HCFC consumption as weighted by ozone depletion potential (ODP) and as weighted by global warming potential (GWP) metric tons; (2) the climate impact of transitioning to HFCs; (3) the climate impact of reducing by-product production and emissions of HFC-23; and (4) the climate impact of transitioning to more energy efficient equipment. Note that while most assumptions are common to all seven policy options, additional specific assumptions are required to estimate the impacts of certain options; these are also described below.

4.1. Consumption Baselines

For the purpose of this analysis, consumption baselines[2] that reflect the current phaseout schedules for A5 and non-A5 countries were developed using historical aggregated HCFC consumption data (i.e., 1986, 1989-2004)[3] from UNEP as reported under Article 7. [4] Consumption under the baseline was assumed to equal the maximum allowable consumption under the Montreal Protocol for both A5 (beginning in 2016) and non-A5 countries (beginning in 2005,); this assumption follows common modeling approaches used by other studies to develop baselines under the Montreal Protocol (UNEP, 2007a). Because the cap on the consumption of HCFCs in A5 countries does not enter into effect until 2016, an assumption regarding the average annual growth rate for consumption was required to project A5 consumption for years 2005 through 2015. A previous version of this analysis assumed an annual growth rate of 12 percent; however, recent discussions on the choice of growth rate within the international community have indicated that a reasonable annual growth rate may fall within the range of 5 to 9 percent (UNEP, 2007a). For the purpose of this analysis, a growth rate of 9 percent was chosen; additionally, Annex C provides a sensitivity analysis that presents the results based on 5, 7, and 12 percent growth rates.

Although it was assumed that consumption would be maximized, in actuality consumption has often been below HCFC caps imposed by the Montreal Protocol. For example, in 2004, HCFC consumption by non-A5 countries was below 11,000 ODP metric tons,[5] far less than the allowed cap of almost 24,000 ODP metric tons, which is due in part to the fact that many countries adopted their own regulations that are stricter than the phaseout schedule of the Montreal Protocol. For example, the United States adopted a “worst first” approach that requires the phaseout of the higher ODP HCFCs (HCFC-22, HCFC-141b, and HCFC-142b) first. In another example, the European Commission’s Regulation (EC) No 2037/2000 prohibits the use of HCFCs in solvent applications after 2001, in foams after 2004, and in refrigeration/AC equipment after 2010. To the extent that actual consumption is less than the assumed consumption baselines, the results (on consumption and emission reductions) could also be less.[6]

Protocol and codified at Section 82.15(f); and (2) imports for use in a process resulting in transformation or destruction, or the exemptions codified at Section 82.15(f).

[2] Consumption of HCFCs is defined by the Protocol as production (the amount of controlled substances produced, minus the amount destroyed, and minus the amount entirely used as feedstock in the manufacture of other chemicals) plus imports minus exports. The amount recycled and reused is not considered as production. Based on this definition, HCFC-22 used as a feedstock is not included in the totals.

[3] Though available, 2005 data were not used in this analysis because data had not been finalized at the time of analysis. Data for 1987 and 1988 were not available.

[4] Published projections such as the TEAP HCFC Task Force Report (May 2003) were considered as sources of data for this analysis, however the data were not utilized due to unrealistically low estimates for the early portion of the time series. In particular, projections for 2002 through 2005 were significantly lower than the UNEP reported data for this period. However, TEAP’s projections for HCFC demand in 2010 and 2015 are comparable to those which were derived using the average growth rate of consumption.

[5] An ODP-metric ton takes into account each ODS’ relative contribution to ozone depletion. Note: one metric ton equals approximately 2,204 pounds.

[6] Consider an example where the calculated baseline assumes maximized consumption of 2,000 MT/year but actual consumption is 1,000 MT/year. Assuming a more stringent phasedown schedule requiring consumption of only 500 MT/year,

Further analysis could be undertaken to more accurately estimate these reductions by taking into account existing national regulations.

4.2. Consumption and Emission Reductions Associated with Reduced HCFC Consumption

4.2.1. Common Methodology for All Options

Two assumptions were common among all options analyzed, and relate to how aggregate consumption was disaggregated into individual HCFCs, and how the consumption changes were translated into changes in emissions. The methodology associated with these two assumptions is detailed below.

Assumptions applied to disaggregate reported and projected HCFC consumption by gas

To determine the ODP-weighted and GWP-weighted emission and consumption reductions associated with each proposed adjustment, it was necessary to first apply assumptions about the composition of total HCFC consumption, reported in aggregate in units of ODP-weighted metric tons, by chemical. Total consumption was disaggregated into consumption of HCFC-22, HCFC-141b, and "other HCFCs." The ODP and direct GWPs of HCFC-123 were used as a proxy for "other HCFCs," since it is assumed that HCFC-123 accounts for the majority of other HCFC use and has low GWP values, thereby biasing downward the climate impacts of ODS associated with each option. The method for determining consumption of HCFC-22, HCFC-141b, and other HCFCs for developing and developed countries is summarized below:

- For **developing countries**, the relative consumption of HCFCs by chemical was based on data available from developing countries, as provided in a preliminary UNDP study distributed at the 51st meeting of the Executive Committee of the Multilateral Fund. The UNDP study is based on detailed surveys from Argentina, Brazil, Colombia, India, Indonesia, Islamic Republic of Iran, Lebanon, Mexico, and Venezuela, which is now available online (UNDP 2007).
- For **developed countries**, the relative consumption of HCFCs by chemical was based on U.S. consumption patterns in the year 2000, as modeled in the EPA's Vintaging Model (EPA, 2006a).[7] The year 2000 was chosen to model consumption of HCFCs by type because other developed countries have not chosen to apply the same "worst-first" approach as the United States, and therefore may still be using HCFCs in the same proportions as the United States was prior to the phaseout of HCFC-141b in 2003.

Assumptions applied to estimate HCFC emission reductions under each scenario

Reductions in consumption of HCFCs associated with each policy scenario were translated into emission reductions using an emission-to-consumption ratio, based on U.S. patterns, of 71% for HCFC-22, 15% for HCFC-141b, and 44% for other HCFCs (based on the emissions-to-consumption ratio for HCFC-123). These ratios were developed based on U.S. consumption and emissions patterns as modeled in the U.S. EPA's Vintaging Model and reflect the relationship between annual emissions from HCFC equipment and annual HCFC consumption. The emission-to-consumption ratios were taken from the modeled year 2000 from the Vintaging Model, and are generally representative of a mature, but not yet declining, market; thus they are assumed to be an appropriate rule of thumb to estimate emissions relative to consumption across all HCFC-using end-uses (EPA, 2006a).[8] Because these ratios

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this analysis would calculate a reduction in consumption of 1,500 MT/year (2,000 MT – 500 MT). However, the actual reduction in consumption would only be 500 MT/year (1,000 MT – 500 MT), which is less than the reduction estimated by the analysis.

[7] The U.S. EPA Vintaging Model estimates consumption and emissions of ODS and ODS substitutes, by analyzing market characteristics and emissions sources form over 60 classes of products reliant on those chemicals. Not all assumptions developed for this analysis rely on the Vintaging Model; in instances when the model is used to develop an assumption, a reference to the model is cited.

[8] Ratios are based on annual ODP-weighted HCFC emissions (from all in-use equipment) divided by annual ODP-weighted HCFC consumption (production + imports – exports) from the year 2000, based on EPA's Vintaging Model (EPA, 2006a). It

are only applied to remaining consumption after a phase-down step (e.g., the remaining 35% of baseline consumption after a 65% phase-down step), this analysis does not capture emission tails (e.g., continued emissions from existing HCFC equipment no longer consuming HCFCs from further servicing events). Thus, the difference between emission tails occurring at each phase-down step and emission tails in the consumption baseline have not been accounted for in this analysis. Over an infinite timeframe, emissions could be considered to be 100% of consumption; however, given that this analysis evaluates changes in emissions over a specified period, the time lag between consumption and emissions is incorporated into the emission to consumption ratio.

These assumptions are summarized in Table 4-1.

Table 4-1. Assumptions [a]

HCFC Type	Article 5 Countries % HCFC Consumption (ODP-weighted MT)	Non Article 5 % HCFC Consumption (ODP-weighted MT)	ODP	Direct GWP	Ratio of Emissions to Consumption
HCFC-22	49.3%	49.6%	0.055	1,780	71%
HCFC-141b	49.3%	44.6%	0.11	713	15%
Other	1.4%	5.7%	0.04	76	44%

[a] Sources: Assumptions regarding consumption for A5 countries are based on the UNDP survey study (UNDP, 2007); assumptions for consumption for non-A5 countries are based on EPA's Vintaging Model (EPA, 2006a). ODP values are taken from the Montreal Protocol (UNEP 2003). Note that UNEP provides a range of 0.02-0.06 for HCFC-123, the HCFC used as the proxy for 'Other'; the median of this range was selected for this analysis. GWP values are taken from IPCC/TEAP (2005). Assumptions regarding the ratio of emissions to consumption are based on EPA's Vintaging Model (EPA, 2006a).

IPCC/TEAP (2005) reports different percentage breakouts for HCFC emissions: between 75-85% for HCFC-22, between 7-17% for HCFC-141b, and 8% for other HCFCs, depending on whether the bottom-up or top-down approach (based on atmospheric concentrations) is used. These percentages of emissions vary significantly from the percentages of consumption reported in Table 4-1 because they are based on emissions in metric tons, whereas the percentages reported in the table above are based on consumption of HCFC in ODP-weighted metric tons. Because HCFC-141b has a high ODP, in a breakout based on ODP-weighted consumption, HCFC-141b appears to account for a higher percentage of consumption than it actually does in real tonnage. Therefore, because the percentages of HCFC emissions by HCFC type in the IPCC/TEAP (2005) are not disaggregated by developed and developing countries, assumptions from the UNDP preliminary survey results (UNDP, 2007) and the EPA's Vintaging Model (EPA, 2006a) were applied in this analysis.

4.2.2. Specific Methodology for Options 4 and 7

To calculate consumption and emission reductions for Options 4 and 7, several additional assumptions were required. Because the "worst first" approach employed under these options does not prescribe specific phase-down steps for lower ODP HCFCs, under Options 4 and 7, other HCFCs would be legally permitted to be consumed up to the level of the cap for all HCFCs. Since it is unlikely that this increased volume of lower ODP HCFCs will be consumed,[9] an additional scenario assuming constant future consumption of lower ODP HCFCs is also modeled under Options 4 and 7.

In general, to ensure comparability of scenarios, this analysis models maximum allowable consumption under all options. Under Option 4, however, this approach means that maximum allowable consumption is equal to the baseline, despite the restrictions on consumption of higher ODP HCFCs. For example, while A5 countries' consumption of higher ODP HCFCs must be restricted to 25% of baseline in 2020 under Option 4, allowable consumption of lower ODP HCFCs can account for the remaining 75% of baseline. This would represent a marked increase in consumption of other HCFCs, which is very unlikely. Thus, given the unique and highly unlikely situation presented under Options 4 and 7 (i.e., maximum allowable consumption significantly diverges from anticipated future consumption), an additional scenario assuming constant future consumption of lower ODP

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should be noted that emissions include not just annual leakage from in-use equipment, but also losses from servicing and disposal events.

[9] If, for instance, consumption of lower ODP HCFCs reached its maximum allowable level in 2020 of 75% of baseline under Option 4, this would represent an unrealistic increase in consumption of those HCFCs in one year.

HCFCs is also modeled. Specifically, consumption of lower ODP HCFCs is assumed to be constant from 2020 forward for A5 countries and from 2010 forward for non-A5 countries. However, in cases where the assumption of constant levels of lower ODP HCFC consumption would cause total consumption to exceed the cap when combined with projected consumption of higher ODP HCFC consumption, lower ODP HCFC consumption was reduced accordingly. These assumptions were developed based on historically observed patterns of consumption in the United States when higher ODP HCFCs have been restricted. The specific assumptions applied are presented in Annex B.

4.3. Climate Impact of Transition Away from HCFCs to HFCs

Using the Vintaging Model, the climate impact of transitioning away from HCFCs was estimated (EPA, 2006a). First, the Vintaging Model assumptions regarding the projected choice of HCFC alternatives were applied. According to the model, approximately 80% of total HCFC use across all industry sectors is replaced with HFCs over the long run (through 2030), while the remaining 20% of HCFC use transitions to non-fluorinated or not-in-kind alternatives.[10] Next, in order to determine the climate impact of the transition to HFC-based alternatives, the relationship between HCFC consumption and HFC consumption was developed by using the model to identify (1) the year in which U.S. HCFC consumption was maximized; and (2) the year in which U.S. HFC consumption is projected to be maximized (over the period 1985 to 2030). The scenario constructed to model this relationship assumed zero market growth, such that increases in HFC consumption as a result of future growth in the refrigeration and air-conditioning and other markets were excluded from the ratio.[11] This ratio thus takes into account the extent to which the HCFC bank is likely to be replaced with HFCs as well as other not-in-kind or non-fluorinated alternatives. In addition, any HFC consumption associated with CFC (rather than HCFC) replacement was not included. It is important to note that all assumptions built-in to the Vintaging Model were inherently applied to this methodology, including assumed changes to equipment charge sizes associated with the transitions (EPA, 2006a). Thus, a multitude of considerations were accounted for in projecting the amount of HFC consumption that will replace the initial HCFC consumption.

The relationship between HCFC consumption and HFC consumption was broadly applied to HCFC consumption in all countries worldwide, without further disaggregation to distinguish between the developed and developing world or relative use of HFCs and other fluorinated gases as ODS substitutes in any given country.

4.4. Climate Impact of Reducing Production of HFC-23 By-Product

For this factor, HFC-23 emissions are assumed to be 2% of HCFC-22 consumption (on a ton-per-ton basis). At its seventeenth meeting in December 2004, the Executive Board of the Clean Development Mechanism redefined the emissions cap below which certified emission reductions would be issued for the destruction of HFC-23; accordingly, HFC-23 emissions may not exceed 3 percent of HCFC-22 annual output (UNEP 2007a). While actual levels of HFC-23 emissions have been higher or lower than 2%, this value was chosen to be representative of the international market and to ensure that the impact of these emission reductions are not over-stated in this analysis. Annex D provides the results of the analysis assuming that HFC-23 emissions are 3% of HCFC-22 consumption.

4.5. Climate Impact of Transition to More Energy Efficient Equipment

The climate impact of end users transitioning to more energy efficient equipment earlier as a result of an advanced HCFC phaseout was estimated in this analysis based on a top-down approach (i.e., total HCFC consumption data was obtained in aggregate for A5 and non-A5 countries), requiring several assumptions to determine energy efficiency, which is essentially an end-use by end-use calculation that requires a bottom-up approach.
For each of the options, energy efficiency improvements are only calculated for air-conditioning (AC) and refrigeration equipment that use HCFC-22; these equipment types are grouped into two categories according to lifetime—end-uses with a lifetime of less than 15 years (or “small” end-uses, using residential AC equipment and a

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[10] Although well over 80% of HCFCs used in refrigeration/AC applications—which comprise the majority of total US HCFC consumption—will transition to HFC alternatives, significantly less than 80% of HCFCs used in other applications (i.e., foams, fire-protection, and solvents) will transition to such alternatives.

[11] Note, however, that future market growth is modeled in the baseline as explained in Section 4.1.

lifetime of 10 years as a proxy) and end-uses with a lifetime of greater than 15 years (or “large” end-uses, using chillers and a lifetime of 20 years as a proxy).

Additionally, it was assumed that energy efficiency always improves with time at a rate of approximately 10% per decade, or 1% per year (World Bank 2005; UNEP 2007b). This improvement in energy efficiency is assumed to be driven by the purchase of newer, more efficient equipment—not due to refrigerant choice. This assumption should be considered an approximate average; improvements may be better or worse than 1% per year. For example, there are chillers today that use 65 percent less energy than those produced in the 1970s (UNEP 2007b). An assumption greater than 10% energy efficiency improvement per decade would yield greater net global climate benefits.

Incremental improvements in energy efficiency associated with each option are based on the assumption that, with additional phase-down steps, end users will likely choose to transition to new, more energy efficient non-HCFC equipment earlier than they would otherwise have done in the baseline. The driver of this anticipated trend is that the limited availability of HCFCs could lead to market shortages for servicing existing HCFC equipment; as a result, some end users may choose to retire their HCFC equipment before the end of its useful lifetime.

For the initial, less stringent phase-down steps in each option,[12] it was assumed that market shortages will only gradually be felt by end users, as the supply of HCFCs for servicing slowly tightens and the need to switch to non-HCFC equipment is less imperative. Specifically, it was assumed that small equipment containing HCFCs is retired prematurely after 5 years, while large equipment containing HCFCs is retired prematurely after 10 years. For early consumption freezes, such as those proposed under Option 2, no early retirement was assumed to occur.

For the subsequent, more stringent phase-down steps in each option,[13] a quicker transition (i.e., within one year) toward early retirement of all HCFC-containing equipment is assumed, to reflect tighter market conditions expected from a near total phaseout. Under each option, care was taken not to double count any early retiring equipment under the subsequent restrictions that was assumed to have already retired under the initial restriction.

All energy efficiency improvements are associated with changes in the phaseout schedule for A5 countries; no energy efficiency improvements are associated with non-A5 countries under Options 3, 4, 6, and 7 (the only options that affect non-A5 countries) because only incremental improvements in energy efficiency are assumed to be occurring in the baseline.

The specific assumptions employed to calculate improved energy efficiency are shown in Annex A.

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[12] These include the 65% reduction in 2020 under Options 1, 5, 7, and the initial restriction in 2020 of consumption of higher ODP HCFCs under Options 4 and 7.

[13] These include the 90% reduction in 2025 under Options 1, 5, and 7, the subsequent restriction in 2025 of consumption of higher ODP HCFCs under Options 4 and 7, and the 100% reduction in 2030 under Options 3, 6, and 7.

5. RESULTS

This section presents estimated changes in consumption and emissions of chemicals that affect stratospheric ozone (Section 5.1) and the climate (Section 5.2) for each proposed adjustment, **with reductions shown as negative values, and increases shown as positive values.** For reference, the consumption baselines that reflect the current phaseout schedules are presented in Table 5-1.

Table 5-1. Aggregate HCFC Consumption Baseline (ODP-Weighted Metric Tons)

	A5 Countries	Non-A5 Countries	Global
Consumption	1,720,000	504,000	2,230,000
Emissions	742,000	224,000	966,000

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

5.1. ODP-Weighted Changes in HCFC Consumption and Emissions

As shown in Table 5-2 and Table 5-3, **each option (except the first scenario of Option 4) resulted in estimated reductions in ODP-weighted HCFC consumption and emissions from 2010 through 2040**. Option 7 (a combination of Options 1, 2, 3, and 4) produces the greatest reduction in ODP-weighted HCFC consumption and emissions. Additionally, although Option 4 under the maximum allowable consumption scenario does not result in changes in ODP-weighted consumption, because the mix of HCFCs is modified, changes in HCFC emissions result.

Table 5-2. Changes in Aggregate HCFC Consumption (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-856,000	0	-856,000	-38%
Option 2	-480,000	0	-480,000	-22%
Option 3	-511,000	-1,840	-513,000	-23%
Option 4				
Maximum allowable consumption scenario:	0	0	0	0%
Constant lower ODP HCFC consumption scenario:	-906,000	-13,900	-920,000	-41%
Option 5 (combines Options 1 & 2)	-1,040,000	0.0	-1,040,000	-46%
Option 6 (combines Options 2 & 3)	-812,000	-1,840	-814,000	-37%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-1,070,000	-1,840	-1,070,000	-48%
Constant lower ODP HCFC consumption scenario:	-1,090,000	-15,700	-1,110,000	-50%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

Table 5-3. Changes in Aggregate HCFC Emissions (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-368,000	0	-368,000	-38%
Option 2	-206,000	0	-206,000	-21%
Option 3	-220,000	-819	-221,000	-23%
Option 4				
Maximum allowable consumption scenario:	12,300	-27.1	12,300	1%
Constant lower ODP HCFC consumption scenario:	-389,000	-6,180	-396,000	-41%
Option 5 (combines Options 1 & 2)	-446,000	0	-446,000	-46%
Option 6 (combines Options 2 & 3)	-349,000	-819	-350,000	-36%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-460,000	-846	-461,000	-48%
Constant lower ODP HCFC consumption scenario:	-469,000	-7,000	-476,000	-49%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

5.2. GWP-Weighted Changes in HCFC Consumption and Emissions

As shown in Table 5-4, all options result in an **estimated net increase in GWP-weighted HCFC and HFC consumption (i.e., net global climate impact) from 2010 through 2040 with the exception of a slight decrease for the second scenario of Option 4.** Also, as shown in Table 5-5, all options result in **an estimated net decrease in GWP-weighted HCFC and HFC emissions (i.e., net global climate impact), except for Option 2.** The net increase in emissions under Option 2 is caused by a lack of offsets from energy efficiency improvements; Option 2 does not assume improvements in energy efficiency because it only considers an early freeze to A5 baseline consumption. **Under all other proposed adjustments, improved energy efficiency results in decreased CO_2 emissions and thus a climate benefit.** Option 7 produces the greatest reduction in GWP-weighted HCFC consumption and emissions; however, the second scenario of Option 4 produces the smallest reduction in GWP-weighted HCFC consumption. When accounting for transitions to HFCs and energy efficiency improvements, Option 3 yields the largest reduction in total greenhouse gas emissions. Under both combined Options 5 and 6, because the Article 5 countries' baseline is set five years earlier, fewer HCFC-containing units are phased out at each of the interim reductions, and therefore *marginal* energy efficiency improvements are actually less than those experienced under respective Options 1 and 3 alone.

Table 5-4. Changes in Aggregate HCFC Consumption (MMTCE, Using Direct GWP)

Option	*Reductions*	*Increases*	Net Global Climate Impact
	Reduced HCFC Consumption	Transition to Alternatives[a]	
Option 1	-4,480	4,660	180
Option 2	-2,510	2,610	101
Option 3	-2,680	2,790	108
Option 4			
Maximum allowable consumption scenario:	-4,440	5,000	555
Constant lower ODP HCFC consumption scenario:	-4,920	4,910	-10.0
Option 5 (combines Options 1 & 2)	-5,420	5,640	217
Option 6 (combines Options 2 & 3)	-4,260	4,430	171
Option 7 (combines Options 1, 2, 3, & 4)			
Maximum allowable consumption scenario:	-5,830	5,950	121
Constant lower ODP HCFC consumption scenario:	-5,850	5,960	110

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Table 5-5. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-2,760	-29.2	-450	2,980	-257
Option 2	-1,550	-16.4	0	1,670	108
Option 3	-1,650	-17.5	-537	1,790	-421
Option 4					
Maximum allowable consumption scenario:	-2,820	-32.2	-435	3,200	-90.4
Constant lower ODP HCFC consumption scenario:	-3,030	-32.2	-435	3,140	-359
Option 5 (combines Options 1 & 2)	-3,340	-35.3	-350	3,610	-116
Option 6 (combines Options 2 & 3)	-2,620	-27.8	-368	2,830	-184
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-3,600	-38.2	-345	3,810	-171
Constant lower ODP HCFC consumption scenario:	-3,600	-38.2	-345	3,810	-175

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

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Annex A. Energy Efficiency Assumptions by Policy Option

Table A-1. Assumptions on Consumption of HCFC-22 Related to Energy Efficiency CO_2 Emissions*

Input	Option 1:		Option 3:	Option 4:		Units	Source
	65% Reduction in A5, 2020	90% Reduction in A5, 2025	Accelerated Phaseout A5	"Worst First" A5 2020	"Worst First" A5 2025		
HCFC 22 consumption first 10 years	1,826,512	2,205,190	4,072,798	1,826,512	2,205,190	MT	
22 consumed in second 10 years	4,072,798	2,519,828	4,581,505	4,072,798	2,298,762	MT	
22 consumed for large units	50%	50%	50%	50%	50%		
22 consumed for small units	50%	50%	50%	50%	50%		
Lifetime, small units	10	10	10	10	10	yr	1,2
Lifetime, large units	20	20	20	20	20	yr	1,2
Total consumption subject to early retirement, large	2,949,655	2,362,509	4,327,151	2,949,655	2,251,976	MT	
Total consumption subject to early retirement, small	2,036,399	1,259,914	2,290,752	2,036,399	1,149,381	MT	
% consumption for new units	50%	50%	50%	50%	50%		3
% consumption for servicing	50%	50%	50%	50%	50%		3
Charge size, large	250	250	250	250	250	Kg	1
Charge size, small	7.5	7.5	7.5	7.5	7.5	Kg	1
Number of new units built during X years (lifetime), large	5,899,310	4,725,017	8,654,302	5,899,310	4,503,951	number of units	
Number of new units built during X years (lifetime), small	135,759,926	83,994,250	152,716,818	135,759,926	76,625,397	number of units	
kWh/yr/unit Saved, large	33,384	22,886	21,764	33,384	22,886	kWh/yr per unit Saved	4,6,7,8
kWh/yr/unit Saved, small	164	116	110	164	116	kWh/yr per unit Saved	5,6,7,8
Total baseline electricity improvement by large units, per year	2.E+11	1.E+11	2.E+11	2.E+11	1.E+11	kWh/yr for all units	
total baseline electricity improvement by small units, per year	2.E+10	1.E+10	2.E+10	2.E+10	9.E+09	kWh/yr for all units	
Percent of units retired early	25%	100%	100%	25%	100%		
Number of units retired early, large	1,474,827	4,725,017	8,654,302	1,474,827	4,503,951	units retired early	
Number of units retired early, small	33,939,981	83,994,250	152,716,818	33,939,981	76,625,397	units retired early	
Efficiency improvement of all large retiring early	5.E+10	1.E+11	2.E+11	5.E+10	1.E+11	kWh/yr saved by replacing equipment early	
Efficiency improvement of all small retiring early	6.E+09	1.E+10	2.E+10	6.E+09	9.E+09	kWh/yr saved by replacing equipment early	
CO2 emissions factor from electricity generation	0.5	0.5	0.5	0.5	0.5	kg CO2/kWh	9
CO2 saved by efficiency improvements, large	492	1,081	1,884	492	1,031	MMT CO2 over the lifetime of equipment being phased out	
CO2 saved by efficiency improvements, small	28	49	84	28	44	MMT CO2 over the lifetime of equipment being phased out	

* Dark gray represent assumptions common to all options; light gray represents assumptions that vary based on policy options; white cells are calculated values

Sources: 1 = EPA, 2006a; 2 = IPCC, 2006; 3 = EPA, 2006b; 4 = McQuay, 2002; 5 = ACEEE, 2004; 6 = World Bank 2005; 7 = UNEP, 2007b; 8 = ICF 2007; 9 = Average of CO2 emissions factors listed in IPCC/TEAP, 2005

Table A-1. Assumptions: HCFC 22 Consumption Related to Energy Efficiency CO2 Emissions,* CONTINUED

Input	Option 5:		Option 6	Units	Source
	65% Reduction in A5, 2020	90% Reduction in A5, 2025	Accelerated Phaseout A5		
HCFC 22 consumption first 10 years	1,826,512	1,985,279	2,977,664	MT	
22 consumed in second 10 years	2,977,664	1,637,715	2,977,664	MT	
22 consumed for large units	50%	50%	50%		
22 consumed for small units	50%	50%	50%		
Lifetime, small units	10	10	10	yr	1,2
Lifetime, large units	20	20	20	yr	1,2
Total consumption subject to early retirement, large	2,402,088	1,811,497	2,977,664	MT	
Total consumption subject to early retirement, small	1,488,832	818,857	1,488,832	MT	
% consumption for new units	50%	50%	50%		3
% consumption for servicing	50%	50%	50%		3
Charge size, large	250	250	250	Kg	1
Charge size, small	7.5	7.5	7.5	Kg	1
Number of new units built during X years (lifetime), large	4,804,175	3,622,994	5,955,327	number of units	
Number of new units built during X years (lifetime), small	99,255,453	54,590,499	99,255,453	number of units	
kWh/yr/unit Saved, large	33,384	22,886	21,764	kWh/yr per unit Saved	4,6,7,8
kWh/yr/unit Saved, small	164	116	110	kWh/yr per unit Saved	5,6,7,8
Total baseline electricity improvement by large units, per year	2.E+11	8.E+10	1.E+11	kWh/yr for all units	
total baseline electricity improvement by small units, per year	2.E+10	6.E+09	1.E+10	kWh/yr for all units	
Percent of units retired early	25%	100%	100%		
Number of units retired early, large	1,201,044	3,622,994	5,955,327	units retired early	
Number of units retired early, small	24,813,863	54,590,499	99,255,453	units retired early	
Efficiency improvement of all large retiring early	4.E+10	8.E+10	1.E+11	kWh/yr saved by replacing equipment early	
Efficiency improvement of all small retiring early	4.E+09	6.E+09	1.E+10	kWh/yr saved by replacing equipment early	
CO2 emissions factor from electricity generation	0.5	0.5	0.5	kg CO2/kWh	9
CO2 saved by efficiency improvements, large	401	829	1,296	MMT CO2 over the lifetime of equipment being phased out	
CO2 saved by efficiency improvements, small	20	32	55	MMT CO2 over the lifetime of equipment being phased out	

* Dark gray represent assumptions common to all options; light gray represents assumptions that vary based on policy options; white cells are calculated values

Sources: 1 = EPA, 2006a; 2 = IPCC, 2006; 3 = EPA, 2006b; 4 = McQuay, 2002; 5 = ACEEE, 2004; 6 = World Bank, 2005; 7 = UNEP, 2007b; 8 = ICF, 2007; 9 = Average of CO2 emissions factors listed in IPCC/TEAP, 2005

Table A-1. Assumptions: HCFC 22 Consumption Related to Energy Efficiency CO2 Emissions,* CONTINUED

Input	Option 7			Units	Source
	"Worst First" A5 2020	"Worst First" A5 2025	Accelerated Phaseout A5		
HCFC 22 consumption first 10 years	1,826,512	1,985,279	0	MT	
22 consumed in second 10 years	2,977,664	1,494,038	75,483	MT	
22 consumed for large units	50%	50%	50%		
22 consumed for small units	50%	50%	50%		
Lifetime, small units	10	10	10	yr	1,2
Lifetime, large units	20	20	20	yr	1,2
Total consumption subject to early retirement, large	2,402,088	1,739,658	37,741	MT	
Total consumption subject to early retirement, small	1,488,832	747,019	37,741	MT	
% consumption for new units	50%	50%	50%		3
% consumption for servicing	50%	50%	50%		3
Charge size, large	250	250	250	Kg	1
Charge size, small	7.5	7.5	7.5	Kg	1
Number of new units built during X years (lifetime), large	4,804,175	3,479,317	75,483	number of units	
Number of new units built during X years (lifetime), small	99,255,453	49,801,250	2,516,091	number of units	
kWh/yr/unit Saved, large	33,384	22,886	21,764	kWh/yr per unit Saved	4,6,7,8
kWh/yr/unit Saved, small	164	116	110	kWh/yr per unit Saved	5,6,7,8
Total baseline electricity improvement by large units, per year	2.E+11	8.E+10	2.E+09	kWh/yr for all units	
total baseline electricity improvement by small units, per year	2.E+10	6.E+09	3.E+08	kWh/yr for all units	
Percent of units retired early	25%	100%	100%		
Number of units retired early, large	1,201,044	3,479,317	75,483	units retired early	
Number of units retired early, small	24,813,863	49,801,250	2,516,091	units retired early	
Efficiency improvement of all large retiring early	4.E+10	8.E+10	2.E+09	kWh/yr saved by replacing equipment early	
Efficiency improvement of all small retiring early	4.E+09	6.E+09	3.E+08	kWh/yr saved by replacing equipment early	
CO2 emissions factor from electricity generation	0.5	0.5	0.5	kg CO2/kWh	9
CO2 saved by efficiency improvements, large	401	796	16	MMT CO2 over the lifetime of equipment being phased out	
CO2 saved by efficiency improvements, small	20	29	1	MMT CO2 over the lifetime of equipment being phased out	

* Dark gray represent assumptions common to all options; light gray represents assumptions that vary based on policy options; white cells are calculated values

Sources: 1 = EPA, 2006a; 2 = IPCC, 2006; 3 = EPA, 2006b; 4 = McQuay, 2002; 5 = ACEEE, 2004; 6 = World Bank, 2005; 7 = UNEP, 2007b; 8 = ICF, 2007; 9 = Average of CO2 emissions factors listed in IPCC/TEAP, 2005

Annex B. Specific Assumptions for Options 4 and 7

For the purpose of this analysis, the following assumptions were made specific to Option 4 and Option 7.

Option 4

Maximum allowable consumption scenario:

- For A5 countries, starting in 2020, consumption of higher ODP HCFCs is assumed to be 25% of baseline and consumption of lower ODP HCFCs is assumed to be 75% of baseline. From 2025 through 2040, consumption of higher ODP HCFCs is assumed to be 5% of baseline and consumption of lower ODP HCFCs is assumed to be 95% of baseline.
- For non-A5 countries, starting in 2010, consumption of higher ODP HCFC is assumed to be 25% of baseline and consumption of lower ODP HCFCs is assumed to be 10% of baseline (to meet the maximum consumption cap of 35% of baseline). Starting in 2015, consumption of higher ODP HCFCs is assumed to be 5% of baseline, and consumption of lower ODP HCFCs is assumed to be 5% of baseline (to meet the maximum consumption cap of 10% of baseline). From 2020 to 2030, total consumption of HCFCs was assumed to be 0.5% of baseline.

Constant lower ODP HCFC consumption scenario:

- For A5 countries, starting in 2020, consumption of higher ODP HCFCs was assumed to be 25% of baseline and consumption of lower ODP HCFCs is assumed to continue at a constant level of 1.4% of baseline. From 2025 through 2040, consumption of higher ODP HCFCs was assumed to be 5% of baseline and consumption of lower ODP HCFCs is assumed to continue at a constant level of 1.4% of baseline.
- For non-A5 countries, starting in 2010, consumption of higher ODP HCFC is assumed to be 25% of baseline and consumption of lower ODP HCFCs is assumed to continue at a constant level of 5.7% of baseline. Starting in 2015, consumption of higher ODP HCFCs is assumed to be 5% of baseline, and consumption of lower ODP HCFCs is assumed to be 5% of baseline (to meet the maximum consumption cap of 10% of baseline). From 2020 to 2030, total consumption of HCFCs is assumed to be 0.5% of baseline.

Option 7

Maximum allowable consumption scenario:

- For A5 countries, starting in 2020, consumption of higher ODP HCFCs is assumed to be 25% of baseline and consumption of lower ODP HCFCs was assumed to be 10% of the 2010 baseline (to meet the maximum consumption cap of 35% of baseline). From 2025 through 2030, consumption of higher ODP HCFCs is assumed to be 5% of the 2010 baseline and consumption of lower ODP HCFCs is assumed to be 5% of baseline (to meet the maximum consumption cap of 10% of baseline).
- For non-A5 countries, starting in 2010, consumption of higher ODP HCFC was assumed to be 25% of baseline and consumption of lower ODP HCFCs was assumed to be 10% of baseline (to meet the maximum consumption cap of 35% of baseline). From 2015 to 2030, consumption of higher ODP HCFCs was assumed to be 5% of baseline, and consumption of lower ODP HCFCs was assumed to be 5% of baseline (to meet the maximum consumption cap of 10% of baseline).

Constant lower ODP HCFC consumption scenario:

- For A5 countries, starting in 2020, consumption of higher ODP HCFCs was assumed to be 25% of the 2010 baseline and consumption of lower ODP HCFCs was assumed to continue at a constant level of 1.4% of baseline. From 2025 through 2030, consumption of higher ODP HCFCs was assumed to be 5% of baseline and consumption of lower ODP HCFCs was assumed to continue at a constant level of 1.4% of baseline.

- For non-A5 countries, starting in 2010, consumption of higher ODP HCFC was assumed to be 25% of baseline and consumption of lower ODP HCFCs was assumed to continue at a constant level of 5.7% of baseline. From 2015 to 2030, consumption of higher ODP HCFCs was assumed to be 5% of baseline, and consumption of lower ODP HCFCs was assumed to be 5% of baseline (to meet the maximum consumption cap of 10% of baseline).

Annex C. Alternate Growth Rate Scenarios for Article 5 Countries

As described in Section 4.1, the development of consumption baselines for this report assumes an average annual consumption growth rate of 9 percent for Article 5 (A5) countries; for sensitivity, the analysis was run varying this assumption. This Annex presents the estimated changes in consumption and emissions of chemicals that affect stratospheric ozone and/or the climate for each proposed HCFC phaseout adjustment assuming annual consumption growth rates of 5, 7, and 12 percent. Specifically, Section C.1 presents results based on an average annual growth rate of 5 percent for A5 countries, Section C.2 presents results based on a growth rate of 7 percent; and Section C.3 presents results based on the growth rate of 12 percent, as used in the previous version of this analysis. **Reductions are shown as negative values, and increases are shown as positive values.**

C.1. Alternate Results using a 5 Percent Annual Consumption Average Growth Rate for A5 Countries

Table C-1 presents the consumption baselines that reflect the current phaseout schedules based on the assumption of a 5% growth rate for A5 countries.

Table C-1. Aggregate HCFC Consumption Baseline (ODP-Weighted Metric Tons)

	A5 Countries	Non-A5 Countries	Global
Consumption	1,230,000	504,000	1,730,000
Emissions	528,000	224,000	752,000

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

C.1.1. ODP-Weighted Changes in HCFC Consumption and Emissions

Tables C-2 and C-3 present changes in aggregated HCFC consumption and emissions in ODP-weighted metric tons, respectively. As shown, each option (except the first scenario of Option 4) resulted in estimated reductions in ODP-weighted HCFC consumption and emissions from 2010 through 2040.

Table C-2. Changes in Aggregate HCFC Consumption (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-567,000	0	-567,000	-33%
Option 2	-197,000	0	-197,000	-11%
Option 3	-339,000	-1,840	-341,000	-20%
Option 4				
Maximum allowable consumption scenario:	0	0	0	0%
Constant lower ODP HCFC consumption scenario:	-600,000	-13,900	-614,000	-35%
Option 5 (combines Options 1 & 2)	-642,000	0	-642,000	-37%
Option 6 (combines Options 2 & 3)	-463,000	-1,840	-464,000	-27%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-668,000	-1,840	-670,000	-39%
Constant lower ODP HCFC consumption scenario:	-685,000	-15,700	-700,000	-40%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

Table C-3. Changes in Aggregate HCFC Emissions (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-244,000	0	-244,000	-32%
Option 2	-84,900	0	-84,900	-11%
Option 3	-146,000	-819	-147,000	-19%
Option 4				
Maximum allowable consumption scenario:	8,150	-27.1	8,120	1%
Constant lower ODP HCFC consumption scenario:	-258,000	-6,180	-264,000	-35%
Option 5 (combines Options 1 & 2)	-276,000	0	-276,000	-37%
Option 6 (combines Options 2 & 3)	-199,000	-819	-200,000	-27%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-287,000	-846	-288,000	-38%
Constant lower ODP HCFC consumption scenario:	-294,000	-7,000	-301,000	-40%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

C.1.2. GWP-Weighted Changes in HCFC Consumption and Emissions

Tables C-4 and C-5 present changes in aggregated HCFC consumption and emissions in GWP-weighted metric tons, respectively. As shown, all options result in an estimated net increase in GWP-weighted HCFC and HFC consumption (i.e., net global climate impact) through 2040 with the exception of a slight decrease for the second scenario of Option 4. Also, as shown in Table C-5, all options result in an estimated net decrease in GWP-weighted HCFC and HFC emissions (i.e., net global climate impact), except for Option 2.

Table C-4. Changes in Aggregate HCFC Consumption (MMTCE, Using Direct GWP)

Option	*Reductions*	*Increases*	Net Global Climate Impact
	Reduced HCFC Consumption	Transition to Alternatives[a]	
Option 1	-2,970	3,090	119
Option 2	-1,030	1,070	41.4
Option 3	-1,780	1,850	72.0
Option 4			
Maximum allowable consumption scenario:	-2,980	3,350	372
Constant lower ODP HCFC consumption scenario:	-3,300	3,270	-35.1
Option 5 (combines Options 1 & 2)	-3,360	3,490	135
Option 6 (combines Options 2 & 3)	-2,430	2,530	98.0
Option 7 (combines Options 1, 2, 3, & 4)			
Maximum allowable consumption scenario:	-3,710	3,790	79.2
Constant lower ODP HCFC consumption scenario:	-3,730	3,760	31.9

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Table C-5. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-1,830	-19.3	-331	1,970	-203
Option 2	-635	-6.7	0	687	44.5
Option 3	-1,100	-11.6	-364	1,190	-286
Option 4					
Maximum allowable consumption scenario:	-1,890	-21.6	-321	2,150	-90.7
Constant lower ODP HCFC consumption scenario:	-2,040	-21.6	-321	2,090	-289
Option 5 (combines Options 1 & 2)	-2,070	-21.9	-290	2,230	-145
Option 6 (combines Options 2 & 3)	-1,500	-15.8	-294	1,620	-189
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-2,290	-24.3	-286	2,420	-175
Constant lower ODP HCFC consumption scenario:	-2,300	-24.3	-286	2,400	-203

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

C.2. Alternate Results using a 7 Percent Annual Consumption Average Growth Rate for A5 Countries

Table C-6 presents the consumption baselines that reflect the current phaseout schedules based on the assumption of a 7% growth rate for A5 countries.

Table C-6. Aggregate HCFC Consumption Baseline (ODP-Weighted Metric Tons)

	A5 Countries	Non-A5 Countries	Global
Consumption	1,450,000	504,000	1,960,000
Emissions	626,000	224,000	850,000

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

C.2.1. ODP-Weighted Changes in HCFC Consumption and Emissions

Tables C-7 and C-8 present changes in aggregated HCFC consumption and emissions in ODP-weighted metric tons, respectively. As shown, each option (except the first scenario of Option 4) resulted in estimated reductions in ODP-weighted HCFC consumption and emissions from 2010 through 2040.

Table C-7. Changes in Aggregate HCFC Consumption (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-698,000	0.0	-698,000	-36%
Option 2	-321,000	0.0	-321,000	-16%
Option 3	-417,000	-1,840	-419,000	-21%
Option 4				
Maximum allowable consumption scenario:	0.0	0.0	0.0	0%
Constant lower ODP HCFC consumption scenario:	-739,000	-13,900	-753,000	-38%
Option 5 (combines Options 1 & 2)	-819,000	0.0	-819,000	-42%
Option 6 (combines Options 2 & 3)	-619,000	-1,840	-620,000	-32%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-849,000	-1,840	-851,000	-43%
Constant lower ODP HCFC consumption scenario:	-867,000	-15,700	-883,000	-45%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

Table C-8. Changes in Aggregate HCFC Emissions (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-300,000	0	-300,000	-35%
Option 2	-138,000	0	-138,000	-16%
Option 3	-179,000	-819	-180,000	-21%
Option 4				
Maximum allowable consumption scenario:	10,000	-27.1	10,000	1%
Constant lower ODP HCFC consumption scenario:	-318,000	-6,180	-324,000	-38%
Option 5 (combines Options 1 & 2)	-352,000	0	-352,000	-41%
Option 6 (combines Options 2 & 3)	-266,000	-819	-267,000	-31%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-365,000	-846	-366,000	-43%
Constant lower ODP HCFC consumption scenario:	-373,000	-7,000	-380,000	-45%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

C.2.2. GWP-Weighted Changes in HCFC Consumption and Emissions

Tables C-9 and C-10 present changes in aggregated HCFC consumption and emissions in MMTCE, respectively. As shown, all options result in an estimated net increase in GWP-weighted HCFC and HFC consumption (i.e., net global climate impact) through 2040 with the exception of a slight decrease for the second scenario of Option 4. Also, as shown in Table C-10, all options result in an estimated net decrease in GWP-weighted HCFC and HFC emissions (i.e., net global climate impact), except for Option 2.

Table C-9. Changes in Aggregate HCFC Consumption (MMTCE, Using Direct GWP)

Option	*Reductions*	*Increases*	Net Global Climate Impact
	Reduced HCFC Consumption	Transition to Alternatives[a]	
Option 1	-3,650	3,800	146
Option 2	-1,680	1,750	67.4
Option 3	-2,190	2,280	88.4
Option 4			
Maximum allowable consumption scenario:	-3,640	4,100	455
Constant lower ODP HCFC consumption scenario:	-4,030	4,010	-23.7
Option 5 (combines Options 1 & 2)	-4,290	4,460	172
Option 6 (combines Options 2 & 3)	-3,250	3,380	131
Option 7 (combines Options 1, 2, 3, & 4)			
Maximum allowable consumption scenario:	-4,670	4,760	98.2
Constant lower ODP HCFC consumption scenario:	-4,680	4,750	66.8

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Table C-10. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-2,250	-23.8	-386	2,430	-228
Option 2	-1,040	-11.0	0	1,120	72.5
Option 3	-1,350	-14.3	-442	1,460	-348
Option 4					
Maximum allowable consumption scenario:	-2,310	-26.4	-374	2,620	-91.3
Constant lower ODP HCFC consumption scenario:	-2,490	-26.4	-374	2,570	-321
Option 5 (combines Options 1 & 2)	-2,640	-27.9	-318	2,850	-134
Option 6 (combines Options 2 & 3)	-2,000	-21.2	-330	2,160	-189
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-2,880	-30.6	-314	3,050	-175
Constant lower ODP HCFC consumption scenario:	-2,890	-30.6	-314	3,040	-192

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

C.3. Alternate Results using a 12 Percent Annual Consumption Average Growth Rate for A5 Countries

Table C-11 presents the consumption baselines that reflect the current phaseout schedules based on the assumption of a 12% growth rate for A5 countries.

Table C-11. Aggregate HCFC Consumption Baseline (ODP-Weighted Metric Tons)

	A5 Countries	Non-A5 Countries	Global
Consumption	2,230,000	504,000	2,740,000
Emissions	960,000	224,000	1,180,000

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

C.3.1. ODP-Weighted Changes in HCFC Consumption and Emissions

Tables C-12 and C-13 present changes in aggregated HCFC consumption and emissions in ODP-weighted metric tons, respectively. As shown, each option (except the first scenario of Option 4) resulted in estimated reductions in ODP-weighted HCFC consumption and emissions from 2010 through 2040.

Table C-12. Changes in Aggregate HCFC Consumption (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-1,150,000	0	-1,150,000	-42%
Option 2	-798,000	0	-798,000	-29%
Option 3	-689,000	-1,840	-691,000	-25%
Option 4				
Maximum allowable consumption scenario:	0	0	0	0%
Constant lower ODP HCFC consumption scenario:	-1,220,000	-13,900	-1,230,000	-45%
Option 5 (combines Options 1 & 2)	-1,450,000	0.0	-1,450,000	-53%
Option 6 (combines Options 2 & 3)	-1,190,000	-1,840	-1,190,000	-44%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-1,490,000	-1,840	-1,490,000	-55%
Constant lower ODP HCFC consumption scenario:	-1,520,000	-15,700	-1,530,000	-56%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

Table C-13. Changes in Aggregate HCFC Emissions (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-496,000	0	-496,000	-42%
Option 2	-343,000	0	-343,000	-29%
Option 3	-296,000	-819	-297,000	-25%
Option 4				
Maximum allowable consumption scenario:	16,600	-27.1	16,500	1%
Constant lower ODP HCFC consumption scenario:	-525,000	-6,180	-531,000	-45%
Option 5 (combines Options 1 & 2)	-625,000	0	-625,000	-53%
Option 6 (combines Options 2 & 3)	-511,000	-819	-512,000	-43%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-641,000	-846	-642,000	-54%
Constant lower ODP HCFC consumption scenario:	-652,000	-7,000	-659,000	-56%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

C.3.2. GWP-Weighted Changes in HCFC Consumption and Emissions

Tables C-14 and C-15 present changes in aggregated HCFC consumption and emissions in MMTCE, respectively. As shown, all options result in an estimated net increase in GWP-weighted HCFC and HFC consumption (i.e., net global climate impact) through 2040. Also, as shown in Table C-15, all options result in an estimated net decrease in GWP-weighted HCFC and HFC emissions (i.e., net global climate impact), except for Option 2.

Table C-14. Changes in Aggregate HCFC Consumption (MMTCE, Using Direct GWP)

Option	*Reductions*	*Increases*	Net Global Climate Impact
	Reduced HCFC Consumption	Transition to Alternatives[a]	
Option 1	-6,040	6,280	242
Option 2	-4,170	4,340	167
Option 3	-3,610	3,760	145
Option 4			
Maximum allowable consumption scenario:	-5,950	6,690	745
Constant lower ODP HCFC consumption scenario:	-6,590	6,600	15.8
Option 5 (combines Options 1 & 2)	-7,600	7,900	305
Option 6 (combines Options 2 & 3)	-6,230	6,480	250
Option 7 (combines Options 1, 2, 3, & 4)			
Maximum allowable consumption scenario:	-8,060	8,230	166
Constant lower ODP HCFC consumption scenario:	-8,080	8,270	193

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Table C-15. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-3,720	-39.4	-568	4,020	-308
Option 2	-2,570	-27.2	0	2,780	180
Option 3	-2,230	-23.6	-713	2,400	-557
Option 4					
Maximum allowable consumption scenario:	-3,780	-43.1	-548	4,280	-85.5
Constant lower ODP HCFC consumption scenario:	-4,060	-43.1	-548	4,230	-426
Option 5 (combines Options 1 & 2)	-4,680	-49.5	-402	5,060	-74.1
Option 6 (combines Options 2 & 3)	-3,840	-40.6	-434	4,140	-165
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-4,970	-52.7	-396	5,260	-155
Constant lower ODP HCFC consumption scenario:	-4,980	-52.7	-396	5,290	-134

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Annex D. Alternate Ratio of HFC-23 Produced to HCFC-22 Consumed

The analysis presented in the report assumes HFC-23 emissions are 2% of HCFC-22 consumption (on a non-ODP-weighted metric ton per metric ton basis); for sensitivity, the analysis was run varying this assumption. This Annex presents the estimated changes in consumption and emissions of chemicals that affect stratospheric ozone and/or the climate for each proposed HCFC phaseout adjustment assuming HFC-23 emissions are 3% of HCFC-22 consumption. Therefore, the scenario examined in this Annex assumes that (a) HFC-23 emissions are 3% of HCFC-22 consumption, and (b) average annual growth rate in HCFC consumption is 9% in A5 countries (as outlined in the body of this report). **Reductions are shown as negative values, and increases are shown as positive values.**

As shown in Table D-1, as in the results presented in Section 5, all options result in a net decrease in GWP-weighted HCFC and HFC emissions, except for Option 2. There is a very little change in the overall results as presented in Section 5 of this report compared to the results provided in Table D-1. Overall results decreased between zero and ten MMTCE as a result of the adjustment in ratio of HFC-23 produced to HCFC-22 consumed.

Table D-1. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-2,760	-43.8	-450	2,980	-271
Option 2	-1,550	-24.6	0	1,670	100
Option 3	-1,650	-26.2	-537	1,790	-429
Option 4					
Maximum allowable consumption scenario:	-2,820	-48.2	-435	3,200	-106
Constant lower ODP HCFC consumption scenario:	-3,030	-48.2	-435	3,140	-375
Option 5 (combines Options 1 & 2)	-3,340	-53.0	-350	3,610	-133
Option 6 (combines Options 2 & 3)	-2,620	-41.6	-368	2,830	-198
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-3,600	-57.3	-345	3,810	-190
Constant lower ODP HCFC consumption scenario:	-3,600	-57.3	-345	3,810	-194

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

ATTACHMENT B:

ALTERNATE RESULTS BASED ON UPDATED ASSUMPTIONS

(UPDATES FROM SEPTEMBER 2007)

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1. Introduction

Attachment B presents a report containing updated results on changes in HCFC consumption and emissions from the U.S. proposed adjustments for accelerating the HCFC phaseout, based on newly available information on the breakout of HCFCs by gas in Article 5 (A5) countries and updated global warming potentials (GWPs) from the 2007 Report on Scientific Assessment of Ozone Depletion. The preliminary analysis presented in the report "Changes in HCFC Consumption and Emissions from the US Proposed Adjustments for Accelerating the HCFC Phaseout"—which was submitted to the Ozone Secretariat in August 2007 and is presented in Attachment A—uses assumptions for disaggregating total ozone depletion potential (ODP)-weighted HCFC consumption for A5 countries based on a UNDP study that collected detailed surveys from nine A5 countries. The limitations section of the August Report stated that to the extent to which additional information comes to light regarding HCFC consumption by gas, further refinements to the assumptions would provide more precise estimates.

To that end, newer data has been identified on the breakout of HCFC consumption by gas in A5 countries and has been incorporated into the analysis to determine the results based on this new information. The remainder of the report in Attachment B is organized as follows;

- Section 2 outlines the differences between the assumptions used in the August 21 report and those based on newly available data;
- Section 3 describes the observed changes in the results;
- Section 4 presents the full set of results with the updated assumptions; and
- Sections 5 and 6 present the sensitivity analyses with Section 5 presenting results based on different growth rates for Article 5 consumption and Section 6 presenting results based on the use of a different percent of HFC-23 emissions from HCFC-22 consumption.

2. Differences in Assumptions between August Report and September Update

In this report, two revisions were made to the assumptions used in the August Report—i) the breakout of HCFC consumption by gas in A5 countries; and ii) direct GWP values, as described below.

Breakout of HCFC Consumption by Gas in A5 Countries. New data on the breakout of HCFC consumption in A5 countries has become available in a newly released report from the Multilateral Fund Secretariat on the compliance status of A5 countries. The information provided is based on HCFC consumption by gas provided in the country reports of 64 A5 countries as of 2006.[14]

According to the recent study, HCFC-22 represents a larger portion of total HCFC consumption, and HCFC-142b represents the majority of the remaining HCFCs (4.2% out of 4.6%). Thus, HCFC-142b was deemed a more appropriate proxy for the category "Other HCFCs" for A5 countries. Please note that HCFC-123 was used as the proxy for "Other HCFCs" in A5 and non-A5 countries in the August report, and that HCFC-123 continues to be used as the "Other HCFCs" proxy for non-A5 countries.

Table B-1 compares the assumptions used for the August Report and for the results generated for this report ("September Update").

Table B-1. Comparison of Assumptions: A5 Countries, % HCFC Consumption (ODP-weighted MT)

	August Report	September Update
HCFC-22	49.3%	65.7%
HCFC-141b	49.3%	29.7%
Other	1.4%	4.6%

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[14] UNEP. 2007. "Status/Prospects of Article 5 Countries in Achieving Compliance with the Initial and Intermediate Control Measures of the Montreal Protocol." Document number: UNEP/OzL.Pro/ExCom/52/7/Rev.1. 9 July 2007. Data is from Table 12 on page 15 of the report.

Direct GWP Values. To maintain consistency among analyses prepared for the U.S. EPA and European Commission, the direct GWP values for HCFC-22, HCFC-141b, HCFC-123, and HCFC-142b were updated to those cited by the Report on Scientific Assessment of Ozone Depletion.[15] The GWPs used in the August Report were sourced from IPCC/TEAP 2005.[16] Table B-2 presents the GWP values from these different sources.

Table B-2. Comparison of Direct GWP Values

	August Report (IPCC/TEAP 2005)	September Update (WMO/SAP 2007)
HCFC-22	1,780	1,810
HCFC-141b	713	725
Other-A5 Countries	76 (HCFC-123)	2,310 (HCFC-142b)
Other-Non-A5 Countries	76 (HCFC-123)	77 (HCFC-123)

3. Observed Changes in Results

Table B-3 shows the changes in HCFC consumption and emissions reductions between the August Report and the new assumptions in this update. Because most options are calculated based on allowed consumption in ODP-weighted metric tons, aggregate HCFC consumption reductions did not change using the new assumptions, with the exception of consumption reductions attributed to the "constant lower ODP HCFC" scenarios in Options 4 and 7. Under these scenarios, consumption reductions did change slightly because these scenarios assume that consumption does not automatically increase to the ODP-weighted cap.

All estimates of HCFC emission reductions also changed slightly under the new assumptions. With the exception of the maximum allowable consumption scenario under Option 4, the differences between the August Report results and these updated results are relatively minimal. For example, the difference between emission reductions of -461,000 and -562,000 under the maximum allowable consumption scenario of Option 7 is only 2% of baseline emissions (i.e., the difference between reducing 48% from baseline and 50% from baseline). These changes can be attributed to the increased percent of consumption associated with HCFC-22. The consumption to emissions ratio for HCFC-22 is significantly higher than that of HCFC-141b (71% and 15% for HCFC-22 and HCFC-141b, respectively); hence, more emissions are assumed to be avoided using the revised assumptions.

Table B-3. Comparison of Reductions in HCFC Consumption and Emissions, in ODP-Weighted Metric Tons

Option	Changes in Aggregate HCFC CONSUMPTION: ODP-Weighted Impact		Changes in Aggregate HCFC EMISSIONS: ODP-Weighted Impact	
	August Report	September Update	August Report	September Update
Option 1	-856,000	No change	-368,000	-442,000
Option 2	-480,000	No change	-206,000	-248,000
Option 3	-513,000	No change	-221,000	-265,000
Option 4				
Maximum allowable consumption scenario:	0	No change	12,300	-354,000
Constant lower ODP HCFC consumption scenario:	-920,000	-887,000	-396,000	-473,000
Option 5 (combines Options 1 & 2)	-1,040,000	No change	-446,000	-535,000
Option 6 (combines Options 2 & 3)	-814,000	No change	-350,000	-420,000
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-1,070,000	No change	-461,000	-562,000
Constant lower ODP HCFC consumption scenario:	-1,110,000	-1,090,000	-476,000	-570,000

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[15] WMO. 2007. Scientific Assessment of Ozone Depletion: 2006. World Meteorological Organization. Global Ozone Research and Monitoring Project—Report No. 50. p 8.35.

[16] IPCC/TEAP. 2005. IPCC Special Report on Safeguarding the Ozone Layer and Global Climate System—Issues related to Hydrofluorocarbons and Perfluorocarbons, Bert Metz, Lambert Kuijpers, Susan Solomon, Stephen O. Andersen, Ogunlade Davidson, José Pons, David de Jager, Tahl Kestin, Martin Manning, and Leo Meyer (Eds.) Cambridge University Press, UK.

Table B-4 below compares the net global climate impact as presented in the August Report and as generated using the revised assumptions in this update. For the reasons described above, the net climate impact is improved under the new assumptions; under some options, the direction of the impact changed from a net *increase* in GWP-weighted HCFC and HFC consumption to a net *decrease*. Regardless, the conclusion is still the same: adjusting the HCFC phaseout schedule according to the U.S. proposal can have small, but discernable benefits for the climate.

As noted above, these changes can be partly attributed to the revision in the assumed percent breakout of overall HCFC consumption that increased the amount of consumption assumed to be HCFC-22 and decreased the amount assumed to be HCFC-141b. This change means that relatively more HCFC-22 and relatively less HCFC-141b is assumed to be phased out under each of the proposed options. Because HCFC-22 has a higher GWP value (1,810) than HCFC-141b (725), the net global climate impact is improved. The replacement of HCFC-123 with HCFC-142b as the proxy for "Other HCFCs" in A5 countries also contributes slightly to this effect, since HCFC-142b has a higher GWP (2,310) than HCFC-123 (77). A further reason that the revised results show a greater net global climate impact for emissions is that a greater proportion of consumption associated with HCFC-22 means more energy efficiency gains are captured in this analysis. This is because the energy efficiency methodology of this analysis uses HCFC-22 consumption as the basis for determining the potential for energy improvements; more HCFC-22 consumption translates into more HCFC-based refrigeration/AC equipment that is projected to be converted to more efficient alternatives.

Table B-4. Comparison of Net Climate Impact, in MMTCE

Option	Changes in Aggregate HCFC CONSUMPTION: Net Global Climate Impact		Changes in Aggregate HCFC EMISSIONS: Net Global Climate Impact	
	August Report	September Update	August Report	September Update
Option 1	180	-702	-257	-1,020
Option 2	101	-394	108	-236
Option 3	108	-418	-421	-965
Option 4				
Maximum allowable consumption scenario:	555	7,870	-90.4	-33.4
Constant lower ODP HCFC consumption scenario:	-10.0	-684	-359	-1,200
Option 5 (combines Options 1 & 2)	217	-850	-116	-975
Option 6 (combines Options 2 & 3)	171	-665	-184	-889
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	121	-939	-171	-1,140
Constant lower ODP HCFC consumption scenario:	110	-934	-175	-1,090

4. Updated Results

This section presents estimated changes in consumption and emissions of chemicals that affect stratospheric ozone and the climate for each HCFC phaseout proposed adjustment, with reductions shown as negative values, and increases shown as positive values. For reference, the consumption baselines that reflect the current phaseout schedules are presented in Table B-5.

Table B-5. Aggregate HCFC Consumption Baseline (ODP-Weighted Metric Tons)

	A5 Countries	Non-A5 Countries	Global
Consumption	1,720,000	504,000	2,230,000
Emissions	891,000	224,000	1,120,000

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

ODP-Weighted Changes in HCFC Consumption and Emissions. As shown in Table B-6 and B-7, **each option (except the first scenario of Option 4) resulted in estimated reductions in ODP-weighted HCFC consumption and emissions from 2010 through 2040**. Option 7 (a combination of Options 1, 2, 3, and 4) produces the greatest reduction in ODP-weighted HCFC consumption and emissions. Additionally, although Option 4 under the maximum allowable consumption scenario does not result in changes in ODP-weighted consumption, because the mix of HCFCs is modified, changes in HCFC emissions result.

Table B-6. Changes in Aggregate HCFC Consumption (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-856,000	0	-856,000	-38%
Option 2	-480,000	0	-480,000	-22%
Option 3	-511,000	-1,840	-513,000	-23%
Option 4				
Maximum allowable consumption scenario:	0.0	0	0	0%
Constant lower ODP HCFC consumption scenario:	-873,000	-13,900	-887,000	-40%
Option 5 (combines Options 1 & 2)	-1,040,000	0	-1,040,000	-46%
Option 6 (combines Options 2 & 3)	-812,000	-1,840	-814,000	-37%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-1,070,000	-1,840	-1,070,000	-48%
Constant lower ODP HCFC consumption scenario:	-1,080,000	-15,700	-1,090,000	-49%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

Table B-7. Changes in Aggregate HCFC Emissions (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-442,000	0	-442,000	-40%
Option 2	-248,000	0	-248,000	-22%
Option 3	-264,000	-819	-265,000	-24%
Option 4				
Maximum allowable consumption scenario:	-353,000	-27.1	-354,000	-32%
Constant lower ODP HCFC consumption scenario:	-467,000	-6,180	-473,000	-42%
Option 5 (combines Options 1 & 2)	-535,000	0	-535,000	-48%
Option 6 (combines Options 2 & 3)	-420,000	-819	-420,000	-38%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-561,000	-846	-562,000	-50%
Constant lower ODP HCFC consumption scenario:	-563,000	-7,000	-570,000	-51%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

GWP-Weighted Changes in HCFC Consumption and Emissions . As shown in Table B-8, all options result in an **estimated net decrease in GWP-weighted HCFC and HFC consumption (i.e., net global climate impact) from 2010 through 2040 with the exception of an increase for the first scenario of Option 4.** Also, as shown in Table B-9, all options result in **an estimated net decrease in GWP-weighted HCFC and HFC emissions (i.e., net global climate impact). Under all proposed adjustments, decreases to CO_2 emissions resulting from improved energy efficiency result in a climate benefit.** Option 7 produces the greatest reduction in GWP-weighted HCFC consumption and emissions. When accounting for transitions to HFCs and energy efficiency improvements, the second scenario of Option 4 yields the largest reduction in total greenhouse gas emissions. Under both combined Options 5 and 6, because the Article 5 countries' baseline is set five years earlier, fewer HCFC-containing units are phased out at each of the interim reductions, and therefore *marginal* energy efficiency improvements are actually less than those experienced under respective Options 1 and 3 alone.

Table B-8. Changes in Aggregate HCFC Consumption (MMTCE, Using Direct GWP)

Option	*Reductions*	*Increases*	Net Global Climate Impact
	Reduced HCFC Consumption	Transition to Alternatives[a]	
Option 1	-5,890	5,180	-702
Option 2	-3,300	2,910	-394
Option 3	-3,520	3,110	-418
Option 4			
Maximum allowable consumption scenario:	2,460	5,410	7,870
Constant lower ODP HCFC consumption scenario:	-6,010	5,320	-684
Option 5 (combines Options 1 & 2)	-7,130	6,280	-850
Option 6 (combines Options 2 & 3)	-5,590	4,930	-665
Option 7 (combines Options 1, 2, 3, & 4)			
Maximum allowable consumption scenario:	-7,420	6,480	-939
Constant lower ODP HCFC consumption scenario:	-7,520	6,580	-934

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Table B-9. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-3,700	-38.9	-600	3,320	-1,020
Option 2	-2,070	-21.8	0	1,860	-236
Option 3	-2,210	-23.3	-715	1,990	-965
Option 4					
Maximum allowable consumption scenario:	-2,870	-42.4	-581	3,460	-33.4
Constant lower ODP HCFC consumption scenario:	-3,980	-42.4	-581	3,400	-1,200
Option 5 (combines Options 1 & 2)	-4,480	-47.1	-466	4,020	-975
Option 6 (combines Options 2 & 3)	-3,510	-37.0	-491	3,150	-889
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-4,770	-50.5	-461	4,140	-1,140
Constant lower ODP HCFC consumption scenario:	-4,790	-50.5	-461	4,210	-1,090

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

5. Updated Results: Alternate Growth Rate Scenarios in A5 Countries

The analysis presented in the report assumes an average annual growth rate of 9 percent for Article 5 (A5) countries; for sensitivity, the analysis was run varying this assumption. Estimated changes in consumption and emissions of chemicals that affect stratospheric ozone and/or the climate for each proposed HCFC phaseout adjustment are presented below assuming annual consumption growth rates of 5, 7, and 12 percent. **Reductions are shown as negative values, and increases are shown as positive values.**

ALTERNATE RESULTS USING A 5 PERCENT ANNUAL CONSUMPTION AVERAGE GROWTH RATE FOR A5 COUNTRIES

Table B-10 presents the consumption baselines that reflect the current phaseout schedules based on the assumption of a 5% growth rate for A5 countries.

Table B-10. Aggregate HCFC Consumption Baseline (ODP-Weighted Metric Tons)

	A5 Countries	Non-A5 Countries	Global
Consumption	1,230,000	504,000	1,730,000
Emissions	634,000	224,000	859,000

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

ODP-Weighted Changes in HCFC Consumption and Emissions. Tables B-11 and B-12 present changes in aggregated HCFC consumption and emissions in ODP-weighted metric tons, respectively. As shown, each option resulted in estimated reductions in ODP-weighted HCFC consumption (except the first scenario of Option 4) and emissions through 2040.

Table B-11 Changes in Aggregate HCFC Consumption (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-567,000	0	-567,000	-33%
Option 2	-197,000	0	-197,000	-11%
Option 3	-339,000	-1,840	-341,000	-20%
Option 4				
Maximum allowable consumption scenario:	0	0	0	0%
Constant lower ODP HCFC consumption scenario:	-579,000	-13,900	-592,000	-34%
Option 5 (combines Options 1 & 2)	-642,000	0	-642,000	-37%
Option 6 (combines Options 2 & 3)	-463,000	-1,840	-464,000	-27%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-668,000	-1,840	-670,000	-39%
Constant lower ODP HCFC consumption scenario:	-676,000	-15,700	-692,000	-40%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

Table B-12. Changes in Aggregate HCFC Emissions (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-293,000	0	-293,000	-34%
Option 2	-102,000	0	-102,000	-12%
Option 3	-175,000	-819	-176,000	-20%
Option 4				
Maximum allowable consumption scenario:	-234,000	-27.1	-234,000	-27%
Constant lower ODP HCFC consumption scenario:	-310,000	-6,180	-316,000	-37%
Option 5 (combines Options 1 & 2)	-332,000	0	-332,000	-39%
Option 6 (combines Options 2 & 3)	-239,000	-819	-240,000	-28%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-352,000	-846	-353,000	-41%
Constant lower ODP HCFC consumption scenario:	-353,000	-7,000	-360,000	-42%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

GWP-Weighted Changes in HCFC Consumption and Emissions. Tables B-13 and B-14 present changes in aggregated HCFC consumption and emissions in GWP-weighted metric tons, respectively. As shown, all options result in an estimated net decrease in GWP-weighted HCFC and HFC consumption (i.e., net global climate impact) through 2040 with the exception of an increase for the first scenario of Option 4. Also, as shown in Table B-14, all options result in an estimated net decrease in GWP-weighted HCFC and HFC emissions (i.e., net global climate impact).

Table B-13. Changes in Aggregate HCFC Consumption (MMTCE, Using Direct GWP)

Option	*Reductions*	*Increases*	Net Global Climate Impact
	Reduced HCFC Consumption	Transition to Alternatives[a]	
Option 1	-3,900	3,440	-465
Option 2	-1,360	1,190	-162
Option 3	-2,340	2,060	-277
Option 4			
Maximum allowable consumption scenario:	1,590	3,630	5,220
Constant lower ODP HCFC consumption scenario:	-4,020	3,540	-483
Option 5 (combines Options 1 & 2)	-4,410	3,890	-526
Option 6 (combines Options 2 & 3)	-3,190	2,810	-379
Option 7 (combines Options 1, 2, 3, & 4)			
Maximum allowable consumption scenario:	-4,670	4,110	-556
Constant lower ODP HCFC consumption scenario:	-4,750	4,140	-611

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Table B-14. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-2,450	-25.8	-441	2,200	-720
Option 2	-852	-9.0	0	764	-96.9
Option 3	-1,470	-15.5	-484	1,320	-650
Option 4					
Maximum allowable consumption scenario:	-1,930	-28.4	-429	2,320	-64.3
Constant lower ODP HCFC consumption scenario:	-2,660	-28.4	-429	2,260	-855
Option 5 (combines Options 1 & 2)	-2,770	-29.2	-386	2,490	-701
Option 6 (combines Options 2 & 3)	-2,000	-21.1	-392	1,800	-619
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-3,020	-32.1	-382	2,630	-805
Constant lower ODP HCFC consumption scenario:	-3,040	-32.1	-382	2,650	-800

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

ALTERNATE RESULTS USING A 7 PERCENT ANNUAL CONSUMPTION AVERAGE GROWTH RATE FOR A5 COUNTRIES

Table B-15 presents the consumption baselines that reflect the current phaseout schedules based on the assumption of a 7% growth rate for A5 countries.

Table B-15. Aggregate HCFC Consumption Baseline (ODP-Weighted Metric Tons)

	A5 Countries	Non-A5 Countries	Global
Consumption	1,450,000	504,000	1,960,000
Emissions	751,000	224,000	976,000

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

ODP-Weighted Changes in HCFC Consumption and Emissions. Tables B-16 and B-17 present changes in aggregated HCFC consumption and emissions in ODP-weighted metric tons, respectively. As shown, each option resulted in estimated reductions in ODP-weighted HCFC consumption (except the first scenario of Option 4) and emissions from 2010 through 2040.

Table B-16. Changes in Aggregate HCFC Consumption (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-698,000	0	-698,000	-36%
Option 2	-321,000	0.0	-321,000	-16%
Option 3	-417,000	-1,840	-419,000	-21%
Option 4				
Maximum allowable consumption scenario:	0	0	0	0%
Constant lower ODP HCFC consumption scenario:	-712,000	-13,900	-726,000	-37%
Option 5 (combines Options 1 & 2)	-819,000	0	-819,000	-42%
Option 6 (combines Options 2 & 3)	-619,000	-1,840	-620,000	-32%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-849,000	-1,840	-851,000	-43%
Constant lower ODP HCFC consumption scenario:	-858,000	-15,700	-873,000	-45%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

Table B-17. Changes in Aggregate HCFC Emissions (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-361,000	0	-361,000	-37%
Option 2	-166,000	0	-166,000	-17%
Option 3	-215,000	-819	-216,000	-22%
Option 4				
Maximum allowable consumption scenario:	-288,000	-27.1	-288,000	-30%
Constant lower ODP HCFC consumption scenario:	-381,000	-6,180	-387,000	-40%
Option 5 (combines Options 1 & 2)	-423,000	0	-423,000	-43%
Option 6 (combines Options 2 & 3)	-320,000	-819	-320,000	-33%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-446,000	-846	-447,000	-46%
Constant lower ODP HCFC consumption scenario:	-448,000	-7,000	-455,000	-47%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

GWP-Weighted Changes in HCFC Consumption and Emissions. Tables B-18 and B-19 present changes in aggregated HCFC consumption and emissions in MMTCE, respectively. As shown, all options result in an estimated net decrease in GWP-weighted HCFC and HFC consumption (i.e., net global climate impact) through 2040 with the exception of an increase for the first scenario of Option 4. Also, all options result in an estimated net decrease in GWP-weighted HCFC and HFC emissions (i.e., net global climate impact).

Table B-18. Changes in Aggregate HCFC Consumption (MMTCE, Using Direct GWP)

Option	*Reductions*	*Increases*	Net Global Climate Impact
	Reduced HCFC Consumption	Transition to Alternatives[a]	
Option 1	-4,800	4,230	-573
Option 2	-2,210	1,950	-264
Option 3	-2,880	2,540	-341
Option 4			
Maximum allowable consumption scenario:	1,990	4,440	6,420
Constant lower ODP HCFC consumption scenario:	-4,920	4,350	-574
Option 5 (combines Options 1 & 2)	-5,630	4,960	-672
Option 6 (combines Options 2 & 3)	-4,260	3,760	-506
Option 7 (combines Options 1, 2, 3, & 4)			
Maximum allowable consumption scenario:	-5,910	5,180	-728
Constant lower ODP HCFC consumption scenario:	-6,000	5,240	-756

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Table B-19. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO$_2$ from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-3,020	-31.7	-514	2,710	-857
Option 2	-1,390	-14.6	0	1,250	-158
Option 3	-1,810	-19.0	-589	1,620	-794
Option 4					
Maximum allowable consumption scenario:	-2,360	-34.7	-499	2,840	-51.3
Constant lower ODP HCFC consumption scenario:	-3,260	-34.7	-499	2,780	-1,010
Option 5 (combines Options 1 & 2)	-3,540	-37.2	-424	3,170	-827
Option 6 (combines Options 2 & 3)	-2,680	-28.2	-439	2,400	-742
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-3,810	-40.4	-420	3,310	-957
Constant lower ODP HCFC consumption scenario:	-3,820	-40.4	-420	3,350	-931

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

ALTERNATE RESULTS USING A 12 PERCENT ANNUAL CONSUMPTION AVERAGE GROWTH RATE FOR A5 COUNTRIES

Table B-20 presents the consumption baselines that reflect the current phaseout schedules based on the assumption of a 12% growth rate for A5 countries.

Table B-20. Aggregate HCFC Consumption Baseline (ODP-Weighted Metric Tons)

	A5 Countries	Non-A5 Countries	Global
Consumption	2,230,000	504,000	2,740,000
Emissions	1,150,000	224,000	1,380,000

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

ODP-Weighted Changes in HCFC Consumption and Emissions. Tables B-21 and B-22 present changes in aggregated HCFC consumption and emissions in ODP-weighted metric tons, respectively. As shown, each option resulted in estimated reductions in ODP-weighted HCFC consumption (except the first scenario of Option 4) and emissions from 2010 through 2040.

Table B-21. Changes in Aggregate HCFC Consumption (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-1,150,000	0	-1,150,000	-42%
Option 2	-798,000	0	-798,000	-29%
Option 3	-689,000	-1,840	-691,000	-25%
Option 4				
Maximum allowable consumption scenario:	0	0	0	0%
Constant lower ODP HCFC consumption scenario:	-1,180,000	-13,900	-1,190,000	-44%
Option 5 (combines Options 1 & 2)	-1,450,000	0	-1,450,000	-53%
Option 6 (combines Options 2 & 3)	-1,190,000	-1,840	-1,190,000	-44%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-1,490,000	-1,840	-1,490,000	-55%
Constant lower ODP HCFC consumption scenario:	-1,500,000	-15,700	-1,520,000	-56%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

Table B-22. Changes in Aggregate HCFC Emissions (ODP-Weighted Metric Tons)

Option	Article 5 Changes	Non-Article 5 Changes	Total Global Changes	% Change from Global Baseline
Option 1	-596,000	0	-596,000	-43%
Option 2	-412,000	0	-412,000	-30%
Option 3	-356,000	-819	-357,000	-26%
Option 4				
Maximum allowable consumption scenario:	-477,000	-27.1	-477,000	-35%
Constant lower ODP HCFC consumption scenario:	-630,000	-6,180	-636,000	-46%
Option 5 (combines Options 1 & 2)	-751,000	0	-751,000	-55%
Option 6 (combines Options 2 & 3)	-614,000	-819	-615,000	-45%
Option 7 (combines Options 1, 2, 3, & 4)				
Maximum allowable consumption scenario:	-781,000	-846	-782,000	-57%
Constant lower ODP HCFC consumption scenario:	-782,000	-7,000	-789,000	-57%

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

GWP-Weighted Changes in HCFC Consumption and Emissions. Tables B-23 and B-24 present changes in aggregated HCFC consumption and emissions in MMTCE, respectively. As shown, all options result in an estimated net decrease in GWP-weighted HCFC and HFC consumption (i.e., net global climate impact) through 2040 with the exception of an increase for the first scenario of Option 4. Also, all options result in an estimated net decrease in GWP-weighted HCFC and HFC emissions (i.e., net global climate impact) except for the first scenario of Option 4.

Table B-23. Changes in Aggregate HCFC Consumption (MMTCE, Using Direct GWP)

Option	*Reductions*	*Increases*	Net Global Climate Impact
	Reduced HCFC Consumption	Transition to Alternatives[a]	
Option 1	-7,930	6,990	-946
Option 2	-5,490	4,830	-654
Option 3	-4,750	4,180	-564
Option 4			
Maximum allowable consumption scenario:	3,360	7,250	10,600
Constant lower ODP HCFC consumption scenario:	-8,050	7,160	-892
Option 5 (combines Options 1 & 2)	-9,990	8,800	-1,190
Option 6 (combines Options 2 & 3)	-8,180	7,210	-974
Option 7 (combines Options 1, 2, 3, & 4)			
Maximum allowable consumption scenario:	-10,300	8,960	-1,350
Constant lower ODP HCFC consumption scenario:	-10,400	9,150	-1,280

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

Table B-24. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-4,990	-52.4	-757	4,470	-1,320
Option 2	-3,450	-36.3	0	3,090	-392
Option 3	-2,980	-31.4	-950	2,680	-1,290
Option 4					
Maximum allowable consumption scenario:	-3,840	-56.9	-732	4,640	4.6
Constant lower ODP HCFC consumption scenario:	-5,330	-56.9	-732	4,580	-1,540
Option 5 (combines Options 1 & 2)	-6,280	-66.0	-535	5,630	-1,250
Option 6 (combines Options 2 & 3)	-5,140	-54.1	-578	4,610	-1,160
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-6,610	-69.9	-529	5,730	-1,470
Constant lower ODP HCFC consumption scenario:	-6,620	-69.9	-529	5,850	-1,370

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).

6. Alternate Ratio of HFC-23 to HCFC-22 Consumption

The analysis presented in the report assumes HFC-23 emissions are 2% of HCFC-22 consumption (on a ton per ton basis); for sensitivity, the analysis was run varying this assumption. This section presents the estimated changes in consumption and emissions of chemicals that affect stratospheric ozone and/or the climate for each proposed HCFC phaseout adjustment assuming HFC-23 emissions are 3% of HCFC-22 consumption. Therefore, the scenario examined in this section assumes that (a) HFC-23 emissions are 3% of HCFC-22 consumption, and (b) average annual growth rate in HCFC consumption is 9% in A5 countries (as outlined in the body of this report). **Reductions are shown as negative values, and increases are shown as positive values.**

As shown in Table B-25, all options result in a net decrease in GWP-weighted HCFC and HFC emissions. There is little change in the overall results as presented above.

Table B-25. Changes in Aggregate HCFC Emissions (MMTCE, Using Direct GWP)

Option	*Reductions*			*Increases*	*Overall*
	Reduced HCFC Consumption	HFC-23 By-Product	CO_2 from Energy Efficiency Improvement	Transition to Alternatives[a]	Net Global Climate Impact
Option 1	-3,700	-58.3	-600	3,320	-1,040
Option 2	-2,070	-32.7	0	1,860	-247
Option 3	-2,210	-34.9	-715	1,990	-977
Option 4					
Maximum allowable consumption scenario:	-2,870	-63.6	-581	3,460	-54.6
Constant lower ODP HCFC consumption scenario:	-3,980	-63.6	-581	3,400	-1,220
Option 5 (combines Options 1 & 2)	-4,480	-70.6	-466	4,020	-998
Option 6 (combines Options 2 & 3)	-3,510	-55.4	-491	3,150	-908
Option 7 (combines Options 1, 2, 3, & 4)					
Maximum allowable consumption scenario:	-4,770	-75.8	-461	4,140	-1,160
Constant lower ODP HCFC consumption scenario:	-4,790	-75.8	-461	4,210	-1,110

Results have been rounded to three significant digits; totals may not sum due to independent rounding.

[a] Several factors inherent to the Vintaging Model influence the results presented for the transition to alternatives including the quantity of HCFCs estimated to be replaced by HFCs; the GWP of the HFCs; and the change to the charge size associated with the use of the HFCs (EPA, 2006a).