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## Strengthening the Montreal Protocol: Insurance Against Abrupt Climate Change

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### INTRODUCTION

The Montreal Protocol on Substances that Deplete the Ozone Layer has been efficient and effective in reducing damage to the ozone layer. It also has contributed significantly to climate mitigation. This paper recommends further adjustments to the treaty to help finish the job of protecting the ozone layer and provide further though temporary insurance against the threat of abrupt climate change.<sup>1</sup>

The Montreal Protocol is widely considered one of the world's most successful multilateral environmental agreements, having phased out 95 percent of ozone-depleting substances ("ODSs") in developed countries and 50-75 percent of ODSs in developing countries — placing the ozone layer on a path to recover later this century.<sup>2</sup> The Montreal Protocol's success is based on its strict, flexible, and dynamic design, which has driven continuous technology innovations; its evolution through amendments, adjustments, and decisions to reflect the most up-to-date scientific and technological developments; the commitment by developed countries to provide financial assistance to developing countries to ensure its successful implementation; and its attention to compliance from the outset.<sup>3</sup>

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Because many ODSs are also potent greenhouse gases (“GHGs”) that contribute to climate change,<sup>4</sup> their phase-out under the Montreal Protocol has provided an often overlooked bonus for climate mitigation: by the end of the decade, the Montreal Protocol will have done more to mitigate climate change than the initial Kyoto Protocol reduction target, reducing emissions in terms of carbon dioxide (“CO<sub>2</sub>”)-equivalent by five to six times that of the climate treaty, the equivalent of 11 gigatons of carbon dioxide-equivalent per year (“GtCO<sub>2</sub>-eq. yr<sup>-1</sup>”).<sup>5</sup> In effect, the Montreal Protocol has delayed climate impacts — including abrupt and irreversible impacts — by about 10 years, and, with the additional measures discussed below, can delay it still further.<sup>6</sup>

Partly as a result of the Montreal Protocol’s success, there is a public misconception that the problem of ozone depletion has been “solved.” Some in the international community have gone so far as to ask whether the Montreal Protocol should be dismantled or merged into the still unproven climate treaty regime.

But the Montreal Protocol’s work to protect the ozone layer is far from done. In 2006 scientists recorded the near largest ozone hole ever over Antarctica, and new data indicates that the recovery of the ozone layer above the Antarctic will be delayed by fifteen years, with a return to pre-1980 levels not occurring until 2065.<sup>7</sup> Ozone layer recovery at mid-latitudes also is delayed and will not return to pre-1980 levels until 2049.<sup>8</sup> The new data does not take into account illegal trade in banned ODSs nor other challenges of compliance,<sup>9</sup> especially in developing countries where the 2010 ban on chlorofluorocarbons (“CFCs”) is quickly approaching.<sup>10</sup> Without full compliance, the recovery will be delayed further.

The continuing impact of ODSs on the ozone layer, and the significant contribution the ODSs and some of their substitutes are making to climate change, demonstrate that the Parties’ commitment to protect the ozone layer has not yet been fulfilled, and that significant challenges remain.<sup>11</sup> These challenges to the future success of the Montreal Protocol — the most efficient and effective treaty to date in reducing GHG emissions and mitigating climate change, in addition to protecting the ozone layer — come at a time when the impacts of climate change are becoming increasingly apparent.<sup>12</sup>

National Aeronautics and Space Administration scientist James Hansen warns that we may have as few as ten years left before positive feedbacks in the climate system could accelerate global warming and push the climate system across the tipping point for non-linear change that would create “a different planet,” with an ice-free Arctic and coastlines obliterated by rising sea levels.<sup>13</sup> Abrupt non-linear changes to the climate, also known as Rapid Climate Change Events (“RCCEs”), include the melting of the Greenland ice sheet. A complete melting of the Greenland ice sheet would raise sea levels by an estimated seven meters.<sup>14</sup>

But sea levels do not need to rise by seven meters to cause global catastrophe: a 1.5 meter rise would threaten 36,000 square miles of land along the U.S. Atlantic and Gulf Coasts with flooding,<sup>15</sup> as well as causing devastation to vulnerable low-lying island and coastal States. The fallout from this or other abrupt climate change events could destabilize the world’s social and governance institutions, which at the very least would undermine efforts to reduce GHG emissions and at worst could provoke global military conflicts.<sup>16</sup> In any scenario, untold millions would suffer.

The GHG reductions achievable under the Montreal Protocol offer critical low-cost insurance against abrupt changes to the climate, effectively buying the world more time to get the Kyoto

Protocol's global carbon market running effectively and efficiently, and to agree on the post-Kyoto regime.

The Parties have the opportunity to take immediate action at the 20th anniversary of the Montreal Protocol in September 2007 to strengthen the ozone regime's ability to protect the ozone layer, as well as to maximize its ability to mitigate climate impacts — in an amount that may exceed the Kyoto Protocol's reductions. This can be accomplished by adjusting the Montreal Protocol to account for the climate impacts of ODSs and their substitutes, with due regard for the special situation of developing countries and without losing sight of the other challenges currently facing the ozone treaty. This is most effectively accomplished by (1) explicitly focusing on climate benefits in addition to ozone benefits, using Life-Cycle Analysis and Life-Cycle Climate Performance to assess the cumulative environmental impacts of ODS substitutes and other strategies under the Montreal Protocol; (2) minimizing the impacts by favoring the least harmful ODS substitutes, and promoting further technological innovations, including redesign of equipment, processes, substitutes, and products, as well as not-in-kind alternatives; and (3) providing incentives for the destruction of CFCs currently contained in products and equipment, or otherwise regulating end-of-life recovery and destruction.

These adjustments to the Montreal Protocol are consistent with its evolutionary process, as the treaty has repeatedly been adjusted over its nearly twenty year history to reflect current developments in scientific understanding and technological capabilities. Such adjustments also are consistent with more general principles and concepts of international environmental law, which create an obligation to assess and minimize environmental impacts.

### **NEW OZONE & CLIMATE CHALLENGES**

The ozone layer's return to pre-1980 levels at mid-latitudes can be facilitated through two actions. One is to curb higher than anticipated emissions of hydrochlorofluorocarbons ("HCFCs") by 2015. The other is to limit the adverse impacts from emissions of CFCs currently contained in products and equipment (known as "banks") that will be emitted to the atmosphere once those products and equipment reach the end of their useful life. These actions also will delay the impacts of climate change. They should be undertaken as part of a broader effort to ensure that the Montreal Protocol systematically considers and takes into account the climate impacts of ODSs and their substitutes, and minimizes the impact of its strategies on climate.

To protect the ozone layer, the Montreal Protocol mandates the focused phase-out of CFCs and other ODSs, which are used in refrigerators, air conditioning units, and a variety of foams, solvents, and other applications such as aerosol propellants, fumigants, and fire-fighting agents. To facilitate the phase-out, the Montreal Protocol, through its Multilateral Fund, provides financial assistance to developing countries to replace CFCs and other ODSs with chemicals less harmful to the ozone layer, such as HCFCs.<sup>17</sup> HCFCs have lower ozone-depletion potentials ("ODPs") and generally have lower global warming potentials ("GWPs") than CFCs. They were envisioned as short-term substitutes, scheduled for phase out by 2030 in developed countries (with 0.5 percent allowed for servicing after 2020) and 2040 in developing countries (with consumption frozen in 2016 at 2015 levels).

While HCFCs were critical in replacing the more damaging CFCs, their continued use creates problems for the ozone layer and the climate. This is both a problem of under-regulation, where the production of chlorodifluoromethane ("HCFC-22") is rapidly expanding despite the availability of superior substitutes and alternatives, and where banks are not yet regulated at all;

and over-regulation, where the use of dichlorotrifluoroethane (“HCFC-123”) is being phased-out despite its negligible impact on the ozone layer and the higher energy efficiency and lower GHG emissions achieved by its use in large-building air-conditioning units, known as chillers.

#### UNDER-REGULATION OF INFERIOR SUBSTITUTE: HCFC-22 AND ITS HFC-23 BY-PRODUCT

In addition to delaying the recovery of the ozone layer at mid-latitudes,<sup>18</sup> the production of HCFC-22 results in emissions of trifluoromethane (“HFC-23”), an unwanted by-product that is a “super greenhouse gas” 11,700<sup>19</sup> times more powerful at warming the planet than CO<sub>2</sub>.<sup>20</sup> The combined climate emissions of HCFC-22, with a GWP of 1,780, and its HFC-23 by-product, with GWP of 11,700, are projected to reach 1 GtCO<sub>2</sub>-eq. by 2015—roughly equal to the emissions reductions presently required under the Kyoto Protocol.<sup>21</sup>

The production and consumption of HCFCs is projected to expand to levels significantly higher than the 163,000 tonnes by 2015 originally predicted by UNEP’s Technology & Economic Assessment Panel (“TEAP”) in 1998. One specific country alone has an installed annual production capacity of more than 300,000 tons, and over the next decade HCFC production could increase to as much as 800,000 tons (in addition to feedstock use which is not currently controlled under the Montreal Protocol). Approximately 75 percent of all HCFC production will be from HCFC-22, a transitional chemical used in small air conditioning units and refrigerators. The projected increase in HCFC production is being driven by the transfer of the old technology from developed to developing countries, as well as by rapid economic growth in the developing countries. The Kyoto Protocol’s Clean Development Mechanism (“CDM”), as applied to HFC-23, also is partly to blame.

Under Kyoto’s CDM, the capture and destruction of HFC-23 emissions at facilities producing HCFC-22 can generate Certified Emissions Reductions (“CERs”). Given the relatively low cost of HFC-23 destruction compared to the value of CERs on the global carbon market,<sup>22</sup> the CDM is inadvertently creating a “perverse incentive” that has created windfall profits for HCFC-22 producers — effectively acting as a subsidy that is driving the expanded production of HCFC-22.<sup>23</sup> HFC-23 destruction projects have dominated the CDM market, accounting for 52 percent of all project-based carbon volumes transacted in 2006 and 64 percent in 2005.<sup>24</sup> The abundance of CERs from HFC-23 destruction projects appears to be depressing the price of carbon, which in turn harms the competitiveness of other CDM projects.<sup>25</sup>

This problem will not be going away anytime soon. Under the Montreal Protocol, production of HCFC-22 can expand in developing countries until 2016, when the baseline is set at 2015 levels, and then remain in production for another 34 years, with the profits from HFC-23 destruction projects discouraging the transition to superior ODS substitutes that are ozone- and climate-safe. Without the subsidy from HFC-23 destruction projects, it is likely that the projections for HCFC-22 production would be lower. The initial trend of HCFC production and consumption would be higher in such scenario, but later would be similar to developed countries, many of which have already accelerated the phase-out of HCFCs and begun the transition to superior substitutes.<sup>26</sup> The European Union has already phased-out HCFCs<sup>27</sup> and other countries such as Japan and the United States are expected to adopt phase-out dates for HCFCs ahead of the 2030 deadline imposed by the Montreal Protocol for developed countries.

Past transitions from CFCs to HCFCs and hydrofluorocarbons (“HFCs”) helped drive technological innovation in substitutes, manufacturing processes, and equipment, which in many cases resulted in gains in energy efficiency, reduced leakage, or other technological

improvements. To date, about 80% of ODSs that would be in use without the Montreal Protocol have been replaced by non-fluorocarbon chemicals, which do not deplete the ozone layer. These substitutes include not-in-kind chemical substitutes and product alternatives (e.g. a roll-on deodorant instead of a spray can), changes to manufacturing processes, conservation measures, and doing without.) The transition out of HCFCs is likely to produce similar innovations and environmental advances. But developing countries, if they continue their over-reliance on HCFC-22, will be slow to benefit from these positive changes.

#### OVER-REGULATION OF HCFC-123

The Montreal Protocol does not systematically consider the climate impacts from the energy efficiency achieved in equipment that uses ODSs. Equipment that achieves a high rate of energy efficiency is better for the climate, as its lower energy use results in fewer GHG emissions from power generation (assuming the power does not come from renewable sources or sources that do not result in GHG emissions but raise other environmental concerns, such as nuclear reactors). It also results in lower operating costs over the life of the equipment.

Large-building air-conditioning units, or chillers, provide a case in point.<sup>28</sup> The level of their energy efficiency depends in part on the type of refrigerant used, with HCFC-123 allowing for greater efficiency than others. HCFC-123 has a low ODP of 0.02, a low GWP of 76, a short atmospheric lifetime of 1.3 years,<sup>29</sup> and offers significant climate benefits due to its substantial advantage in energy efficiency over the primary alternative, tetrafluoroethane (“HFC-134a”).<sup>30</sup> In addition, it operates at a low pressure in chillers designed to minimize leaks and is therefore considered to have a negligible impact on ozone depletion.<sup>31</sup> At present, HCFC-123 offers superior performance for low pressure chillers (although more energy efficient alternatives may be developed in the future).<sup>32</sup>

UNEP’s Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee concluded in their 2002 Assessment that, “Based on integrated assessments, considering the trade-offs between negligible impacts on stratospheric ozone and important benefits in addressing global warming, these studies recommend consideration of a phase out exemption for HCFC-123.”<sup>33</sup>

But because it is an HCFC, it is scheduled for phase-out with the rest of the HCFCs. Chillers are very expensive (U.S. \$200,000 to \$600,000), and have 30-year life-cycles. As a result, the phase-out of HCFC-123 could force building owners looking to buy a chiller within the next several years to use alternatives that are less energy efficient, more costly to operate, and more damaging to the climate.<sup>34</sup>

#### FAILURE TO REGULATE ODS BANKS

The Montreal Protocol does not place any controls on emissions from “banks” and provides minimal incentives for their recovery and destruction.<sup>35</sup> Banks are defined as the chemicals contained in equipment and products or stored in tanks. Large amounts of CFCs and other ODS substitutes such as HCFCs and HFCs (not an ODS but a GHG) currently exist in refrigerators, air conditioners, insulating foams, and chemical stockpiles, where they can leak. When equipment reaches the end of its useful life, the chemicals inside are usually released into the atmosphere.

With limited incentives for recovery and destruction of ODS banks, most of the CFCs in banks will be emitted into the atmosphere over the next decade, with detrimental impacts for both the

ozone layer and the climate.<sup>36</sup> In addition to contributing to the expected delay in ozone recovery, emissions from CFC banks by 2015 could equal approximately 7.4 GtCO<sub>2</sub>-eq. yr<sup>-137</sup> — more than seven times the size of the emissions reductions initially targeted by the Kyoto Protocol.<sup>38</sup>

## COMPLIANCE CHALLENGES

The full phase-out of CFCs in 2010 in developing countries may present the most difficult compliance challenge yet for the Montreal Protocol.<sup>39</sup> Illegal trade in CFCs and other ODSs is expected to increase once the complete ban on CFCs takes effect, which will exacerbate the black market operating in both developed and developing countries.<sup>40</sup> Illegal trade currently is estimated to represent about 10-20 percent of all trade in ODSs, which in CFCs alone comprises 7,000-14,000 tons per year, with a value of U.S. \$25-60 million.<sup>41</sup> The Montreal Protocol instituted a licensing system for the transboundary shipments of ODSs to combat illegal trade, but compliance remains a critical issue.<sup>42</sup>

Other compliance challenges arise from the lack of control measures for use of ODSs, such as HCFC-22 and methyl bromide, in feedstock, process agents, and Quarantine and Preshipment (“QPS”) applications. This makes it possible for ODSs produced for these applications to be used illegally in other applications that have been phased out. Feedstock and process agent applications are not subject to control measures because, in theory, the ODSs used in these applications are either converted to chemicals that do not harm the ozone layer or are destroyed in the conversion process.<sup>43</sup> But this does not take into account any by-products, such as HFC-23 or CTCs, nor the possibility some will be diverted to illegal trade.

## LEGAL AND POLICY ANALYSIS

### ASSESSING CLIMATE IMPACTS OF ODS SUBSTITUTES

The Montreal Protocol and its Parties have previously recognized the need to consider full the environmental impacts of their strategies, especially the climate impacts of ODS substitutes, which often are the most significant impacts. Article 2F(7) of the Montreal Protocol sets forth the control measures for HCFCs and states that in addition to minimizing ozone depletion, the decision to use HCFCs should meet other environmental standards, *i.e.*: “Controlled substances in Group I of Annex C [HCFCs] are selected for use in a manner that minimizes ozone depletion, in addition to meeting other environmental, safety and economic considerations.”

This approach was supported by Decision V/8 (Fifth Meeting of the Parties, Bangkok 1993) which requested the Parties to consider ODS substitutes in light of Article 2F and their “environmental aspects.” This was expanded in Decision VI/13 (Sixth Meeting of the Parties, Nairobi 1994), stating that the TEAP “should consider how available alternatives compare with hydrochlorofluorocarbons with respect to such factors as energy efficiency, total global warming impact, potential flammability, and toxicity . . . .”

Subsequently, a group of 41 Parties issued a Declaration at the Tenth Meeting of the Parties (Cairo 1998) reiterating their support for the consideration of climate impacts, noting the “scientific indications that global warming could delay the recovery of the ozone layer” and that “environmentally sound alternative substances and technologies are commercially available for virtually all HCFC applications.” The Declaration urged “all Parties to the Montreal Protocol to consider all ODS replacement technologies, taking into account their global-warming potential,

so that the use of alternatives with a high contribution to global warming should be discouraged where other, more environmentally friendly, safe and technically and economically feasible alternatives or technologies are available.”<sup>44</sup>

The consideration of environmental impacts is part of a general obligation under principles and concepts of international environmental law. Specifically, the Environmental Impact Assessment (“EIA”) principle places a general duty on States to consider the cumulative environmental impacts of proposed actions where there are possible transboundary or global impacts.<sup>45</sup> The EIA principle is related to the concept of Integrated Pollution Prevention and Control (“IPPC”), which was developed to respond to the fact that environmental regulations targeting a single problem can simply shift pollution from one medium to another rather than eliminate it. Broadly, it requires a holistic assessment of environmental impacts when developing regulations, particularly for the use of chemicals, and has been incorporated into numerous MEAs and other international instruments, including the European Commission’s 1996 IPPC Directive.

IPPC requires a “life cycle analysis” of environmental impacts to measure the “cradle-to-grave” impacts of a product, chemical, or technology. This kind of Life Cycle Analysis (“LCA”) was codified by the International Standards Organization (“ISO”) 14040 Series. It was described in the IPCC/TEAP Special Report as involving an “inventory of relevant inputs and outputs of the system itself and of the systems that are involved in those inputs and outputs (Life Cycle Inventory Analysis). The potential environmental impacts of these inputs and outputs are then evaluated . . . .”<sup>46</sup>

The concept of Life Cycle Climate Performance (“LCCP”) is considered a submethod of LCA.<sup>47</sup> LCCP was proposed by the TEAP to calculate the “cradle-to-grave” climate impacts of the use of ODSs in equipment, measuring the “direct” GWP of ODSs as well as the “indirect” GWP from GHG emissions from power generation used in operating the equipment, placing a premium on energy efficiency. The TEAP explained LCCP:

The concept of Life-Cycle Climate Performance (LCCP) is intended to provide a rational way of assessing only those environmental aspects affecting climate (*i.e.* only a sub-segment of item (a)) [of Decision V/8 requesting each Party “. . . to give consideration in selecting alternative substitutes . . . to: Environmental aspects . . .”]. . . . The total impact on climate of any technology results from a combination of the “direct” emissions of greenhouse gases from the system throughout its life cycle and the “indirect” emissions of greenhouse gases associated with the energy used or saved by the system. . . . When the use of a specific technology creates an incremental energy saving, the reduction in CO<sub>2</sub> emissions from the energy use can far outweigh the direct emissions over the expected life of the product.<sup>48</sup>

LCCP provides a more complete assessment than an earlier concept known as Total Equivalent Warming Impact (“TEWI”)<sup>49</sup> because it includes fugitive emissions from the manufacture of the ODSs and emissions from operating, servicing, and the disposal of the ODSs at the end of the equipment’s useful life.<sup>50</sup>

## MINIMIZING THE CLIMATE IMPACTS OF ODS SUBSTITUTES

Based on such a holistic environmental assessment, the Montreal Protocol then must minimize the climate impacts of ODS substitutes and alternatives, an approach that is consistent with the Montreal Protocol’s ultimate objective of eliminating the use of ODSs through policies based on “developments in scientific knowledge, taking into account technical and economic considerations. . . .”<sup>51</sup>

Developments in scientific knowledge include the link between ozone depletion and climate change. The link is based on complex atmospheric interactions between ozone and climate and the fact that many ODSs are also GHGs, as described by TEAP<sup>52</sup> and the joint IPCC/TEAP Special Report.<sup>53</sup> This is acknowledged in the Montreal Protocol, which states that the Parties are “[c]onscious of the potential climatic effects of emissions of these substances (*i.e.* ODSs).”

The IPCC/TEAP stated that “[o]ptions chosen to protect the ozone layer could influence climate change. Climate change may also indirectly influence the ozone layer.”<sup>54</sup> The Scientific Assessment Panel elaborated further, noting that climate change is likely to obscure or even harm the recovery of the ozone layer.<sup>55</sup>

The replacement of ODSs with substitutes and other alternatives, including not-in-kind alternatives, will produce climate benefits to the extent the changes result in higher energy efficiency or otherwise reduce climate emissions. A more explicit and focused set of strategies is needed within the Montreal Protocol to minimize climate impacts.

This is supported by Agenda 21, which calls on Parties to “[r]eplace CFCs and other ozone-depleting substances, consistent with the Montreal Protocol, recognizing that a replacement’s suitability should be evaluated holistically and not simply based on its contribution to solving one atmospheric or environmental problem.”<sup>56</sup> This is further supported by the exclusion of gases regulated by the Montreal Protocol from the UN Framework Convention on Climate Change and the Kyoto Protocol. The exclusion was made with knowledge that many of these gases have extremely high GWPs and that their emissions can substantially contribute to climate change, thereby placing additional responsibility on the Parties to the Montreal Protocol to minimize the climate impacts of ODS substitutes.

As with the assessment requirement, the minimization requirement is based on principles and concepts of international environmental law that place a general obligation on States to: (1) ensure that the activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction; (2) prevent damage to the environment by reducing, limiting, or controlling activities that might cause such damage; and (3) cooperate in addressing environmental problems.<sup>57</sup>

This obligation, which has been codified in a broad form by the European Commission’s Integrated Pollution Prevention and Control Directive, places an affirmative duty on States to take preventative measures against pollution.<sup>58</sup> More specifically, this obligation is embodied in the Substitution Principle, which is generally defined as “the replacement or reduction of hazardous substances in products and processes by less hazardous or non-hazardous substances, or by achieving an equivalent functionality via technological or organisational measures.”<sup>59</sup>

The Substitution Principle has been codified domestically in numerous regulations governing the use of hazardous chemicals.<sup>60</sup> Recently, it was included in the European Union’s new chemical policy entitled the Regulation, Evaluation, Authorisation and Restriction of Chemicals (“REACH”), which requires manufactures, importers, and users of chemical substances to “analyse the availability of alternatives and consider the risks and the technical and economic feasibility of substitution.”<sup>61</sup>

UNEP, in conjunction with the U.S. EPA, Japan’s Ministry of Economy, Trade, and Industry, and the Alliance for Responsible Atmospheric Policy, has developed its own version of the

Substitution Principle, known as Responsible Use, which recommends the use of technologies so long as the undesirable effects are minimized and the technology achieves higher environmental performance than its alternatives.<sup>62</sup> Responsible Use Principles would permit the use of ODS substitutes “only in applications where they provide safety, energy efficiency, environmental, or economic advantage”<sup>63</sup> and where “undesirable effects are minimized and the technology achieves higher environmental performance than its alternatives.”<sup>64</sup>

## RECOMMENDATIONS

An assessment of the environmental impacts of ODS substitutes, under the cumulative LCA methodology and the climate-specific LCCP methodology, would include direct impacts from a substance’s ODP and GWP. Moreover, indirect impacts such as by-product emissions, leakage, charge size, recovery/destruction options, and energy efficiency also would be incorporated.

Such an assessment, together with the duty to minimize environmental impacts, dictates three immediate and attainable adjustments: accelerating the phase out of HCFC-22; allowing the continued use of HCFC-123 until superior alternatives emerge; and creating greater incentives for, or otherwise regulating, the recovery and destruction of ODS banks. The problem of compliance also warrants further attention. In addition to strengthening protection of the ozone layer, these adjustments have the potential to reduce GHG emissions by up to 1.2 GtCO<sub>2</sub>-eq. yr<sup>-1</sup> by 2015 – which is greater than the required reductions under the Kyoto Protocol.

### ACCELERATED PHASE OUT OF HCFC-22 AND ITS HFC-23 BY-PRODUCT

The accelerated phase-out of HCFC-22 in the developed and developing countries will avoid the projected increase of HCFC-22 production and emissions of its “super greenhouse gas” HFC-23 by-product.<sup>65</sup> It also would reduce the perverse transfer of the old technology to manufacture HCFC-22 and its raw material to developing countries.<sup>66</sup>

The availability of substitutes for ODSs was affirmed by Regulation (EC) No. 2037/2000 of the European Parliament and of the Council of 29 June 2000 on substances that deplete the ozone layer, which adopts stricter control measures for ODSs, including the accelerated phase-out of HCFCs, due to the “earlier than anticipated availability of technologies for replacing ozone-depleting substances.” The IPCC/TEAP Special Report also clarified the availability of substitutes for many HCFC applications, including HFC 134a, HFC blends, CO<sub>2</sub>, hydrocarbons, and ammonia.<sup>67</sup> Many of these substitutes provide better energy efficiency and can be assessed based on LCA/LCCP before selection.

Under an LCA/LCCP analysis, determining which substitute offers superior environmental performance depends as much on the indirect impacts such as leakage, charge size, potential for recovery/destruction at equipment end-of-life, and energy efficiency, as it does the more direct measures of ODP and GWP. For example, HFC-134a and HFC blends would qualify as superior alternatives in minimizing climate impacts *only if* they were used in equipment that achieves greater energy efficiency than HCFC-22 and the other substitutes. Reduced leak rate and greater recovery/destruction also would enhance its standing. Use of CO<sub>2</sub>, hydrocarbons, and ammonia would qualify as superior alternatives in minimizing climate impacts *only if* their lower energy efficiency levels were improved or offset by their low GWPs.

The accelerated phase-out of HCFCs raises several issues that must be resolved by the Parties as they proceed, including the need to ensure that developed countries will continue to fulfill their

commitment to provide additional financial assistance to developing countries through the Multilateral Fund to ensure compliance with phase-out schedules.<sup>68</sup> While some growth in HCFC consumption may be unavoidable and economically necessary for some developing countries, an aggressive phase-out schedule is nevertheless technologically and economically feasible. It should start by moving the base year forward, *i.e.*, to 2006, perhaps with some controlled growth allowed until 2010, and then a series of step-downs to ensure continuing progress and avoid the compliance problems that would otherwise arise (*i.e.*, 35 percent reduction by 2015, 65 percent reduction by 2020, and 99.5 percent reduction by 2030, with 0.5 percent allowed for servicing until 2040). This approach, coupled with financial assistance for the transition to superior substances and technologies, would ensure immediate and continuous progress, and avoid the extremely high levels of growth otherwise projected. It also would make it possible for the global carbon market to factor in whatever CERs, if any, the CDM allows for the destruction of HFC-23 from new production beyond that allowed by the current methodology.<sup>69</sup> Regulators in the EU as well as the architects of the post-Kyoto regime would be able to calculate the maximum HFC-23 emissions, and the likely CDM credits possible, and set the overall emissions cap accordingly.

#### CONTINUED USE OF HCFC-123 UNTIL SUPERIOR ALTERNATIVES EMERGE

This same analysis applies to the need to exempt HCFC-123 from phase-out and allow its continued use until superior substitutes are developed. The continued use would be based on its negligible ozone impacts and the energy efficiency advantage of HCFC-123 chillers over the primary alternative, HFC-134a, where HCFC-123 results in lower GHG emissions associated with power generation to run the chillers, as well as lower operating costs over the 30-year life of the equipment.

At the Science Symposium held in Prague in 2004 and chaired by Dr. Mario Molina in conjunction with the 16th Meeting of the Parties, it was reported that “HCFC-123 could be allowed in specific air conditioning applications where its use promotes superior energy efficiency and assures near-zero refrigerant emissions.”<sup>70</sup>

Without the continued use of HCFC-123 until superior alternatives emerge, the energy efficiency standard for chillers will decrease, adversely impacting the climate and lowering the threshold against which future improvements in energy efficiency will be measured. HCFC-123 has a very low ozone-depletion potential, a lower global warming potential than HFC-134a, and operates at a low pressure in chillers designed to minimize leaks. UNEP and others have stated that its continued use would have a virtually negligible impact on the ozone while offering superior environmental benefits over alternatives.<sup>71</sup>

Allowing the continued use of HCFC-123 would create a precedent only for ODSs that achieve superior environmental performance over existing alternatives; its continued use could be structured to encourage continuing innovation for superior alternatives, perhaps requiring re-application after 2040, or after better substitutes are identified by the TEAP, assuming existing use is permitted through product life cycles. At present, HCFC-123 is the only ODS that meets this environmentally superior criteria. Moreover, any impact on the ozone layer from HCFC-123 could be offset by requiring the destruction of ODSs from banks on a ODP-weighted basis of 1:1 or greater, which would have the added benefit of addressing the other cause of the ozone layer’s delayed recovery: CFC banks expected to be emitted into the atmosphere over the next decade. It also would provide additional incentive for further innovation to find superior alternatives, as would incentive schemes like the Energy Star Program.<sup>72</sup>

## GREATER INCENTIVES FOR DESTRUCTION OF ODS BANKS

Emissions of CFCs and other ODSs from banks could be avoided by creating greater incentives for their recovery and destruction. The Montreal Protocol should provide greater incentives for destruction of banks, for example, by allowing credits to carry forward for more than one year and to transfer among chemical groups, where the destruction of an amount of CFCs would allow the production or consumption of an equal amount, on an ODP-weighted basis, of HCFCs.<sup>73</sup>

The Montreal Protocol could provide still greater incentives by linking with the Kyoto Protocol to provide Certified Emissions Reductions under the Clean Development Mechanism for the destruction of ODS banks, given the high GWPs of CFCs. The destruction of banks would help ensure compliance, since the ODS in banks could not be reused or recycled after the CFC ban enters into force in 2010 in developing countries.<sup>74</sup>

## STRENGTHENING COMPLIANCE

The Montreal Protocol should strengthen its compliance efforts by building on work already underway in the Secretariat, UNEP OzonAction's compliance assistance program, and elsewhere, to promote an ambitious capacity building program. This can be accomplished by linking with the Green Customs Initiative of UNEP, and the International Network for Environmental Compliance & Enforcement ("INECE"). A much more aggressive effort is warranted by the combined ozone and climate benefits from strict compliance.

Under Decision XVII/16, the Parties to the Montreal Protocol requested a feasibility study for developing systems for monitoring transboundary movements of ODSs. The study proposed options for monitoring systems that could help reduce illegal trade in ODSs, which has become a worldwide problem as the phase-out of CFCs and other ODSs has progressed.<sup>75</sup> To combat illegal trade, the study made a series of recommendations, including a proposal to set up a global ODS tracking system that builds on current licensing and reporting systems and includes cross-checking of licenses and quotas in a centralized manner.<sup>76</sup>

With regard to the use of ODSs for feedstocks, process agents, and QPS applications, requiring mandatory periodic review of current uses and their direct and indirect impacts on the ozone and climate, utilizing a Life Cycle Analysis, would lay the groundwork for future action banning the use of ODSs where alternatives that are less harmful to the environment are available.

## CONCLUSION

The Montreal Protocol must explicitly assess the environmental impacts, including both ozone and climate impacts, of ODSs and ODS substitutes, and implement policies that minimize these impacts by favoring ODS substitutes that are the least harmful to the environment, until superior substitutes emerge.<sup>77</sup> The failure to do so will jeopardize the continued success of the Montreal Protocol in protecting the ozone layer and mitigating climate change by perpetuating a market that actually works against the most environmentally-friendly ODS substitutes. Conversely, the requirement to assess and minimize the environmental impacts of ODSs and their substitutes will create a fair market that favors the most environmentally-friendly ODS substitutes, resolve the perverse incentives problem, and ensure the continued success of the Montreal Protocol in protecting the ozone layer and mitigating climate change. The Montreal Protocol also must

address the significant ODSs stored in banks that otherwise will be released at end-of-life, and that represent more than seven times Kyoto's reductions in terms of climate emissions .

Ultimately, avoiding the worst impacts of climate change depends upon the successful evolution of the Kyoto Protocol (and its successor), including its international emission trading system, with universal participation and expanded targets after 2012 to reduce GHG emissions enough to avoid dangerous anthropogenic interference with the climate, including abrupt climate change events. Significant progress has been made with Kyoto's market-based mechanisms. But Kyoto and the global carbon market remain works in progress, with the prospect of achieving the substantial reductions necessary to avoid dangerous anthropogenic interference still many years, if not decades, away.

The emissions reductions achieved under the Montreal Protocol are buying more time to develop a sufficiently strong climate regime, with a robust and efficient global carbon market, that efficiently and effectively delivers the needed carbon reductions. It is impossible to say just how much the planet will warm before triggering an abrupt climate change event, but critical thresholds could be as near as 10 years away, and it is imperative to adjust the Montreal Protocol to avoid every ton of CO<sub>2</sub>-eq. emissions that it can. In addition to finishing the job of protecting the ozone layer, this is one of the best insurance policies the world can buy to give us time to succeed with our long-term climate controls. And it is an insurance policy that we can be confident will be delivered by the world's best environmental treaty.

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<sup>1</sup> Several Parties have submitted adjustments or amendments for the 20th Anniversary meeting of the Montreal Protocol in September 2007.

<sup>2</sup> World Meteorological Organization & U.N. Env't. Programme, Science Assessment Panel of the Montreal Protocol on Substances that Deplete the Ozone Layer, *Scientific Assessment of Ozone Depletion: 2006, Executive Summary*, at 3 (Aug. 18, 2006), available at [http://www.wmo.ch/web/arep/ozone\\_2006/exec\\_sum\\_18aug.pdf](http://www.wmo.ch/web/arep/ozone_2006/exec_sum_18aug.pdf) (last visited Feb. 3, 2007) [hereinafter "Science Assessment of Ozone Depletion: 2006"].

<sup>3</sup> RICHARD BENEDICK, *OZONE DIPLOMACY: NEW DIRECTIONS IN SAFEGUARDING THE PLANET* (Harvard University Press 1991); see also STEPHEN O. ANDERSEN & K. MADHAVA SARMA, *PROTECTING THE OZONE LAYER: THE UNITED NATIONS HISTORY* (Earthscan Publications Ltd. 2002); DAVID HUNTER, JAMES SALZMAN, & DURWOOD ZAELEKE, *INTERNATIONAL ENVIRONMENTAL LAW & POLICY*, Ch. 9 (Foundation Press, 3<sup>rd</sup> ed 2007).

<sup>4</sup> U.N. Env't. Programme, Intergovernmental Panel on Climate Change, Technology and Economic Assessment Panel, *Special Report: Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons*, at 3-4 (2005) [hereinafter "IPCC/TEAP Special Report"].

<sup>5</sup> Guus J. M. Velders, et. al., *The importance of the Montreal Protocol in protecting climate*, 104 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 4814 (2007), and supplemental graphs. See also Summary of Stockholm Group Meeting (Feb. 26, 2007) (noting that Montreal Protocol climate reductions would be several times Kyoto's by 2010). The Stockholm Group is an informal gathering of like-minded experts meeting in their personal capacity to discuss key challenges facing the Montreal Protocol. See also IPCC/TEAP Special Report, *id.* at 4 (by phasing out CFCs and replacing them with substances that generally have lower GWPs, such as HCFCs and HFCs, the relative contribution made by CFCs, HCFCs, and HFCs to global warming from 1990 to 2000 declined under the Montreal Protocol from 33 percent to 10 percent when compared to fossil fuel emissions). Kyoto's required emissions reduction target, in terms of CO<sub>2</sub>-equivalent, is -5.8 percent of a baseline of 18.4 GtCO<sub>2</sub>-eq. or -0.97 GtCO<sub>2</sub>-eq yr<sup>-1</sup> by 2008–2012. UNFCCC, *Key GHG Data: Highlights from Greenhouse Gas Emissions Data for 1990-2003* (Nov. 2005). Kyoto's actual emissions reductions will be closer to 2 GtCO<sub>2</sub>-eq. yr<sup>-1</sup> by 2012 if avoided emissions from business-as-usual projections over that timeframe are considered.

<sup>6</sup> Velders, *supra* note 5 (describing a series of measures to strengthen protection of the ozone layer, including accelerating the phase-out of HCFCs, promoting the transition to low GWP substitutes and more energy efficient equipment, and increasing the recovery and destruction of ODS banks, that will further reduce GHG emissions by approximately 1.2 GtCO<sub>2</sub>-eq. yr<sup>-1</sup> and delay the onset of climate change, and stating that the climate benefits of an accelerated phase-out depend on the use of low GWP substitutes and more energy efficient equipment).

<sup>7</sup> Science Assessment of Ozone Depletion: 2006, *supra* note 2, at 21.

<sup>8</sup> Science Assessment of Ozone Depletion: 2006, *supra* note 2, at 21.

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<sup>9</sup> Science Assessment of Ozone Depletion: 2006, *supra* note 2, at 21.

<sup>10</sup> See Env't Investigation Agency, *An Unwelcome Encore: The Illegal Trade in HCFCs* (Oct. 2006) [hereinafter "EIA Illegal Trade in HCFCs"] at 6 (noting that illegal trade in ODS began to grow after the 1999 freeze date for CFCs in developing countries).

<sup>11</sup> Science Assessment of Ozone Depletion: 2006, *supra* note 2.

<sup>12</sup> See Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis Summary For Policy Makers*, 10 (2007).

<sup>13</sup> Steve Connor, *If We Fail to Act, We Will End Up With a Different Planet*, THE INDEPENDENT, Jan. 1, 2007; see also James Hansen, *A Slippery Slope: How Much Global Warming Constitutes 'Dangerous Anthropogenic Interference'?* 68 CLIMATE CHANGE 269 (2005).

<sup>14</sup> See *supra* note 12..

<sup>15</sup> James G. Titus & Charlie Richman, *Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations along the U.S. Atlantic and Gulf Coasts*, CLIMATE RESEARCH, Vol. 18 (2001). Even after passing a critical threshold, melting of the Greenland Ice Sheet could take hundreds or even thousands of years. See Hansen, *supra* note 13.

<sup>16</sup> Peter Schwartz & Doug Randall, *An Abrupt Climate Change Scenario and Its Implications for United States National Security* (2003). See also, Durwood Zaelke, Oran Young, & Scott Stone, *After 'The Day After Tomorrow': What Will Society Learn from the Inevitability of Rapid Climate Change Events*, NATIONAL STRATEGY FORUM REVIEW, Fall 2006.

<sup>17</sup> Allowing the use of HCFCs and HFCs as one of the ODS substitutes was instrumental in the successful phase out of CFCs. U.N. Env't Programme, HFC and PFC Task Force of the Technology and Economic Assessment Panel, *The Implications to the Montreal Protocol of the Inclusion of HFCs and PFCs in the Kyoto Protocol*, at 36-38 (Oct. 1999) [hereinafter "TEAP Oct. 1999"]. HFCs do not deplete the ozone layer, but they are potent GHGs regulated under the Kyoto Protocol for their contributions to climate change. The failure of the Montreal Protocol to account for the climate impacts of HFCs creates a regulatory environment where the best chemicals to protect the atmospheric environment – considering both ozone and climate – are not favored. See IPCC/TEAP Special Report, *supra* note 4. This raises the question of how Parties to the Montreal Protocol could expand jurisdiction to regulate all ODS substitutes to minimize their overall environmental impacts and create a regulatory environment that favors the chemicals and other alternatives that are least harmful to both the ozone layer and the climate. It also raises broader governance issues presented by the Montreal Protocol's focused approach to regulation compared to the Kyoto Protocol's over-arching approach, and specifically whether there are other climate sources and sinks that would be better regulated under more focused regimes like the Montreal Protocol, although still coordinated with the overarching approach.

<sup>18</sup> Science Assessment of Ozone Depletion: 2006, *supra* note 2. In addition, the short-term ODP of some HCFCs rivals that of CFCs, meaning that they will cause near-term damage to the ozone layer at a time when it is expected to recover. See Susan Solomon & Dan Albritton, *Time-Dependent Ozone Depletion Potentials for Short- and Long-Term Forecasts*, NATURE, Vol. 357, May 7, 1992.

<sup>19</sup> The UNFCCC reporting guidelines use GWP values from the IPCC Second Assessment Report, where HFC-23 has a GWP of 11,700. The IPCC Third Assessment Report lists HFC-23's GWP as 14,310 +/- 5,000. IPCC/TEAP Special Report, *supra* note 4, at 30.

<sup>20</sup> Another result of HCFC-22 production is the production of carbon tetrachloride ("CTC"). CTC has an ODP of 1.1 and a GWP of 1,400. It is produced as a by-product of chloromethane, which generates four by-products: methyl chloride, methylene chloride (or dichloromethane), chloroform (or trichloromethane) and CTC. HCFC-22 production requires chloroform, but results in unwanted CTC. As production of HCFC-22 increases, so will unwanted CTC, only a portion of which will be consumed as feedstock. See U.N. Env't Programme, *Report on the Intermediate Evaluation of CFC Production Sector Phase-Out Agreements*, U.N. Env't Programme, UNEP/OzL.Pro/ExCom/42/12 (March 3, 2004), available at <http://www.multilateralfund.org/files/evaluation/4212.pdf> (last visited Feb. 14, 2007).

<sup>21</sup> Env't Investigation Agency, *Turning Up the Heat: Linkages Between Ozone Layer Depletion and Climate Change: The Urgent Case of HCFCs and HFCs*, at 7 (August 2006), available at <http://www.eia-international.org/files/news/324-1.pdf> (last visited Feb. 14, 2007) [hereinafter "EIA Report"]. HFC-23 are projected to increase from 0.195 GtCO<sub>2</sub>-eq yr.<sup>-1</sup> in 2002 to 0.330 GtCO<sub>2</sub>-eq yr.<sup>-1</sup> in 2015. IPCC/TEAP Special Report, *supra* note 4 at 11. In addition, HCFC emissions by 2015 under a business-as-usual trajectory are projected to be 0.828 GtCO<sub>2</sub>-eq. yr.<sup>-1</sup> U.N. Env't Program, *Supplement to the IPCC/TEAP Report*, at Annex (Nov. 2005), available at [http://unep.ch/ozone/teap/REPORTS/TEAP\\_REPORTS/teap-supplement-ippc-teap-report-nov2005.pdf](http://unep.ch/ozone/teap/REPORTS/TEAP_REPORTS/teap-supplement-ippc-teap-report-nov2005.pdf) (last visited Feb. 3, 2007) [hereinafter IPCC/TEAP 2005 Supplement]. See also Velders, *supra* note 5. The emissions reductions in CO<sub>2</sub>-eq. achieved by an accelerated phase-out would depend upon the technology innovations driven by an accelerated schedule, including improvements in energy efficiency, charge size, leakage containment, end-of-life recovery, destruction, etc., as well as the relative GWP of any substitutes selected, although not-in-kind alternatives with low ozone and climate impacts would be expected for much of the transition, as was the case for previous ODS

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phase-outs where 80% of the ODS were replaced by non-fluorocarbon alternatives, including not-in-kind alternatives, alternative products, changes in manufacturing processes, and conservation. Velders, *supra* note 5. Criteria, guidelines, and funding practice of the Multilateral Fund also could strongly influence the size of the ultimate climate benefits. See U.N. Env't Programme, Multilateral Fund for the Implementation of the Montreal Protocol, *Policies, Procedures, Guidelines and Criteria*, at 582 (As of July 2006), available at <http://www.multilateralfund.org/files/Policy49.pdf> (last visited Feb. 14, 2007) [hereinafter Policies Report] (requesting project reviews to consider ODP and GWP impacts).

<sup>22</sup> IPCC/TEAP Special Report, *supra* note 4, at 77-82; see also Michael Wara, *Is the Global Carbon Market Working?* NATURE, VOL. 445, February 8, 2007, 595-96 (discussing that cost to the developed world for installing technology to capture and destroy HFC-23 at the 17 production facilities in the developing world would be €100 million, compared to €4.7 billion in value for CERs generated under CDM through 2012, based on €10/ton price of carbon at time of author's calculations, and neglecting taxes).

<sup>23</sup> IPCC/TEAP 2005 Supplement, *supra* note 20, at 7; Wara, *id.* at 596 (stating that "HFC-23 emitters can earn twice as much from CDM credits as they can from selling the refrigerant—by any measure a major distortion of the market."). See also Michael Connolly, *Beijing's Greenhouse-Gas Effort Attracts Heat*, WALL STREET JOURNAL, January 8, 2007; Jeffrey Ball, *et. al.*, *China Cashes In on Global Warming: Critics Fret Lucrative Carbon Credits Hurt Clean-Energy Efforts*, WALL STREET JOURNAL, January 8, 2007, A10; Keith Bradsher, *Outsize Profits, and Questions in Effort to Cut Warming Gases*, NEW YORK TIMES, December 21, 2006.

<sup>24</sup> International Emissions Trading Association & World Bank, *State and Trends of the Global Carbon Market 2006 (Update: January 1 – September 30, 2006)*, at 11 (Oct. 2006), available at <http://www.ieta.org/ieta/www/pages/getfile.php?docID=1929> (last visited Feb. 3, 2007).

<sup>25</sup> See Wara, *supra* note 22, at 596 ("Perversely, the presence of cheap non-CO2 credits such as HFC-23 in the market is a disincentive to developing new carbon-limiting energy projects...."). Some EU Member States are allowing up to 50 percent of their emissions targets to be met using credits from Kyoto mechanisms, including the Clean Development Mechanism and Joint Implementation. See Fraunhofer Institute Systems and Innovation Research and Centre for Energy and Environmental Markets, *An Early Assessment of National Allocation Plans for Phase 2 of EU Emission Trading*, Working Paper Sustainability and Innovation No. S1/2006, November 9, 2006, available at [http://www.isi.fraunhofer.de/n/Projekte/pdf/NAP2\\_assessment.pdf](http://www.isi.fraunhofer.de/n/Projekte/pdf/NAP2_assessment.pdf) (last visited February 14, 2007).

<sup>26</sup> See IPCC/TEAP Special Report, *supra* note 4, at 43-48, 53-60 (discussing available substitutes for HCFCs and other ODSs).

<sup>27</sup> See Regulation (EC) No 2037/2000 of June 29 2000 on substances that deplete the ozone layer.

<sup>28</sup> See STEPHEN O. ANDERSEN & DURWOOD ZAELEKE, *INDUSTRY GENIUS: INVENTIONS AND PEOPLE PROTECTING THE CLIMATE AND FRAGILE OZONE LAYER* (Greenleaf 2003) 161-62, 168-70.

<sup>29</sup> IPCC/TEAP Special Report, *supra* note 4, at 8; Scientific Assessment of Ozone Depletion: 2006, *supra* note 2.

<sup>30</sup> U.N. Env't Programme, *Report of the Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee* ("RTOC") (Jan. 1, 2002) [hereinafter RTOC Report]. See also *INDUSTRY GENIUS*, *supra* note 28.

<sup>31</sup> James M. Calm & David A. Didion, *Trade-Offs in Refrigerant Selections: Past, Present, and Future*, REFRIGERANTS FOR THE 21<sup>ST</sup> CENTURY, PROCEEDINGS OF THE ASHRAE-NIST CONF., 1997. See also Donald Wuebbles and James Calm, *An Environmental Rational for Retention of Endangered Chemicals*, 278 SCIENCE 1090 (November 1997).

<sup>32</sup> James M. Calm, *Emissions and Environmental Impacts From Air-Conditioning and Refrigeration Systems*, 25 INT'L J. OF REFRIGERATION 293 (2002) 301.

<sup>33</sup> RTOC Report, *supra* note 30.

<sup>34</sup> See Andersen & Zaelke, *supra* note 28.

<sup>35</sup> IPCC/TEAP Special Report, *supra* note 4, at 11.

<sup>36</sup> IPCC/TEAP Special Report, *supra* note 4, at 11.

<sup>37</sup> IPCC/TEAP 2005 Supplement, *supra* note 21, at Annex.

<sup>38</sup> Or more than three times the size if the Kyoto reductions include the avoided emissions from the 6% growth rate since 1990; refer to endnote 5 for further information.

<sup>39</sup> See K. Madhava Sarma, *Compliance with the Montreal Protocol*, MAKING LAW WORK: ENVIRONMENTAL COMPLIANCE & SUSTAINABLE DEVELOPMENT, Vol. 1 (Durwood Zaelke, Donald Kaniaru, & Eva Kruzikova, eds.) (Cameron May 2005), at 287-306.

<sup>40</sup> EIA Illegal Trade in HCFCs, *supra* note 10, at 6.

<sup>41</sup> EIA Illegal Trade in HCFCs, *supra* note 10, at 2.

<sup>42</sup> EIA Illegal Trade in HCFCs, *supra* note 10, at 2.

<sup>43</sup> See IPCC/TEAP Special Report, *supra* note 4, 77-82.

<sup>44</sup> U.N. Env't Programme, *Report of the Tenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer*, "Declaration on Hydrochlorofluorocarbons ("HCFCs"), Hydrofluorocarbons ("HFCs")

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and Perfluorocarbons (“PFCs”),” UNEP/OzL.Pro.10/9, (1998), *available at* <http://www.unep.ch/ozone/pdf/10mop-rpt.pdf> (last visited Feb. 14, 2007); *c.f.* Policies Report, *supra* note 21.

<sup>45</sup> DAVID HUNTER, JAMES SALZMAN & DURWOOD ZAELKE, *supra* note 3.

<sup>46</sup> IPCC/TEAP Special Report, *supra* note 4, at 208. *See also* UNEP/SETAC, LIFE CYCLE APPROACHES: THE ROAD FROM ANALYSIS TO PRACTICE, 20-43 (2005).

<sup>47</sup> IPCC/TEAP Special Report, *supra* note 4, at 205; *see also* Policies Report, *supra* note 21.

<sup>48</sup> TEAP Oct. 1999, *supra* note 17.

<sup>49</sup> IPCC/TEAP Special Report, *supra* note 4, at 205.

<sup>50</sup> IPCC/TEAP Special Report, *supra* note 4, at 205, 207; *see also* TEAP Oct. 1999, *supra* note 17.

<sup>51</sup> Montreal Protocol, Preamble, *available at* <http://www.unep.org/OZONE/pdfs/Montreal-Protocol2000.pdf> (last visited Feb. 3, 2007).

<sup>52</sup> TEAP Oct. 1999, *supra* note 17, at 13.

<sup>53</sup> IPCC/TEAP Special Report, *supra* note 4, at 3-4. *See also* Velders, *supra* note 5.

<sup>54</sup> IPCC/TEAP Special Report, *supra* note 4, at 3-4.

<sup>55</sup> Science Assessment of Ozone Depletion: 2006, *supra* note 2, at ch. 5. Destruction of the ozone layer also results in some cooling that offsets the contribution of ODS to global warming. Velders, *et al.*, calculate that the cooling offset is approximately 20% of direct positive radiative forcing. Velders, *supra* note 5.

<sup>56</sup> U.N. Conference on Environment and Development, *Agenda 21*, at Section 9.23 (June 1992) *available at* <http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm> (last visited Feb. 3, 2007).

<sup>57</sup> *See* Charter of the United Nations, Article 74 (1945); Declaration of Principles on International Law Concerning Friendly Relations and Cooperation Among States in Accordance with the Charter of the United Nations (1972); Declaration of the United Nations Conference on the Human Environment (1972), Principles 6, 7, 15, 18, 21, 24; Rio Declaration on Environment and Development (1992), Principles 2, 11, 27; Convention on the Prevention of the Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972), Preamble; United Nations Convention on the Law of the Sea (1982), Articles 123, 194, 197; Stockholm Convention on Persistent Organic Pollutants (POPs) (2001), Article 1.

<sup>58</sup> European Union Council Directive 96/61/EC of 24 Sept. 1996 concerning integrated pollution prevention and control, *at* <http://europa.eu/scadplus/leg/en/lvb/128045.htm> (last visited Feb. 3, 2007).

<sup>59</sup> Commission of European Communities, *Substitution of Hazardous Chemicals in Products and Processes: Report Compiled for the Directorate General Environment, Nuclear Safety and Civil Protection of the Commission of the European Communities*, at i, March 2003 (*prepared by* Ökopol GmbH and Kooperationsstelle Hamburg), *at* [http://ec.europa.eu/environment/chemicals/pdf/substitution\\_chemicals.pdf](http://ec.europa.eu/environment/chemicals/pdf/substitution_chemicals.pdf) (last visited Feb. 3, 2007); *see also* Greenpeace, *Safer Chemicals Within REACH: Using the Substitution Principle to Drive Green Chemistry* (Feb. 2005) at 5, *available at* <http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/6031.pdf> (last visited Feb. 3, 2007).

<sup>60</sup> *See, e.g.* Finland’s Chemicals Act (744/1989, amendment 1198/1999, art 16 a).

<sup>61</sup> Regulation (EC) No 1907/2006 of the European Parliament and of the Council, Dec. 18 2006, *at* [http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l\\_396/l\\_39620061230en00010849.pdf](http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_396/l_39620061230en00010849.pdf) (last visited Feb. 3, 2006).

<sup>62</sup> *Responsible Use Principles for HFCs*, *at* <http://www.arap.org/textonly/responsible.html> (last visited Feb. 3, 2007).

<sup>63</sup> TEAP Oct. 1999, *supra* note 17, at 82.

<sup>64</sup> ANDERSEN & ZAELKE, *supra* note 28, at 168.

<sup>65</sup> *See* Velders, *supra* note 5.

<sup>66</sup> Accelerated phase-out of HCFC-22 provides additional collateral benefits by reducing the unnecessary production of chloromethane (four chlorinated products manufactured in one process: Methyl Chloride, Methylene Chloride, Chloroform, and Carbon Tetra Chloride-CTC).

<sup>67</sup> *See* IPCC/TEAP Special Report, *supra* note 4.

<sup>68</sup> The next replenishment for the Multilateral Fund for the period 2009-2011 will be decided by the Parties in 2008; adjustments at the September 2007 MoP on additional control measures can be conditioned on the availability of funding in the future. *See e.g.* U.N. Environment Programme, *Report of the Tenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer*, UNEP/OzL.Pro.9/12, at Page 25 (Sept. 25, 1997), *available at* [http://ozone.unep.org/Meeting\\_Documents/mop/09mop/9mop-12.e.pdf](http://ozone.unep.org/Meeting_Documents/mop/09mop/9mop-12.e.pdf) (last visited Feb. 14, 2007) (regarding Decision IX/5: Conditions for control measures on Annex E substance in Article 5 Parties).

<sup>69</sup> *See* Revision to the approved baseline and monitoring methodology AM0001 “Incineration of HFC-23 waste streams,” Clean Development Mechanism – Executive Board, *at* [http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF\\_AM\\_GJ7T352090TABWUMR95QDQXMJWC6EM](http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_GJ7T352090TABWUMR95QDQXMJWC6EM)

<sup>70</sup> U.N. Environment Programme, *Report of the Sixteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer*, UNEP/OzL.Pro.16/17 (Nov. 22-26, 2004).

<sup>71</sup> RTOC Report, *supra* note 30.

<sup>72</sup> *See* ANDERSEN & ZAELKE, *supra* note 28, at 70-83 (discussing Energy Star Program).

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<sup>73</sup> See Velders, *supra* note 5 (noting that greater incentives for the recovery and destruction of ODS banks would remove a significant threat to both the ozone layer and the climate).

<sup>74</sup> Even more cost effective destruction could be possible by initiating the consideration of the common “packaged” incinerator that destroys not only CFCs and HFCs, but also other hazardous chemicals like persistent organic pollutants (“POPs”).

<sup>75</sup> Chatham House & Env’t Investigation Agency, *ODS Tracking: Feasibility Study on Developing a System for Monitoring the Transboundary Movement of Controlled Ozone-Depleting Substances Between the Parties* (Sept. 2006).

<sup>76</sup> Chatham House, *id.* at 6.

<sup>77</sup> A discussion of these and other issues is under way. At the 18th Meeting of the Parties to the Montreal Protocol, held in New Delhi, India, in October-November 2006, the Parties agreed to convene a two-day “dialogue” in mid-2007 on future challenges facing the Montreal Protocol. See U.N. Env’t Programme, “In the decision on dialogue on key future challenges to be faced by the Montreal Protocol,” UNEP/OzL.Pro/L.2/Rev.1, Decision XVIII/34 (2006). In addition, the Stockholm Group is discussing key challenges facing the Montreal Protocol.