Research Paper

Stephen O. Andersen, Duncan Brack and Joanna Depledge
Energy, Environment and Resources | July 2014

A Global Response to HFCs through Fair and Effective Ozone and Climate Policies

CHATHAM HOUSE
The Royal Institute of International Affairs

Contents

Summary

Hydrofluorocarbons (HFCs) are replacements for many of the chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) currently being phased out under the Montreal Protocol on Substances that Deplete the Ozone Layer. Unlike those ozone-depleting substances (ODS), HFCs do not destroy the ozone layer, but they are very powerful greenhouse gases (GHGs) – up to thousands of times more damaging to the climate than carbon dioxide – and their use is currently growing faster than any other category of GHGs. Projections show HFC use increasing as much as 30-fold by 2050, adding up to 0.1°C of global average temperature rise by mid-century, and increasing up to fivefold, to 0.5°C, by 2100. This clearly makes it more difficult to limit the rise in global temperature to the internationally agreed ceiling of 2°C – and thereby avoid dangerous climate change – by the end of the 21st century.

As GHGs, HFCs fall under the purview of the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and are explicitly listed under the UNFCCC's 1997 Kyoto Protocol, which controls emissions of HFCs and other GHGs. They are not, however, subject to any specific measures under the climate agreements, and this is unlikely to change in the near future. Accordingly, the last five years have seen proposals to amend the Montreal Protocol to phase down the production and consumption of HFCs.

Such a step would have a number of advantages. Since substitutes already exist for almost all uses of HFCs, the consumption and production phase-out model of the Montreal Protocol is better suited to controlling HFCs than the emissions limits controls of the climate regime; and the individuals and organizations involved in implementing the Montreal Protocol have accumulated substantial experience and expertise in dealing with precisely those industrial sectors in which HFCs are used, including refrigeration and air-conditioning, foams, solvents and aerosols.

This paper, which draws on the discussions at a workshop held at Chatham House in April 2014, outlines the main issues around the question of how best to craft a fair and effective global response to the growth in HFC use. A number of key issues are central to the debate: the principle of equity between developed and developing countries; the availability of alternatives to HFCs; the need for financial support for developing countries; the legal relationship between the climate and ozone regimes; and, underlying all these, the need for political will to resolve these challenges.

Replacing HFCs: alternatives, barriers and opportunities

A wide range of mature and sustainable substitutes for, and alternatives to, HFCs already exists, and others are rapidly developing. In some applications, however, there is still no clear choice of alternatives; and in many applications economy of scale and competitive prices have not been reached, and/or new (and potentially superior) alternatives are only just emerging. This suggests that a flexible approach to the phase-down of HFCs is sensible, allowing countries to determine which HFCs in which applications to phase down first.

As the experience of the Montreal Protocol has shown, the single most effective action the international community can take is to create a climate of regulatory certainty that HFCs will be phased down. The agreement on the original Protocol, in 1987, and its subsequent amendments and

adjustments, spurred a wave of technical innovation that saw the emergence of substitutes (both alternative substances and alternative technologies) at a much faster rate than had originally been anticipated. Although several countries already regulate HFC use, a global regulatory framework is preferable to a patchwork of different national regulations which does not send such a clear signal.

The Montreal Protocol's experience has also shown that additional benefits can be expected from the development of new technologies. Every new generation of refrigeration and air-conditioning systems, for example, has shown increases in energy efficiency, generally by at least 20 per cent in each transition; and further innovations in turn build on those new developments.

The speed of action is important: the faster the transition can begin, the less HFC-using equipment is installed and the lower the future demand for HFCs for servicing. This points to the need for financial assistance to be made available for developing countries even before any potential control schedule is applied. This is particularly true given that – unlike in the early years of the Protocol – new technologies using HFCs and their alternatives are emerging and being commercialized in developing as well as developed countries.

Governments, in both developing and developed countries, can do much to accelerate the development, commercialization and implementation of alternatives, in advance of, or alongside, regulation. Public procurement policies can be used to favour non-HFC-using equipment acquired by the public sector; and standards, such as those for buildings, can be modified to prefer or require equipment using HFC alternatives.

Finance

The availability of financial assistance, including support for institutional strengthening, training and access to appropriate technology, to help developing countries make the transition to climate-friendly alternatives to HFCs lies at the heart of the debate. For most developing countries, which have just begun the transition away from HCFCs, the immediate focus of efforts will be on preventing further increased use of HFCs. This 'leapfrogging' – moving from HCFCs directly to climate-friendly alternatives – would deliver important benefits to the climate, as well as being cost-effective in the long run as compared with a two-stage scenario.

In principle, there are many possible sources of funding for avoiding and reducing HFC use, in both the climate and ozone regimes. Funding under the ozone regime has the major advantage of predictability, with its regular formal replenishment rounds specifically addressing the funding needs of a particular phase-out schedule. The Montreal Protocol Multilateral Fund (MLF) has proved successful in its targeting of funds and partnerships with implementing agencies and governments. At the same time, although general expressions of intent have been voiced, donor countries have not yet made explicit pledges to fund a transition away from HFCs.

The issue of funding under the climate regime has always been more contentious, with long-standing controversies over funding allocation and adequacy. Climate finance also has a far wider range of potential uses of funds, with HFCs not occupying a particularly high profile. However, in terms of sheer quantity, the sums available to the climate change regime will inevitably be greater, even if donor countries fall short on their promises.

Combining the institutional advantages of the ozone regime with the larger sums available through climate channels could prove to be a fruitful approach. One option would be to enable joint funding between the MLF and the new Green Climate Fund (GCF; or Global Environment Facility – GEF).

Even before agreement on a global phase-down, there are immediate steps that can be taken. Depending on the funding available, the MLF premium for projects converting HCFC uses to low-GWP (low-global warming potential) alternatives could be increased above 25 per cent. The GEF could adopt similar guidelines for its support to transition economies. Another useful measure would be to fund the drawing up of HFC inventories in developing countries, many of which do not have a clear picture of their current patterns of HFC consumption.

The ozone and climate regimes: relationships and responsibilities

One argument against the introduction of HFC control schedules into the Montreal Protocol has been that HFCs are already included under the climate regime. This ignores the distinction of production and consumption controls under Montreal and emissions controls under Kyoto. Furthermore, it is by no means uncommon for substances or activities to be subject to more than one multilateral environmental agreement, and the fact that the climate and ozone regimes share similar goals means that, *a priori*, there is no legal conflict or incompatibility between them. None the less, establishing clear boundaries of responsibility to ensure legal clarity between the climate and ozone regimes would be useful.

As the 2013 G20 Leaders' Declaration, for example, has argued, HFCs could continue to be included 'within the scope of UNFCCC and its Kyoto Protocol for accounting and reporting of emissions'. An arrangement could be envisaged whereby countries would report their detailed production and consumption data under the Montreal Protocol, and emissions under the climate regime. The more detailed data would then be useful for the implementation of effective measures (e.g. management plans and country programmes) to reduce HFC use under the Montreal Protocol. Similarly, the existing mechanisms for information-sharing and technical cooperation – for example between the two regimes' secretariats – could be extended and strengthened.

The negotiations on a future agreement under the climate change regime provide an opportunity to develop a new approach. Whatever its legal nature, the new, 2015 text could be drafted so as to be legally consistent with any sharing – or transfer – of responsibilities for HFCs with the Montreal Protocol that might be agreed. Collaboration between the two regimes could be established in a number of different ways. Any new arrangements on HFCs could be included as legal text in the 2015 agreement, if this takes the form of a new legal treaty; this could have a similar form to the wording in the Kyoto Protocol on aviation and marine bunker fuel emissions, control of which has been 'delegated' to other international bodies. Decisions by the UNFCCC COP (Conference of the Parties) and Montreal Protocol MOP (Meeting of the Parties) could set out the new arrangements, in whatever detail was deemed necessary, and perhaps establish a memorandum of understanding – covering, for example, collaborative funding arrangements.

There are many other ways in which national and regional action could be motivated through the climate regime. A COP decision could encourage parties to take accelerated action on HFCs at domestic and regional levels. A political declaration, adopted at a COP, could do something similar; a register of pledges of action on HFCs could be initiated, including funding pledges to assist

developing countries with phase-down. Furthermore, the UN Secretary-General's scheduled 2014 Climate Summit also provides an opportunity for countries and regions to make such political declarations.

Issues and options under the Montreal Protocol

There are strong arguments for adding HFCs to the Montreal Protocol, with their own control schedules and access to finance from the MLF. Developing specific international control schedules for HFCs – like the ODS phase-out schedules under the Protocol – sends a clear signal to industry, encouraging the development and commercialization of alternatives; such a signal is unlikely to be delivered by the climate regime, the controls of which extend over a wide basket of gases and are not substance-specific. Unlike the climate regime, the institutions of the Montreal Protocol have considerable experience of dealing with exactly those sectors, such as refrigeration and air-conditioning, in which HFCs are being used. Also, the MLF, with its narrower focus and stable basis of funding, is more likely to be able to deliver targeted financial assistance than are the climate funds. Moreover, the Montreal Protocol possesses an effective compliance regime.

Article 2.2(b) of the Vienna Convention, the Montreal Protocol's parent agreement, provides a possible legal mandate for action on HFCs in its commitment to 'control, limit, reduce or prevent human activities under their jurisdiction or control should it be found that these activities have or are likely to have adverse effects resulting from modification or likely modification of the ozone layer'. It could also be possible to decide that HFCs are not controlled substances in the meaning of the Protocol (since current proposals, at least, do not envisage their total phase-out) but are 'other substances' which would be subject to similar control measures but which would continue to be emitted.

Any amendment to the Protocol needs to set out the baseline, ultimate phase-down target and interim steps, and differentiate between developed and developing countries. The amendments tabled for the last five years address these issues, but given persistent opposition to them, it is worth exploring potential modifications. This includes:

- For non-Article 5 parties, a potential joint HCFC/HFC baseline, and a phase-down for a significant reduction by 2030 (similar to some existing national regulations).
- Given the high volume of HFC products manufactured in developing countries, a long grace period for Article 5 parties may be less necessary than in the case of ODS; it would allow a long period of growth of HFC use while denying access to MLF funding. One solution is to make financing available to Article 5 parties wishing to phase down in advance of the control schedule.
- Given also the relatively poor data on HFC inventories in some developing countries, another option is to adopt an initial binding commitment of avoiding an increase in climate impact as a result of HCFC phase-out efforts, leaving the determination of a full reduction schedule to a future date.
- Alternatively, Article 5 parties could agree to a freeze in HFC consumption, leaving the future reduction schedule to be determined when better information becomes available.

- Given the large share of production in Article 5 parties (mainly China), there may be less of a case for a grace period for production.
- HFCs could be divided into groups for the purpose of controls, allowing tailored control of each application; this would allow each sector to do its part in protecting the climate, protect companies from HFC price increases when alternatives are not available, and avoid sheltering HFC uses where alternatives are easily available but other sectors are more easily satisfying the phase-down.
- Given that the amendments so far propose only a phase-down, not a phase-out, there is less of a case for the kind of exemptions used for essential uses of ODS after their total phase-out.

Conclusions

Rising HFC use poses a significant threat to intergovernmental efforts to combat climate change. Arising largely from the success of the Montreal Protocol, yet falling also within the climate regime, the issue provides a stark example of how the global atmosphere scorns arbitrary legal divisions. The result is that, at present, there is a glaring regulatory gap, with HFCs not being dealt with effectively in either regime. This is, however, by no means inevitable: both regimes can and should be mutually reinforcing. The fact that they are not is due partly to outstanding concerns, and partly to politics.

Practical ways of moving forward to address the remaining concerns and try to unblock the politics include solid assurances from donor countries over finance; a request to the ozone and/or climate change secretariats to prepare a (joint) paper on issues of cooperation and legal concerns; and continued analysis of emerging alternatives to HFCs.

Although challenging, there is no reason why the international community cannot come together to address this new problem of coordination and ensure that legal regimes support each other, especially when the potential gains to be made are so great. All that is needed is the political will – and political courage – to do so.

Glossary

Basel Convention	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
CBD	Convention on Biological Diversity
CBDR-RC	common but differentiated responsibilities and respective capabilities
CDM	Clean Development Mechanism (Kyoto Protocol)
CERs	certified emission reductions
CFCs	chlorofluorocarbons
CH_4	methane
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO_2	carbon dioxide
COP	Conference of the Parties (UNFCCC)
COPD	chronic obstructive pulmonary disease
CTCN	Climate Technology Centre and Network
EPA	(United States) Environmental Protection Agency
ETS	emissions trading system (EU)
EU	European Union
F-gas(es)	fluorinated gases
GCF	Green Climate Fund
GEF	Global Environment Facility
GHGs	greenhouse gases
GT $CO_{2\text{-eq}}$	gigatonnes of CO_2-equivalent
GWP	global warming potential
HCFCs	hydrochlorofluorocarbons
HFCs	hydrofluorocarbons
HFOs	hydrofluoroolefins
ICAO	International Civil Aviation Organization

IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LDCs	least developed countries
MAC	mobile air-conditioning
MDIs	metered-dose inhalers
MEAs	multilateral environmental agreements
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
Montreal Protocol	Montreal Protocol on Substances that Deplete the Ozone Layer
MOP	Meeting of the Parties (Montreal Protocol)
N_2O	nitrous oxide
NAMAs	nationally appropriate mitigation actions
NF_3	nitrogen trifluoride
NOUs	National Ozone Units
ODP	ozone-depleting potentia
ODS	ozone-depleting substance
OEWG	Open-Ended Working Group (of the Parties to the Montreal Protocol)
PFCs	perfluorocarbons
RAC	refrigeration and air-conditioning
Rotterdam Convention	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
SBSTA	Subsidiary Body for Scientific and Technological Advice (UNFCCC)
SF_6	sulphur hexafluoride
SNAP	Significant New Alternatives Policy (EPA)
Stockholm Convention	Stockholm Convention on Persistent Organic Pollutants
TEAP	Technology and Economic Assessment Panel
TOCs	technical options committees

UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard
Vienna Convention	Vienna Convention for the Protection of the Ozone Layer
W/m^2	watts per square metre

Introduction

Hydrofluorocarbons (HFCs) are currently the fastest growing category of greenhouse gases (GHGs). Synthetic chemicals used in applications such as refrigeration and air-conditioning, foams, solvents and aerosols, their use is expanding rapidly because they are being used as substitutes for the ozone-depleting chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) that are being phased out under the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. Growing global demand for air-conditioning and refrigeration, especially in emerging economies, is also accelerating the demand for HFCs. Unlike CFCs and HCFCs, HFCs do not deplete the ozone layer, but they are very powerful GHGs – up to thousands of times more damaging to the climate than carbon dioxide (CO_2) – and the rapid rate of increase in their use has the potential to contribute significantly to climate change.

The Montreal Protocol is widely acknowledged to be the world's most effective environmental treaty. Under its terms, 98 per cent of the production and consumption of ozone-depleting substances (ODS) has now ended; and the ozone layer is projected to recover to its pre-Antarctic ozone hole state over the next 50 or so years, and to its pre-industrial state in about 500 years.[1] At the same time, the Montreal Protocol has also made a major contribution to slowing the rate of global warming; almost all ODS, including CFCs and HCFCs, are themselves powerful GHGs, typically far more powerful even than HFCs. For example, replacing CFC-12 (GWP = 10,200) with its typical substitute HFC-134a (GWP = 1,300) delivers an 800 per cent reduction in climate forcing from direct chemical emissions. None the less, rising HFC use risks cancelling out the overall climate benefits of the CFC and HCFC phase-out and casts a significant shadow over the Montreal Protocol's success story. At the same time, effective action to tackle climate change is becoming ever more urgent, as the small window of time available to limit global temperature rise to the internationally agreed target of 2°C is closing rapidly.

To date, HFCs have caused less than 1 per cent of total global warming. None the less, production, consumption and emissions of HFCs are rising faster than any other category of GHGs, at a rate of 10–15 per cent per year.[2] HFCs and other fluorinated GHGs, which include sulphur hexafluoride (SF_6) and perfluorocarbons (PFCs), are already the fastest growing climate pollutants in many countries, including Australia, China, the EU, India and the United States. If unabated, the present high growth rate for HFCs will cause significant future warming. Projections show HFCs increasing as much as 30-fold by 2050, with climate impact rising from a current level of radiative forcing of 0.012 W/m² (watts per square metre) to as much as 0.40 W/m². Continued expansion in HFC use is accordingly projected to contribute up to 0.1°C of global average temperature rise by mid-century, increasing up to fivefold, to 0.5°C, by 2100.

The significant environmental impact of rising HFC emissions resulting from the ODS phase-out has prompted calls for the introduction of production and consumption controls for these substances under the Montreal Protocol, even though they are not ozone-depleting substances. As

[1] Velders, G. J. M et al. (2012), *Preserving Montreal Protocol Climate Benefits by Limiting HFCs*, SCI. 335: 922–23.
[2] Xu Y., Zaelke D., Velders G. J. M. and Ramanathan V. (2013), *The Role of HFCs in Mitigating 21st Century Climate Change,* Atmos. Chem. Phys. 13: 6083-89; see also Hare B. et al. (2013), *Closing the 2020 Emissions Gap: Issues, options and strategies;* and Ramanathan V. and Xu Y. (2010), *The Copenhagen Accord for Limiting Global Warming: Criteria, Constraints, and Available Avenues*, Proc. Nat'l Acad. Sci. USA 107: 8055–62 (the Ramanathan and Xu study was the first to model the climate benefit of HFC mitigation in combination with SLCPs, CO_2 and other long-lived greenhouse gases).

GHGs, emissions of HFCs naturally fall under the purview of the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and are explicitly listed under the UNFCCC's 1997 Kyoto Protocol. They are not, however, subject to any specific measures under the climate regime, and are unlikely to be so in the near future, adding weight to proposals to address HFC production and consumption under the ozone regime.

There are several other arguments in favour of using the Montreal Protocol to control HFCs. Since substitutes already exist for almost all uses of HFCs, the consumption and production phase-out model of the Montreal Protocol is better suited to controlling HFCs than are the emissions limits controls of the climate regime. Moreover, the individuals and organizations involved in implementing the Montreal Protocol to date have accumulated substantial experience and expertise in dealing with precisely those industrial sectors in which HFCs are used.

Over the past five years, several proposals have been put forward to amend the Montreal Protocol to phase down HFCs, and this approach has also been endorsed in other intergovernmental forums, such as the G20 and the UN Conference on Sustainable Development (Rio+20). Although there is general agreement that rising HFC use and emissions must be addressed, this has not extended to consensus on the way forward. Concerns have been raised, among others, over the technical feasibility and cost implications of replacing HFCs, the legal relationships between the ozone and climate regimes, and the availability of finance to support developing countries. Broader political dynamics have also come into play, in effect preventing the ozone regime from entering into substantive negotiations on the proposed amendments. Large emerging economies, in particular, have been wary of proposals to take aggressive action on HFCs. The upshot is that the intergovernmental arena has so far been incapable of taking effective decisions. This is especially regrettable given that, compared with many other potential climate mitigation measures, reducing the rate of growth of HFCs is highly cost-effective, representing a potential 'easy win' for the climate.

How best to craft a fair and effective global response to HFCs, in the context of this overlap between the ozone and climate regimes, was the subject of discussion at a workshop held at Chatham House in April 2014. This paper, a draft of which was used to facilitate the workshop's discussions, outlines the main issues that shape the current international debate. In so doing, the paper aims to reflect the key points that emerged from the workshop. Responsibility for the paper and any opinions expressed, however, remain with the authors and should not be taken to represent those of workshop participants or funders.

The paper begins by reviewing the current regulatory framework for HFCs, including a brief description of the key relevant features of the ozone and climate change regimes, as well as existing national and regional approaches. It then outlines the central issues that have emerged in discussions on HFCs to date, before focusing on three of those issues in more detail: availability of alternatives to HFCs; finance; and the relationship between the ozone and climate change regimes. The paper then considers options for designing a way forward under the Montreal Protocol, before presenting conclusions.

Background: the current regulatory framework

The ozone regime

Commitments

Since its entry into force in 1989, the Montreal Protocol has proved to be a flexible and adaptable instrument. It has been amended on four occasions, to add new chemicals and introduce other new provisions, and adjusted six times to accelerate the speed of phase-out, in response to changing scientific evidence and technological developments. The protocol, and its parent 1985 Vienna Convention on the Protection of the Ozone Layer, now enjoy the universal participation of all UN member states – the only multilateral agreement on any topic to do so.

The Montreal Protocol divides parties into two categories. An 'Article 5 party' is a developing country whose level of consumption of the main CFCs (after the entry into force of the protocol for that country, up until 1999) was less than the limit set out in paragraph 1 of Article 5 of the protocol (0.3 kilograms per capita per year). 'Non-Article 5 parties' are developing countries with higher consumption levels and developed countries. Parties can be moved between the categories by decision of a Meeting of the Parties (MOP), and this has happened on a number of occasions. Currently, 147 countries are categorized as Article 5 parties and 50 as non-Article 5 parties.[3]

The Montreal Protocol control schedules set timetables for the phase-out of both the production and consumption of ODS. ODS are organized into groups (currently nine) that are separately scheduled for phase-out. Each party aggregates the production and consumption of all ODS within the group, based on the substances' ozone-depleting potential (ODP). The control schedules for Article 5 parties have generally begun later, and feature more interim steps, than those for non-Article 5 parties. Article 5 parties also qualify for funding to cover the agreed incremental costs of phase-out from the regime's Multilateral Fund (MLF).

Six of the nine groups of ODS, including the two original groups included in the protocol when it was negotiated (CFCs and halons), have now been completely phased out everywhere (with a few temporary exceptions for essential uses). Phase-out of methyl chloroform and methyl bromide is complete in non-Article 5 parties (again, with some temporary exceptions) and should be so in Article 5 parties by 2015. Phase-out of HCFCs, widely used as replacements for CFCs but with much lower ODPs, is well under way in non-Article 5 parties, which met a 75 per cent reduction target in 2010 and should reach total phase-out by 2030; and is just starting in Article 5 parties, which should have met a production and consumption freeze (at 2009–10 levels) at the beginning of 2013, and should reach total phase-out by 2040.

While the Montreal Protocol requires a phase-out of each group of controlled ODS, there is complete flexibility in terms of how phase-out commitments can be met within the group. For example, the fire protection community, the main users of halons, phased out about 90 per cent of original use by halting testing and discharge during service and training, restricting use to important applications voluntarily, revising safety standards, and using stockpiled and recycled

[3] The list of A5 parties can be found at http://ozone.unep.org/new_site/en/parties_under_article5_para1.php, and the list of non-A5 parties at: http://ozone.unep.org/new_site/en/parties_under_article5_para1.php?na5.

halons to satisfy applications where alternatives were not suitable. Similarly, the refrigeration and air-conditioning industry developed and implemented recovery and recycling, and switched to the best available substitutes, including natural refrigerants and now hydrofluoroolefins (HFOs – a class of HFCs with generally much lower GWPs).

Institutions

Much of the success of the Montreal Protocol has been attributed to its institutional design. The supreme decision-making body of the ozone regime is the MOP, with preparatory discussions taking place in the Open-Ended Working Group (OEWG). These bodies have proved, in contrast to those in many other multilateral environmental agreements (MEAs), generally harmonious forums for resolving the key political, technical and financial issues faced by the parties. A sense of community has traditionally prevailed, which has been helpful in resolving disputes (although unfortunately, as further discussed below, this positive atmosphere has not extended to discussions on HFCs, which have been comparatively acrimonious).

The ozone regime's small secretariat is well regarded and generally trusted. Parties have accordingly allowed it to be proactive in identifying and bringing to their attention emerging scientific, technical and administrative challenges and opportunities, as well as liaising with secretariats of other MEAs and international institutions to resolve issues of overlap.

Many commentators have identified the ozone regime's dedicated financial mechanism, the MLF, as a key factor in the Montreal Protocol's achievements. Established in 1991 to assist Article 5 parties in meeting their commitments under the treaty, the MLF has successfully financed new technology that has almost continuously kept all Article 5 parties in full compliance. The MLF is managed by an Executive Committee, which features equal representation of non-Article 5 and Article 5 parties; and its staff are technical experts in their own right, with specialized knowledge of satisfactory technologies in technical, economic and environmental performance.

The MLF is replenished every four years, through a process of negotiation among the parties, based on an objective estimate of financial requirements prepared by the Technology and Economic Assessment Panel (TEAP – see below). The financial contributions of parties are then determined according to the UN scale of assessment. This system thus provides some certainty over the scale and adequacy of funding available to the MLF. However, the past few replenishment rounds have seen a decline in the total funding agreed, raising concerns that financing for the still ongoing ODS phase-out in developing countries may not be sufficient.

Critical to the Montreal Protocol's success was the MLF's early decision to support 'institutional strengthening' in Article 5 parties, allowing the establishment and maintenance of National Ozone Units (NOUs) and associated regional networks. This has helped to provide a continuous effort and momentum in phasing out ODS, including acting as the bridge to the thousands of companies that must make investments in new technology, sharing information on suppliers and on the important details of training, infrastructure development and public awareness.

Another envied feature of the ozone regime is its assessment panels, which are generally respected for their objectivity and expertise. The TEAP and its several technical options committees (TOCs) analyse which technologies can technically and economically replace ODS, including consideration of product safety and environmental impacts. The Scientific Assessment Panel (SAP) and the

Environmental Effects Assessment Panel (EEAP) publish regular reports outlining the consequences of stratospheric ozone depletion, climate change and ecological damage from the decomposition products of ODS and the chemical substances that replace ODS. The proactive and day-to-day involvement of the assessment panels in the negotiation and implementation of control measures have been important to their effectiveness.

A strong compliance regime, managed by the Implementation Committee, has helped to ensure that cases of persistent non-compliance have been very rare. The committee works in a flexible and primarily consensual way with parties in potential or actual non-compliance to identify the reasons and agree plans of action with specific benchmarks to return them to compliance, underpinned by a credible threat of sanctions (chiefly trade measures).

Nearly 30 years after its inception, the ozone regime has now reached a mature stage, where its institutions are well established and its main objective – the phase-out of the production and consumption of ODS – has been largely met. The Montreal Protocol, however, is still faced with several challenges, and not just that of rising HFC use: illegal trade in ODS, and the disposal of banks of stored ODS, for example, remain important concerns. None the less, it is true to say that the Montreal Protocol is widely accepted as a highly effective regime. The corollary of this, however, is that the issue of ozone protection has largely dropped down the international agenda, receiving only limited political attention. This contrasts, in particular, with the climate regime.

The climate regime

The UNFCCC was adopted in 1992, five years after the Montreal Protocol, with the ultimate objective of stabilizing 'greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' (Article 2). Although both treaties deal with the state of the global atmosphere, the problem of climate change is far more complex than that of ozone depletion. The root causes of climate change lie in fossil fuel combustion and land-use change, activities that remain central to economic development and pervade every aspect of human society. Preventing dangerous climate change will require fundamental transformations in the way in which the world generates and uses energy – inevitably leading to winners and losers, and therefore political conflict. Although combating stratospheric ozone depletion presented – and still presents – difficult challenges to the international community, these pale in comparison with the complexities surrounding climate change.

In common with other MEAs adopted at that time, the UNFCCC is founded on the explicit principle of 'common but differentiated responsibilities and respective capabilities' (CBDR-RC – Article 3.1), which translates (similarly to the Montreal Protocol) into differentiated commitments for developed and developing countries. However, unlike the Montreal Protocol formula for qualifying for financing and later control measures, the UNFCCC itself includes a list of what it considers to be the developed country parties – known as the 'Annex I parties' – who should 'take the lead' in addressing climate change (Article 3.1). All other parties that are not listed are known as non-Annex I parties.

Under the UNFCCC, 40 or so Annex I parties were thus subject to an obligation to 'aim' to return their GHG emissions to 1990 levels by 2000. Almost all of the Annex I parties also took on quantified emission targets under the 1997 Kyoto Protocol for its first commitment period (2008–

12), with some 30 countries signing up to targets for the second period (2013–20). Non-Annex I parties, for their part, have a general obligation to mitigate and adapt to climate change, but no specific targets. All parties must also report on the action that they are taking to address climate change, and submit national inventories of their GHGs, although requirements for non-Annex I parties are more lenient – including on the content and frequency of submissions. The least developed countries (LDCs) are given special status under the treaty in view of the particular challenges for them in addressing climate change.

This classification of Annex I and non-Annex I parties has remained virtually intact since the UNFCCC was adopted; there have been additions to Annex I adopted by amendment, but these have mostly been new EU member states. Concerns have been raised that the two-way division is becoming increasingly outdated, given that several non-Annex I parties are now highly industrialized and among the largest aggregate GHG emitters. The issue of how to respect the principle of CBDR-RC in this context, while ensuring the effectiveness of climate mitigation, is the central question in the climate negotiations.

The UNFCCC's objective, which also applies to other related instruments such as the Kyoto Protocol, covers all GHGs. Its definition of greenhouse gases (Article 1.5) includes 'both natural and anthropogenic' gases 'that absorb and re-emit infrared radiation', which therefore embraces HFCs. The treaty does, however, limit the coverage of its commitments to GHGs 'not controlled by the Montreal Protocol', with this specific wording included in both Article 4, on commitments, and Article 12, on national inventories, and also elsewhere in the UNFCCC. This division of responsibility between the two regimes – climate and ozone – was therefore ingrained in the international arena early on. It can be assumed that the exclusion of controlled substances under the Montreal Protocol from the UNFCCC was motivated by the desire for clarity over the legal scope of the two regimes, and probably the assumption that emissions of these substances would eventually be completely eliminated under the production and consumption controls of the Montreal Protocol. (That assumption was, in the event, incorrect, because the Montreal Protocol does not control the emissions of ozone-depleting GHGs held in banks of refrigeration, air-conditioning and fire protection at the time of product disposal.)

(In fact, the UNFCCC does not include a definition of the 'Montreal Protocol', although that treaty, and the Vienna Convention, is referenced in full in the preamble. This omission was corrected in the Kyoto Protocol, which includes a definition of the Montreal Protocol as 'the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in Montreal on 16 September 1987 and as subsequently adjusted and amended'. The final clause was added specifically to reflect the ongoing evolution of the Montreal Protocol – including, it can be assumed, beyond the date of adoption of the Kyoto Protocol.)

The only gas referred to by name in the UNFCCC is carbon dioxide, which is not surprising, given that it is by far the most important GHG in terms of contribution to global warming. The absence of any other listing of gases in the UNFCCC – in contrast to the approach taken in the Montreal Protocol, which lists all the chemicals it controls – reflects the general and qualitative nature of the treaty's commitments, which do not require exact definitions for compliance purposes.

However, the emission reporting guidelines adopted under the UNFCCC had the effect of defining the scope of the climate change regime more precisely. These guidelines were based on

methodologies for estimating emissions devised by the Intergovernmental Panel on Climate Change (IPCC), and covered all GHGs (those known to have global warming potential – GWP) that were not already being controlled and reported under the Montreal Protocol. The UNFCCC reporting guidelines thus state that inventories should, 'at a minimum', include data on 'carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulphur hexafluoride (SF_6)'. Annex I parties have therefore been required to report disaggregated data on their HFC emissions as part of their annual emission inventories under the climate regime since 1994. The rules and reporting schedule for non-Annex I parties are more lenient – biennial submission of inventories has only just been agreed – but disaggregated HFC emissions data are required as part of the desired information, and have been supplied by most large HFC emitters.

The Kyoto Protocol

The Kyoto Protocol to the UNFCCC, agreed in 1997, introduced legally binding quantitative emission targets for Annex I parties, initially for the commitment period 2008–12, and now for a second period covering 2013–20. Given the legally binding nature of its targets, along with the establishment of market mechanisms allowing the transfer of emission credits, the Kyoto Protocol defines its reach much more clearly than does the UNFCCC. It thus includes a listing of the GHGs that it covers, including sectors and source categories, in its Annex A. That listing includes HFCs (as a single category), along with CO_2, CH_4, N_2O, and PFCs and SF_6 (as a combined category); nitrogen trifluoride (NF_3) was added for the second commitment period only.

The inclusion of the original six gases mirrors the *de facto* scope of the UNFCCC, as established by its broad definitions and then by more specific reporting guidelines. There was, however, considerable debate as to which GHGs should be included under the Kyoto Protocol, notably with regard to HFCs.[4] Some parties, in particular the EU, called for a three-gas target, with the option of including HFCs, PFCs and SF_6 at a later date. The possibility, proposed by Norway, of a five-gas target – minus HFCs – was also briefly considered. The United States and several other non-EU developed countries promoted a six-gas target. In the end, a compromise was reached to include the six gases, but with parties allowed to use a 1990 or 1995 baseline for HFCs, PFCs and SF_6, to take account of the fact that, for some parties, emissions had increased considerably in the few years after 1990, in line with efforts to phase out CFCs.

Although the Kyoto Protocol lists the gases that it covers individually, its emission targets are based on the 'basket' approach that aggregates emissions of all the GHGs, based on their GWP-weighted CO_2 equivalence. Parties can therefore choose which combination of the controlled GHGs to address in order to meet their targets. The Kyoto Protocol takes a similarly flexible approach with regard to the policy actions that parties might choose to control their emissions. Some policies and measures are mentioned in the treaty (Article 2), but only in the most general terms, and only as options.

Another feature of the climate change regime relevant to HFCs is the Clean Development Mechanism (CDM) of the Kyoto Protocol, which assists developed countries to meet their emissions reduction targets by earning 'certified emission reductions' (CERs) from emission reduction projects in developing countries. In the early years of the CDM, many projects were put forward to

[4] See FCCC/TP/2000/2, paras 147–59.

fund the destruction of HFC-23, an unwanted by-product of the production of HCFC-22. Although destruction of HFC-23 was a rational aim, overpayment and evidence of gaming the system quickly emerged, with some companies increasing their production of HCFC-22 simply in order to generate income from destroying HFC-23. From 2005 to June 2012, 19 manufacturers of refrigerants were issued with 46 per cent of all the CERs from the CDM, worth an estimated $20–40 million per year per plant, for a total of well over $1 billion.[5] The rules on such projects have since been tightened, and no new HFC projects have been registered since 2005. In addition, in 2011 the EU banned the use of HFC CERs in its Emissions Trading Scheme from 1 May 2013, helping to shut off a main driver of the activity.

The Copenhagen Accords/Cancun Agreements

A number of Annex I parties (including Japan, New Zealand and the Russian Federation) have not joined the Kyoto Protocol's second commitment period, or are not parties to the Kyoto Protocol at all (Canada and the United States). These countries have, instead, pledged quantified, economy-wide emission reduction targets for the period up to 2020 under the 2010 Cancun Agreements, based on the 2009 Copenhagen Accords.

These *voluntary* pledges are similarly all based on aggregate emissions, and the inclusion of HFCs is assumed, but not explicit. Several non-Annex I parties have also pledged nationally appropriate mitigation actions (NAMAs) under the Cancun Agreements that include targets (mostly on emissions intensity); these also refer to emissions in general. Many more non-Annex I parties have pledged to implement specific policies (rather than declare targets); to date, none of these has explicitly mentioned HFCs, but some may involve the implementation of policies that will involve their elimination. Some NAMAs that foresee measures to improve the energy efficiency of old refrigeration equipment include activities eliminating substances controlled under the Montreal Protocol, and potentially also HFCs.

The future shape of the climate change regime

Overall, the climate regime's approach to the control of GHGs avoids prescribing, prohibiting or indeed recommending any particular approach, policy or technology. There is complete flexibility in terms of how targets can be achieved; compliance under the Kyoto Protocol is based only on whether the emissions target has been met in aggregate. Although the regime includes many mechanisms aimed at helping parties to implement their commitments, and often plays host to workshops, round tables and other discussion forums on specific issues or policy approaches, all these are purely facilitative and have no remit to impose or recommend policy. Likewise, while the IPCC plays an important role in assessing the science of climate change, and policy options for mitigation, it does not have the same proactive and day-to-day involvement in the negotiations, finance and technology implementation that characterizes the Montreal Protocol's assessment panels.

The climate change regime is at a very different stage than is the ozone regime, in that the achievement of its ultimate objective remains a very distant goal – reflecting the far greater complexities involved in tackling this most intractable of problems. The Copenhagen Accords/Cancun Agreements marked an important step forward in the evolution of the regime,

[5] Elisabeth Rosenthal and Andrew W. Lehren, 'Profits on Carbon Credits Drive Output of a Harmful Gas', *New York Times*, 8 August 2012.

adding further precision to the UNFCCC's objective by agreeing 'to hold the increase in global average temperature below 2°C above pre-industrial levels'.[6] This 2°C ceiling now stands as the yardstick of the climate regime, even if it is deemed far too weak by some and desperately overambitious by others. In contrast to the ozone regime, the climate negotiations have always been highly politicized, largely along North–South lines, revolving around issues of responsibility and burden-sharing that are not easily resolved. Although the climate change regime enjoys very high levels of political attention and engagement, this has not translated into any more effective negotiations.

Unlike the Montreal Protocol, the climate change regime is in a state of major transition, with negotiations currently under way to design the next stage of commitments post-2020. This negotiating round, under the so-called Durban Platform, is due to conclude at the 21st Conference of the Parties (COP 21) in Paris in 2015. The 2011 Durban Platform mandates the negotiations 'to develop a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties' that 'shall raise the level of ambition'. This rather general mandate, agreed only after the most difficult of negotiations, gives little indication of what the eventual agreement might look like, and negotiations to date have not provided any clearer signals. The climate regime, however, appears to be generally moving away from the top-down, legally binding structure of the Kyoto Protocol towards a looser arrangement of nationally defined commitments. It is very unlikely that the 2015 agreement will include a third commitment period to the Kyoto Protocol, and indeed there is no guarantee that any new legally binding treaty at all will be agreed. This suggests that the prospect of the climate regime itself agreeing specific targets on HFC reduction is remote.

Regional and national approaches to HFCs

Although there are no specific international controls on HFC production, consumption or emissions, a number of countries and regions have already adopted domestic commitments to reduce their use, and many industry associations and corporations are implementing policy to avoid and eliminate HFCs.

In May 2014, for example, the new Fluorinated Gases (F-Gas) Regulation entered into force in the EU. This replaced the 2006 regulation, which aimed only at containment, including the control of leaks, proper servicing of equipment and recovery of the gases at the end of the equipment's life. The new regulation will see a reduction in sales of HFCs on the EU market to 21 per cent (GWP-weighted) of 2009–12 levels by 2030, with interim reduction steps starting in 2015. The use of HFCs with a GWP greater than 150 will be banned in new equipment in a number of sectors, in particular in the area of commercial refrigeration and foams, and from 2020 very high-GWP HFCs will no longer be used to service and maintain refrigeration equipment. This will reduce EU emissions of F-gases by two-thirds from 2010 levels by 2030.

The regulation also stipulates that importers and EU producers of fluorinated GHGs will have to provide evidence that HFC-23 from the production of these gases, and from the production of feedstocks used in the process, was either destroyed or recovered for subsequent use. In addition,

[6] Decision 1/CP.16, para. 4, UNFCCC, 2010.

the EU Directive on mobile air-conditioning systems (MACs) (the MAC Directive), also adopted in 2006, prohibits the use of F-gases with a GWP of more than 150 in new types of cars and vans introduced from 2011 and in all new cars and vans produced from 2017. Taken together, EU policies on fluorinated gases (including HFCs) will save a projected 1.5 GT $CO_{2\text{-eq}}$ by 2030, and more than 5 GT $CO_{2\text{-eq}}$ in 2050, compared with a business-as-usual scenario.

In the United States, the Climate Action Plan announced by President Barack Obama in June 2013 set out a number of measures to address HFCs. It has been estimated that eliminating certain HFCs could provide 23 per cent of the emissions reductions needed to achieve the United States' 2020 reduction goal (17 per cent below 2005 emissions).[7] This included the use of the Environmental Protection Agency's (EPA) Significant New Alternatives Policy (SNAP) programme, established to evaluate and regulate ODS replacements; the programme publishes lists of acceptable and unacceptable substitutes. Two new rules are currently in preparation, one expanding the list of low-GWP alternatives to ODS, and a second changing the listing of some HFCs for particular end uses from acceptable to unacceptable. The EPA also runs the GreenChill partnership with food retailers to reduce refrigerant emissions and their impact on the ozone layer and climate change. In addition, the US government is aiming to purchase cleaner alternatives to HFCs whenever feasible, and to transition over time to equipment that uses safer and more sustainable alternatives.

Regulations banning use, prohibiting venting, and taxing or promoting alternatives to HFCs are also in place in the following countries:

- Austria: bans almost all HFC uses in new equipment; fiscal incentives for HFC-free alternatives;
- Canada: federal and provincial regulations prohibiting the release of HFCs from refrigeration and air-conditioning equipment are supported by a Refrigeration Code of Practice that outlines best practices to minimize and eliminate emissions in the cooling sectors;
- Denmark: bans almost all HFC uses; containment (leak/emission prevention); tax on HFCs; promotion of HFC-free alternatives;
- Japan: revised law phases down HFCs, promotes low-GWP equipment and products, improves containment in commercial equipment, and requires registration and approval of fillers and recyclers;
- Namibia: promotion of low-GWP alternatives under national carbon-neutral policy; plans for compulsory reporting of HFC refrigerant imports;
- Norway: tax/refund scheme for HFCs;
- Serbia: import and export licensing and reporting for HFCs (GWP >150); bans sale of certain equipment/products that rely on F-gases; containment and mandatory gas recovery; record-keeping;

[7] Bianco N. et al. (2013), *Can the U.S. Get There from Here?: Using Existing Federal Laws and State Action to Reduce Greenhouse Gas Emissions*, World Resources Institute, 3–4.

- Switzerland: bans many HFCs uses, emission reduction measures for remaining HFC uses; discourages new uses of HFCs; promotes HFC-free alternatives; reports on HFC imports.

Recent years have also seen an increasing trend for major companies and industry associations to adopt voluntary commitments on environmentally sustainable sourcing and behaviour. In 2010, for example, the Consumer Goods Forum, a global industry network of more than 400 retailers, manufacturers and service providers, adopted a commitment for its member companies to start, by 2015, phasing out HFCs in refrigeration. It also agreed to work on public policy and regulatory barriers, in particular in the United States, to facilitate the collection of performance metrics and methodologies to create 'one source of truth' for HFC-free technologies, and to demonstrate progress among its member companies, with the aim of encouraging others.[8] There are also many examples of individual companies, such as AEON, Carrefour, Coca-Cola, Heineken and Nestlé, adopting commitments not to use HFCs in new equipment, and to phase out the use of HFCs in existing equipment.

The broader international arena is also seeing increasing support for the accelerated reduction of HFCs. At the G20 St Petersburg Leaders' Summit in 2013, for example, the member countries agreed on 'using the expertise and the institutions of the Montreal Protocol to phase down the production and consumption of HFCs, based on the examination of economically viable and technically feasible alternatives' and to 'continue to include HFCs within the scope of UNFCCC and its Kyoto Protocol for accounting and reporting of emissions'.[9] This built on the outcome of the Rio+20 UN Conference on Sustainable Development, in June 2012, which expressed support for 'a gradual phase-down in the consumption and production of hydrofluorocarbons'.[10]

The combined effect of these measures is to encourage the rapid development and commercialization of alternatives to HFCs, and to reduce or close off consumer markets to HFCs and HFC-containing equipment – a matter of significance to major exporters of this technology even if they do not control their own HFC use.

These many initiatives, however, do not mean that internationally agreed rules on HFCs would be redundant. As the past experience of the Montreal Protocol (and other MEAs) has shown, a patchwork of different national measures does not give as strong a signal to the market as globally applicable, legally binding reduction schedules, which have accelerated technological development and innovation. Furthermore, international agreement should provide guaranteed finance and institutional support for developing countries. The continued steep rise in HFC use, despite the many domestic and regional steps already taken, suggests there could be significant value added to international agreement on the control of these substances.

[8] See Consumer Goods Forum web page on refrigeration, http://sustainability.mycgforum.com/refrigeration.html.
[9] G-20 Leaders' Declaration, September 2013, para. 101.
[10] *The Future We Want*, para. 222.

Key issues

The debate over additional measures to control and reduce the use of HFCs, and specifically over a potential amendment to the Montreal Protocol, has been in progress for more than five years. Over the course of the debate, several key issues have emerged that will need to be resolved before any agreement can be reached. These are outlined below, and discussed in more detail in the later sections of this paper.

Equity

Key to the politics of the issue is the principle of equity. Under the climate regime, action on HFCs will be guided by the UNFCCC's principles of equity, and CBDR-RC (UNFCCC, Article 3.1). The Montreal Protocol predated the general acceptance of this specific wording in MEAs, but similarly contains a commitment to 'equitably reduce' emissions of ODS, and also the recognition that 'special provision is required to meet the needs of developing countries, including the provision of additional financial resources and access to relevant technologies' (Preamble). Ensuring that any new commitments on HFCs under the Montreal Protocol respect the principle of equity is obviously crucially important, with implications for differentiating commitments entered into by developed and developing countries (both in scale and speed) and in the provision of financial and institutional support, and technology transfer.

The issue, however, extends beyond a general acceptance of equity; there is clearly a concern among some countries, notably emerging economies, that the specific principle of CBDR-RC should also be explicitly upheld for HFCs, including if they are controlled under the Montreal Protocol. It may not be enough to point to the Montreal Protocol's existing provisions on equity; some specific wording on CBDR-RC may be needed. The concern is not just one of wording, but also one of practical implementation. Under the climate change regime, CBDR-RC means that non-Annex I parties have been treated very differently to Annex I parties. To date, non-Annex 1 parties possess only qualitative and general commitments. This contrasts with the notion of equity under the Montreal Protocol, whereby developing countries are also subject to legally binding targets – but with those targets differentiated in their strength and timetable. The insistence on CBDR-RC on the part of some emerging economies would seem to suggest a reluctance to agree to the Montreal Protocol's approach of legally binding targets for all.

Feasibility of introducing alternatives

Many developing countries have raised concerns over the availability of alternatives to HFCs, and the feasibility of introducing these, particularly given that, in most cases, they are just beginning the process of phasing out HCFCs. Replacing HFCs – or moving straight from HCFCs to climate-friendly alternatives – will clearly be easier where alternatives to HFCs already exist. As discussed the next section, the evidence suggests that substitutes are already available in most – though not all – applications, although there are still problems with some uses, especially in very hot countries.

In this regard, it is important to remember that the question is not just the *existence* of alternative substances, but also the feasibility of introducing them, in terms of cost, safety, applicability to all environments, maintenance requirements, and so on. As the Montreal Protocol has shown, some

chemicals and processes have proved relatively easy to phase out, while some have been much more challenging. The flexibility of the ozone regime in allowing countries maximum choice over which chemical in each group to phase out, and also in permitting time-limited exemptions for specific uses, has been important. This flexibility would, in all probability, also characterize any new controls on HFCs.

At the same time, the consistent experience of the Montreal Protocol, and of many national environmental regulations, is that regulatory pressure spurs innovation, encouraging new alternatives to emerge which would not do so (or would do so much more slowly) in the absence of regulation. The emergence of effective HFC policies in some major countries using these substances will support the further development of relevant technologies, and reduce costs through economies of scale.

Availability of finance

At the heart of the debate lies the availability of financial assistance – including support for institutional strengthening, training and access to appropriate technology – to help developing countries make the transition to climate-friendly alternatives to HFCs. For most developing countries, which are still transitioning away from HCFCs, the immediate focus of efforts will be on preventing further increased use of HFCs. This concept of 'leapfrogging', i.e. moving direct from HCFCs to climate-friendly alternatives, would deliver important benefits to the climate, as well as being cost-effective in the long run as compared with a two-stage scenario. The availability of sufficient and predictable finance will be critical in enabling this to happen.

There are many possible sources of funding for avoiding and reducing HFC use, in both the climate change and ozone regimes (see the section on finance below). A key problem, however, is that of trust. In the ozone regime, recent replenishment rounds for the MLF have resulted in steadily declining resources. At the same time, although general expressions of intent have been voiced, donor countries have not made explicit pledges to fund a transition away from HFCs. There is arguably much more money available in the climate change regime, given its high political profile (although also many more demands on resources), but the overall atmosphere surrounding financial provision is one of mistrust and strong perceptions of 'broken promises'. None the less, the establishment of the Green Climate Fund (GCF; or Global Environment Facility – GEF) and other recent institutional breakthroughs suggest that the time may be ripe to tap into climate resources to help fund an HFC phase-out.

Legal relationship between the climate and ozone regimes

A key argument against the introduction of HFC control schedules within the Montreal Protocol has been that such substances are already included under the climate change regime. It is by no means uncommon, however, for substances or activities to be subject to more than one MEA or other treaty (see below the section on the ozone and climate regimes). It is not necessary for HFCs to be covered only by one agreement, and the fact that the climate and ozone regimes share similar goals means that, *a priori*, there is no legal conflict or incompatibility between them. None the less, establishing clear boundaries of responsibility to ensure legal clarity between the climate and ozone regimes would be useful, helping to generate synergies between the regimes while avoiding overlap

and potential issues in the future. Options in this regard are taken up below in the section on the ozone and climate regimes.

Political will

Aside from these key substantive issues, a central – and far more elusive – challenge is that of political will. As this paper makes clear, the rational case for adopting more stringent measures on HFCs is strong. In broad terms, the case for doing so primarily under the Montreal Protocol, while obviously requiring careful consideration and negotiation to address the various issues at stake, is also robust. The main problem that has so far thwarted attempts to enter into serious negotiations to go down this path is a political one.

This is not primarily an issue that divides developed and developing countries: most developing countries, along with most developed countries, broadly support entering into negotiations on how to tackle HFCs under the Montreal Protocol. Rather, there are a handful of mostly large economies that, it would seem, fear the economic consequences of a transition away from HFCs. These economies are also important players in the climate negotiations, and are unhappy with what could be perceived as attempts to introduce climate-relevant commitments 'through the back door'.

The fact that landmark climate negotiations are ongoing is a double-edged sword for attempts to devise a stronger approach to addressing HFCs. On the one hand, there is a high-level political window of opportunity to raise the topic; on the other, HFCs may be used as a bargaining chip by parties, preventing any progress outside the climate change regime until those negotiations are over. It is as critical to understand these political dimensions of the HFC issue as it is to grasp the more technical ones.

Replacing HFCs: alternatives, barriers and opportunities

The Montreal Protocol's TEAP has been producing reports on alternatives to HFCs – or, more precisely, on 'high-GWP alternatives to ODS' – since 1999 (including a TEAP Task Force and a joint workshop with the IPCC in 1999, and a Special Report with the IPCC in 2005); these have generated considerable discussion among the parties and affected industries. In addition, many industry associations, and regional and national governments have undertaken comprehensive assessments of technical alternatives to HFCs. This section attempts to give a snapshot of the current situation.

When the Montreal Protocol was adopted in 1987, substitutes were easily available for cosmetic and convenience aerosol products; but few alternatives were available for other uses of ODS, particularly in solvent cleaning, medicine, sterilization, fire protection, flexible and rigid foams, and refrigeration and air-conditioning (RAC). In due course, in-kind fluorocarbon alternatives – HCFCs and HFCs – were used as replacements in only 15 per cent of applications. Not-in-kind alternatives – including doing without, and recovery, recycle and reuse – accounted for the remaining 85 per cent. (See Table 1 for a summary.)

Table 1: In-kind and not-in-kind alternatives to ODS

Application	In-kind (fluorocarbon) alternatives	Not-in-kind alternatives
Aerosol products	HFCs and HFOs	Hydrocarbon, CO_2, compressed air and nitrogen propellants; pumps, sprays, sticks, wicks and creams
Refrigerants	HFCs and HFOs	Natural refrigerants; alternative cooling in root cellars and spring houses; evaporative and electromagnetic cooling
Solvents	HFCs, HFOs and PFCs	No-clean, aqueous, semi-aqueous and hydrocarbon
Metered-dose inhalers (MDIs)	HFC MDIs	Dry-powder inhalers (DPIs), nebulizers, injections, patches and oral drug therapy
Fire protection	HFCs	Inert gases, water, dry powder, foam; reducing or eliminating combustible materials (fire load) and sources of ignition; halting testing and training with halons
Thermal foams	HFCs and HFOs	CO_2, water, hydrocarbon and methyl formate blowing agents; mineral wool, fibreglass, cellulose, vermiculite
Pest control	Table text centred	Organic practices, biological pesticides including genetically modified organisms (GMOs), integrated pest control, heat and cold, mechanical traps, hygiene, crop rotation and growing crops in locations less challenged by pests

One important category of not-in-kind alternatives that was used extensively before the invention of CFCs is making a comeback now that the ozone and climate hazards of CFCs, HCFCs and HFCs are appreciated: the so-called 'natural refrigerants' such as ammonia, CO_2 and hydrocarbons. Ammonia was never entirely replaced by ODS and, along with hydrocarbons, was among the first to make a comeback as a result of the Montreal Protocol; the first hydrocarbon refrigerators were introduced in the early 1990s in Germany with the support of Greenpeace, and in China with support of the US and German governments.

In MAC, all parties have now replaced CFC-12 (GWP = 10,200) with HFC-134a (GWP = 1,300). In RAC uses, most non-Article 5 parties have replaced HCFC-22 with the HFC blend HFC-410A (GWP = 2,100), while most Article 5 parties are still using HCFC-22 – giving them the opportunity to leapfrog HFC-410A as non-Article 5 parties phase it down.

In foams, both non-Article 5 and Article 5 parties have undertaken a more gradual phase-out of ODS. The first steps were often to reduce the concentration of CFC blowing agents; then to substitute HCFCs for CFCs; and then to replace HCFCs with hydrocarbons, CO_2, water and HFCs. The most recent steps have been to move more towards hydrocarbons and CO_2, and sometimes HFCs where safety may be a problem. In addition, companies are now moving to low-GWP HFOs – although these are energy-intensive and (currently) expensive to produce, and break down into other substances that cause different environmental problems.

HFCs have been used only to a limited extent to replace halons for fire protection and to replace CFCs in technical aerosol products, and usually only were required for safety and/or technical performance. HFCs have not been used to replace CFCs, HCFCs, carbon tetrachloride or methyl chloroform for solvents, nor to replace methyl bromide for pest control.

The ozone and climate impacts of these chemicals vary widely. HCFCs can have ODPs from 0.02 (HCFC-123 and HCFC-225) to 0.12 (HCFC-141b); HFCs can have GWPs from 124 (HFC-152a) to 14,800 (HFC-23), and HFOs can, as indicated in the IPCC Fifth Assessment Report, 100-year GWPs of less than 1 (the reference value for CO_2) to as high as 6. Atmospheric lifetimes also vary widely; HFCs usually have low lifetimes, in the order of several years to decades, although some (e.g. HFC-23, HFC-236fa) are more persistent. For most HFCs, therefore, a 20-year GWP gives a better value than a 100-year GWP, as this is closer to the actual lifetime.

In addition, when fossil fuels or biomass are the energy sources for the uses of HFCs in refrigeration and air-conditioning, a significant proportion of the total climate forcing derives from energy consumption, although this will vary with leakage rates, standards of servicing and maintenance, and other factors. The Life Cycle Climate Performance (LCCP) metric is an attempt to measure the overall climate impact, accounting for the direct emissions of chemical refrigerants and foam-blowing agents based on the volume of emissions and their GWP; the indirect emissions from the energy necessary for the application and the carbon intensity of the power; and the embodied emissions necessary to produce, transport and use the chemicals and other materials employed in the product over its useful life, and for recycle and reuse. This is not universally accepted, however, and there are in any case other important criteria for choosing alternatives – including flammability, toxicity, atmospheric fate and cost.

Alternatives

There is seldom any single alternative to the use of HFCs in any given sector, but in many applications a wide range of mature and sustainable alternatives exists, and others are rapidly developing.[11] However, some applications continue to pose problems, e.g. where there are still no

[11] Montreal Protocol Technology and Economic Assessment Panel (2009) *Task Force Decision XX/8 Report: Assessment of Alternatives to HCFCs and HFCs and Update of the TEAP 2005 Supplement Report Data*; Montreal Protocol Technology and Economic Assessment Panel (2010), *TEAP 2010 Progress Report*, Vol. 1, 27–33; and Schwarz W., et al. (September 2011), *Preparatory Study for a Review of Regulation (EC) No 842/2006 on Certain Fluorinated Greenhouse Gases, Final Report*.

clear choices of alternatives, where economy of scale and competitive prices have not been reached, or where new (and potentially superior) alternatives are just emerging. This suggests that a flexible approach to the phase-down of HFCs is sensible, allowing countries to determine which HFCs in which applications to phase down first – akin to the ODS phase-out schedules under the Montreal Protocol. Below we summarize the current and just-emerging range of alternatives.

RAC

There are already clear choices in this sector. Hydrocarbons such as HC-290 (propane) or HC-600 (isobutene) are already widely used all over the world in small equipment such as stand-alone units or domestic refrigerators. The flammability of hydrocarbons can be mitigated by using small charge sizes, by eliminating sources of ignition in the appliance itself, and by designing equipment to keep the flammable refrigerant from leaking into the occupied spaces.

In larger refrigeration equipment, CO_2 is a good option, in particular for large centralized systems such as those used in supermarkets, although CO_2 requires more robust equipment design because of the higher pressures used. In equipment outside general public access (where toxicity is less of a concern), for instance in industrial food-processing, ammonia is a good option because of its excellent energy efficiency. Other options include HFC-32, which has a third of the GWP of the HCFC-22 and HFC-410A that it replaces, but which is flammable, and HFC/HFO blends with lower flammability. All these options have better high ambient cooling capacity and energy efficiency performance in RAC than does HFC-410A.

In the case of high-pressure building air-conditioning chillers, HFO-1234yf is an expensive alternative to HFC-134a in new equipment. Low-pressure HFO and HFO/HFC blend alternatives are being evaluated that have very low to no flammability and offer similar energy efficiency to large building air-conditioner chillers.

Leading choices in next-generation low-GWP alternatives are as follows:

- Domestic and commercial small refrigerators and freezers: HC-600
- Beverage vending machines: CO_2, HC-600
- Supermarket refrigeration: ammonia, CO_2, hydrocarbons
- Room air-conditioning: HC-290, HFC-32; HFC/HFO blends emerging
- Large tonnage chillers: HFO-1233zd, HFO-1234ze; HFO/HFC blends emerging

Companies in China (Gree) and India (Godrej) have been the first to commercialize HC-290 in RAC, and sales have increased steadily over the last few years. In these countries, safety standards have been revised in line with technology improvements to allow the safe use of hydrocarbon

refrigerants.[12] A dozen other companies in China are currently commercializing HC-290 RAC uses for a combined production capacity of about 6 million units a year.

In Europe, CO_2 is already widely used in supermarkets, and will be the standard system from 2022 under the new F-Gas Regulation. As of 2013, more 2,800 supermarket outlets used a transcritical CO_2 system, while another 1,700 used a cascade system of CO_2 and another refrigerant (mostly an HFC).[13] The latter option can also be operated efficiently under high ambient temperatures.

Japan and India were the first countries to commercialize HFC-32 (GWP = 716) in RAC. In India Daikin has a manufacturing facility capable of producing 1 million RAC units a year.[14] Manufacturing facilities for HFC-32 RACs are being built in China, Indonesia, Japan, Thailand and other countries.[15] HFC-32 is considered safe in RACs up to about 3 tonnes capacity. In the United States companies are also working with the government to secure SNAP approval for HC-290 and HFC-32 for RAC, and to amend federal, state and local safety standards and building codes (examples of regulatory barriers that often need to be addressed).

In addition, emissions from commercial RAC can be dramatically reduced by enforcing no-venting rules, implementing best service practices, and upgrading leak detection and recovery and recycling equipment.

MAC

Leading choice:

- HFO-1234yf; HFC-152a is emerging, and CO_2 is being developed by some manufacturers

HFO-1234yf (GWP <1) is currently the preferred choice of most car manufacturers in Japan, North America and Europe, although it is slightly flammable; the exceptions are Daimler, Audi and Porsche, which are aiming to commercialize the use of CO_2 (GWP = 1).[16] Secondary-loop MAC designed for half the refrigerant charge, near-zero refrigerant emissions and higher energy efficiency are being considered for the safe use of either HFO-1234yf or HFC-152a (GWP = 140).

As above, emissions from MAC can be significantly reduced by proper maintenance, including prohibiting recharge without repair, and by selling refrigerants only to certified technicians working in shops equipped with proper tools.

Foams

Leading choice:

- Hydrocarbons, CO_2 and HFOs, with methyl formate for small and medium-sized enterprises

[12] Council on Energy, Environment & Water, Institute for Governance & Sustainable Development, Natural Resources Defense Council and The Energy and Resources Institute (TERI), in cooperation with the Confederation of Indian Industry (2013), *Cooling India with Less Warming: The Business Case for Phasing Down HFCs in Room and Vehicle Air Conditioners*.
[13] Environmental Investigation Agency (2013), *Chilling Facts V*.
[14] Daikin Group (2013), *CSR Report: Environment*.
[15] Montreal Protocol Technology and Economic Assessment Panel (2013) *TEAP 2013 Progress Report*, Vol. I, 49; see also Stanga M. (2013), 'Update on R32 Air-conditioning and Heat Pump Manufacturing and Sales', (Daikin Industries, Ltd. presentation at Bangkok Technology Conference, 29 June 2013).
[16] Montreal Protocol Technology and Economic Assessment Panel (May 2013), *TEAP 2013 Progress Report* Volume I, 51; and Institute for Governance & Sustainable Development, National Resource Defense Council and Council on Energy, Environment & Water (March 2014), *Maximizing energy efficiency gains when transitioning to new MAC refrigerants: Global automakers moving to HFO-1234yf, except some German automakers waiting for CO_2 systems*.

In general, HFC use in foams is easier to replace than is the case in RAC or MAC. There are a wide number of low-GWP thermal insulating foam options, with the exception of some foam products used for safety applications. Hydrocarbons and CO_2/water already comprise a significant proportion of the global market for polyurethane foam products, and fibrous materials comprise most of the market for insulation in western Europe. HFOs are also used.[17]

Sectors without a leading alternative

While low-GWP alternatives are available and coming to market in a majority of sectors, there are still a number of sectors and applications that are highly dependent on high-GWP HFCs, including:

- Servicing of refrigeration and air-conditioning equipment designed for non-flammable HFC refrigerants. (Retrofit to flammable and toxic refrigerants is hazardous.) Alternatives for retrofitting do exist, with GWPs of about 2,000; while high, this is about half the GWP of today's most commonly used HFC blends.
- Military equipment where toxic and flammable alternatives are problematic.
- Metered-dose inhalers (MDIs) for asthma and chronic obstructive pulmonary disease (COPD).

Barriers

The flammability of HFC alternatives is often an issue with safety regulations that have not been updated in line with technological progress. In general, such barriers have been removed for the use of slightly or mildly flammable refrigerants (HFO-1234yf and HFC-152a, respectively) in MACs, with mildly flammable HFC-32 authorized for RACs in Japan and some other countries, and with EU standards being finalized for flammable HFC-32 and HC-290 refrigerants. However, the United States has not yet authorized the use of either HFC-32 or HC-290 under SNAP (except for household refrigerators), and in many jurisdictions flammable refrigerants are either banned or discouraged.

Where flammable refrigerants are allowed but regulations for safe use have not been enacted, there can be a risk of accidents in manufacture, installation, service or use. Responsible manufacturers of RACs with flammable refrigerants recognize the importance of safety standards in assuring the commercialization and market penetration of their products. A lack of suitable training and equipping of service technicians for the safe use of flammable refrigerants, along with inadequate service infrastructure, can also be a barrier. An additional complication is that manufacturers of non-flammable refrigerants may try to slow the approval of new standards allowing competition from flammable refrigerants.

More broadly, from the earliest days of the Montreal Protocol, concern was expressed that intellectual property owners would extract monopoly profits from the sale of alternatives to ODS, and that patents for new HCFCs and HFCs would render countries dependent on foreign sources from a small number of multinational companies. At the same time, there was concern among the inventors of new technologies that they should be rewarded for their investment and be able to recover the costs of commercialization.

[17] UN Environment Programme (2011), *HFCs: A Critical Link in Protecting Climate and the Ozone Layer – A UNEP Synthesis Report*, 29.

In general, these concerns did not prove well founded. Once the protocol's control schedules were in place, more options were developed – in particular, as seen above, in not-in-kind alternatives – than had originally been expected, and in almost all applications there has been a high level of competition in the supply of alternatives. In cases in which there were patents that claimed exclusive rights for the application of new HCFCs and HFCs, there have been few reported problems in MLF projects – either because other alternatives were available, or because the MLF was able simply to pay the surcharge or licensing fees.

Replacing HFCs: options for action

As the experience of the Montreal Protocol has shown, the single most effective action that the international community can take to accelerate the replacement of HFCs is to create a climate of regulatory certainty that HFCs will be phased down. The agreement on the original protocol, in 1987, and its subsequent amendments and adjustments, spurred a wave of technical innovation that saw the emergence of alternatives (both alternative substances and alternative technologies) at a much faster rate than had originally been anticipated. (Also, as noted above in the section on the current regulatory framework, a global regulatory framework is preferable to a patchwork of different national regulations, which does not send such a clear signal.)

The protocol's experience has also shown that additional benefits can be expected from the development of new technologies. Every new generation of refrigeration systems, for example, has shown increases in energy efficiency, generally by at least 20 per cent in each transition; and further innovations in turn build on those new developments.

The speed of action is also important: the faster the transition can begin, the less HFC-using equipment is installed and the lower the future demand for HFCs for servicing. This points to the need for financial assistance to be made available for developing countries even before any potential control schedule is applied (see further in the next section and in the section on designing a way forward). This is particularly true given that – unlike in the early years of the protocol – new technologies using HFCs and their alternatives are emerging and being commercialized in developing as well as in developed countries.

It is, of course, the private sector that develops HFC alternatives. But governments, in both developing and developed countries, can do much to accelerate this development, in advance of international or even national regulation. Public procurement policies can be used to favour non-HFC-using equipment acquired by the public sector; and standards, such as those for buildings, can be modified to prefer or require equipment using HFC alternatives.

Finance

The availability of finance to support developing countries in their efforts to replace HFCs is a vital component of any global strategy. This section reviews potential sources of support.

Ozone finance

The MLF

The MLF has been an important factor behind the success of the Montreal Protocol. Established in 1991 after the 1990 London Amendment to the protocol extended phase-out commitments to developing countries, it provides financial support to help developing countries meet the incremental costs of replacing ODS with non-ozone-depleting alternatives. Contributions to the MLF from developed countries are determined according to the UN scale of assessment. As at May 2014, the contributions made to the MLF since its inception by some 45 countries totalled more than $3.21 billion. The Fund has been replenished on eight occasions, most recently for the period 2012–14, with $400 million. The next replenishment process, for 2015–17, is ongoing.

Since the inception of the MLF, the Executive Committee has approved expenditure of approximately $3.1 billion for the implementation of projects including industrial conversion, technical assistance, training and capacity-building, resulting in the phase-out of more than 463,000 ODP tonnes of ODS (on full implementation). The committee has also approved 144 country programmes and 139 HCFC phase-out management plans, and has funded the establishment and the operating costs of ozone offices in 145 Article 5 parties – the 'institutional strengthening' which, as noted above in the section on the current regulatory framework, has been so valuable in establishing the human capacity to carry out phase-out in developing countries.

As HFCs are not controlled substances under the protocol, the MLF cannot directly support HFC phase-down activities. In 2010, however, in accordance with MOP Decision XIX/6, the Executive Committee agreed to award a funding premium of up to 25 per cent for projects converting HCFC uses to low-GWP alternatives, thereby helping to avoid developing countries opting for HFCs.

In addition, the 2013 MOP, after a discussion on the latest TEAP report on low-GWP alternatives to ODS, decided:

> To request the Executive Committee of the Multilateral Fund to consider the information provided in the [TEAP report] […] and other related reports, with a view to considering whether additional demonstration projects to validate whether low-GWP alternatives and technologies, together with additional activities to maximise the climate benefits in the HCFC production sector, would be useful in assisting parties operating under paragraph 1 of Article 5 in further minimising the environmental impact of the HCFC phase-out;[18]

The MOP in 2014 will agree the next (2015–17) replenishment of the MLF. In preparation for this, the 2013 meeting followed the normal procedure in commissioning a TEAP study, which included:

[18] Decision XXV/5, para. 4.

> That, as a separate element [...] the Panel should provide indicative figures for additional resources that would be needed to enable parties operating under paragraph 1 of Article 5 to gradually avoid high-GWP alternatives to ODS, taking into account the availability of safe, environmentally friendly, technically proven and economically viable technologies.[19]

The GEF

In addition to the MLF, the GEF has provided assistance to 18 countries with economies in transition: these states in the former Soviet Union and Eastern Europe have not been eligible for MLF funding because they are not developing countries. To date, the GEF Council has approved projects worth about $180 million, which have additionally leveraged about $190 million in co-financing (generally a requirement of GEF funding).

Bilateral support

There is also the option of providing assistance direct from donor countries. Under MOP Decision II/8, bilateral funding can count towards a maximum of 20 per cent of a party's assessed contributions to the MLF, as long as it is considered (by the Executive Committee) to be consistent with the criteria used by the MLF.

Climate finance

The financial architecture of the climate change regime is more complex than that of the Montreal Protocol; this reflects the more multifaceted nature of the issue, which involves, for example, adaptation as well as mitigation. As well as the GEF, which manages several funds under the Convention (including the LDC Fund and the Special Climate Change Fund), the climate regime is now also served by the GCF, operating directly under the COP. Formally established during the 2010 COP, the GCF's governing instrument was adopted the following year, and it should soon be fully operational.

Under the UNFCCC, Annex II parties (i.e. the Annex I parties that are members of the OECD)[20] are required to provide financial and technological resources to developing countries to help them meet their commitments (including on reporting). However, unlike for the Montreal Protocol, there is no system of assessed contributions, and the regular replenishment process under the GEF takes place through financial pledges by donors independent of the climate change negotiations. The GCF has not yet established a formal replenishment process, although countries have begun making funding pledges. Funding is as important an issue in the climate change regime as it is under the Montreal Protocol. The satisfactory initial capitalization of the GCF, expected to run to $10 billion, as well as the finalization of the GCF's rules, are absolute prerequisites for striking a deal on any new commitments for developing countries in 2015.

The sums involved in climate finance are certainly much larger than are the funds available to the ozone regime, and are set to rise. Since its inception in 1991, the GEF has directed $4 billion towards climate mitigation, and leveraged $27.2 billion in co-financing.[21] These are small amounts, however, compared with future expectations. Donor countries have already met, and indeed exceeded, the fast-start financing goal under the Copenhagen Accords/Cancun Agreements of

[19] Decision XXV/8, para. 3.
[20] That is, minus the economies in transition of the former Soviet Union and Eastern Europe, and other new EU entrants.
[21] Report of the GEF to the COP, FCCC/CP/2013/3, para. 8.

mobilizing $30 billion over the period 2010–12. The long-term goal is to raise $100 billion a year by 2020, but where this money will come from remains unclear. Although traditional government funding retains its central role, the climate regime is expanding its understanding of 'climate finance' to include other public, private and alternative sources, as cited in the Copenhagen Accords/Cancun Agreements. A Standing Committee on Finance, along with a work programme on long-term finance, have been set up to advise the COP on the full range of issues associated with ensuring that developing countries have access to predictable and adequate financing to combat climate change.

Technology transfer

The climate regime has other mechanisms in place to assist parties, mostly developing countries, with the implementation of climate mitigation measures (and also with adaptation). Technology transfer is one important pillar of the regime, with the technology provisions recently expanded through the establishment of a Climate Technology Centre and Network (CTCN – based in Copenhagen, and hosted by a UNEP-led consortium). The CTCN has a facilitative, catalytic, advisory and information-based remit to assist developing countries, although it does not actually have a mandate to advise parties.

Finance: options for action

Both the GEF and the GCF could, in principle, support HFC reduction projects in developing countries. Interestingly, in an early 2002 decision, the COP had called on the climate parties to consider funding for HFC projects 'in addition to funding by the Multilateral Fund under the Montreal Protocol, in particular through the Global Environment Facility and the Clean Development Mechanism'.[22]

The fact that the GCF is still developing its procedures, in particular, opens a window of opportunity to ensure that HFC projects are included within its scope. A potential problem, however, lies in the concentration of HFC production facilities in large emerging economies, notably in China. There is an ongoing debate over whether such emerging economies should be restricted in their eligibility to access climate mitigation funding from the GCF. Ironically, the relative cost-effectiveness of phasing down HFCs in many applications may lead to some reluctance to fund such projects.

One option would be to develop modalities that would enable joint funding between the MLF and the GCF (or GEF). This would require close coordination between these bodies, as well as carefully drafted guidance from the ozone MOP and climate COP. Exploring this option could begin by inviting the ozone and climate secretariats, drawing on expertise from their funding mechanisms, to prepare a paper outlining how such coordination might work. The above-mentioned Standing Committee on Finance, along with the work programme on long-term finance, might usefully be involved in these discussions.

It is worth emphasizing that the ozone and climate regimes have different strengths when it comes to finance. Funding under the ozone regime has the major advantage of predictability, with its regular formal replenishment rounds specifically addressing the funding needs of a particular

[22] See, for example, Decision 12/CP.8, para. 7; note that the GCF had not yet been established.

control schedule, based on TEAP advice. At the same time, the MLF has proved generally successful in its targeting of funds and partnerships with implementing agencies and governments. The institutional set-up of the climate regime has been more contentious, with long-standing controversies over funding allocation and adequacy; and of course it has a far wider range of potential uses of funds, with HFCs not occupying a particularly high profile. In terms of sheer numbers, however, the sums available to the climate change regime will inevitably be greater, even if donor countries fall short on their promises. Combining the institutional advantages of the ozone regime with the larger sums available through climate channels could prove to be a fruitful approach.

Carbon markets, and project-based market mechanisms, are playing an increasingly important role throughout the world in incentivizing GHG emission reductions. They are unlikely, however, to be an important factor in helping to fund the replacement of HFCs. Within the climate change regime, the CDM could, in principle, provide an avenue for funding HFC reduction projects. All the same, its future after 2020 is currently uncertain, and low prices for credits are not encouraging its further expansion. Its experience with HFC destruction projects (see the section above on the current regulatory framework) may also make it politically difficult to harness the CDM to tackle HFCs at scale, even for projects that do not provoke concerns over perverse incentives and overpayment. In terms of other market mechanisms, such as the voluntary carbon markets that have emerged to allow companies and individual consumers to purchase carbon offsets, the prospects are similarly unpromising. The main thrust of the carbon markets, at present, appears to be directed at banning credits derived from HFC reductions, as the EU emissions trading system (ETS) has done. By way of example, the Verified Carbon Standard (VCS) – the world's leading voluntary greenhouse gas programme – has also announced a ban on HFC credits.

In terms of technology transfer, the CTCN could be deployed to help promote the replacement of HFCs. In this respect, it would benefit from input from, and perhaps the participation of, TEAP experts to advise its Technology Executive Committee.

Even before agreement on a global HFC phase-down, there are some immediate steps that could be taken to accelerate the replacement of HFCs. Depending on the funding available, the MLF premium for projects converting HCFC uses to low-GWP alternatives could be increased above 25 per cent. The GEF could adopt similar guidelines for its support to transition economies. Another useful measure would be to fund the drawing up of HFC inventories in developing countries, many of whom do not have a clear picture of their current patterns of HFC consumption. In fact, the Climate and Clean Air Coalition is already carrying out this work in some developing countries, as well as developing sector-specific case studies.

The ozone and climate regimes: relationships and responsibilities

Relationships between MEAs

The issue of HFCs is just one example among many of environmental problems that do not fit into convenient, neat categories. It is not unusual, therefore, for substances, species or activities to be affected by more than one MEA. To choose one Montreal Protocol-related example, imports and exports of ODS recovered from used equipment and destined for disposal or recycling are not controlled by the Montreal Protocol (they are not included in the calculation of 'consumption' for the purposes of the control measures), but by the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, which includes halogenated organic substances in its list of wastes to be controlled. In principle, the Basel Convention should permit the international movement of ODS wastes, but its wording is vague and both bodies recognized that clarification would be helpful. In 1995 agreement was reached that recycled CFCs and halons meeting ISO purity specifications would not be considered to be wastes under the Basel Convention.[23]

Many similar examples could be cited. The group of chemicals and wastes MEAs, including the Basel Convention, the Rotterdam Convention (on the prior informed consent procedure for pesticides and other industrial chemicals) and the Stockholm Convention (on persistent organic pollutants), all overlap and now share a joint secretariat. Several MEAs affect various species of fish and wildlife, among them the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), regional agreements such as the Lusaka Convention and regional fisheries management agreements. The interaction of several MEAs with the provisions of the World Trade Organization has spawned a long-standing – and not entirely resolved – debate, and in some cases specific wording in MEAs (e.g. the protocol on biosafety under the CBD).

The ozone and climate regimes

Similarly, climate change is an extremely wide-ranging problem, touching on almost every aspect of human activity. Accordingly, the climate regime claims to be welcoming of input and support from other international bodies. The UNFCCC mandates its COP to 'seek and utilize, where appropriate, the services and cooperation of, and information provided by, competent international organizations and intergovernmental and non-governmental bodies',[24] and this clause is mirrored in the Kyoto Protocol.[25] On this basis, the climate regime, largely through the secretariat, is engaged in many relevant initiatives within the UN system, working with a whole range of other UN and international organizations. Such initiatives are largely focused on implementation projects and support to developing countries, notably on technology, finance, capacity-building and training.

One example of a UN-wide initiative to support the activities of the climate regime is forestry. Here, funding from donors has enabled the establishment of the UN Collaborative Programme on

[23] See Decision VII/31 of the Montreal Protocol.
[24] UNFCCC, Article 7.2(l).
[25] Kyoto Protocol, Article 13.4(i).

Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD). This programme, working with other related initiatives, has helped to build national-level capacity to act on deforestation while the negotiations on the topic in the climate regime are ongoing.

The climate change secretariat maintains a particularly close institutional relationship with the other 'Rio Conventions'[26] – i.e. the CBD and the UN Convention to Combat Desertification; a Joint Liaison Group between the three secretariats meets on an occasional basis. However, cooperation is largely confined to highlighting synergies between the objectives of the three conventions in public forums, rather than any concrete collaboration on commitments.

The UN system itself is becoming more aware of the need to 'deliver as one', including on climate change. To this end, the UN System Chief Executives Board for Coordination (CEB), chaired by the UN secretary-general, has established the Climate Change Action Framework. The UN secretary-general also has a Climate Change Support Team (CCST) in place to provide advice and support on coordinating UN activities on climate change. A UN Climate Summit is scheduled take place in September 2014, to which the UN secretary-general has asked leaders to bring 'bold announcements and actions'.

There are also some precedents for the climate regime 'contracting out' certain tasks or functions to other organizations. As would be expected, the IPCC works closely with the climate regime, acting as its main source of scientific information. The GEF serves as a financial mechanism of the UNFCCC and Kyoto Protocol, with a memorandum of understanding with the COP (adopted at COP 2 in 1996) governing the relationship between the two bodies. The UN Environment Programme (UNEP) now heads a consortium that runs the newly established CTCN; again, a memorandum of understanding was adopted between UNEP and the COP (at COP 18 in 2012). These are, however, implementation functions, with the climate regime retaining authority over the nature of the commitments.

There are two sectors, however, where the climate regime has largely delegated mitigation activities to other bodies: GHG emissions from aviation and marine bunker fuels. The Kyoto Protocol (Article 2.2) states that Annex I parties (the developed countries with targets) 'shall pursue limitation and reduction of emissions from greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels working through the International Civil Aviation Organization [ICAO] and the International Maritime Organization [IMO]'. These sectors have special status in the climate regime because their emissions are not included under national GHG inventories, instead being reported separately; parties have never agreed on how aviation and marine emissions should be allocated between states. These emissions are not therefore counted for compliance purposes.

The ICAO and IMO report regularly to the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) on action that they are taking to control bunker fuel emissions. For many parties, however, action by these bodies has been disappointing. Part of the problem has been the different set of principles whereby ICAO and IMO operate, in that they do not possess the

[26] The MEAs that were signed at the 1992 UN Conference on Environment and Development, in Rio de Janeiro.

differentiation between developed and developing countries that is a feature of the ozone and climate regimes. Attempts by some parties to develop further provisions on aviation and maritime emissions under the climate regime have not been successful hitherto, and the prospects for doing so are not promising. One problem, ironically, is that parties opposing stronger provisions point to the delegation of responsibilities to ICAO and IMO as a justification for not acting in the climate regime.

The Ozone Secretariat, acting on the instructions of the MOP, has had considerable experience of resolving issues with other MEAs and international institutions, including the reorganization of customs codes to allow tracking of the growing list of ODS; collaboration over customs training and law enforcement to stop illegal trade; removal of barriers in government procurement such as telecommunication and military standards that once required ODS use; revision of maritime and aviation safety standards to allow alternatives to halons; rationalization of quarantine definitions and procedures to allow methyl bromide phase-out; and much more.

In institutional terms, cooperation between the ozone and climate secretariats is light-touch but already well established, initially prompted by the issue of the linkages between the two regimes that was first raised in the climate context in 1998. This first foray into cooperation led to the co-organizing of a 1999 workshop held in Petten, Netherlands, on options for the limitation of emissions of HFCs and PFCs. In 2005 the IPCC and TEAP jointly published their special report on *Safeguarding the Stratospheric Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons*.[27]

Informal liaison is continuing between the two secretariats. Representatives of the Ozone Secretariat and the TEAP have often attended climate meetings as observers, and also addressed the negotiating bodies. The same is true for representatives of the climate secretariat and ozone meetings. Experts from the ozone secretariat and the TEAP have assisted the climate secretariat in the preparation of technical papers on relevant issues, while joint workshops have been held. The MLF secretariat is accredited as an observer to the GCF.

Relationships between the ozone and climate regimes: options for action

The global atmosphere does not respect categories devised by international negotiators, and in terms of environmental impact there is no clear division between the substances controlled by the ozone and climate regimes. Almost all the ODS controlled by the Montreal Protocol are also GHGs, often with very high GWPs. The Kyoto basket of GHGs includes: CH_4, which influences stratospheric ozone depletion but is not itself an ODS; N_2O, which is an ODS; HFCs, which are exclusively ozone-safe substitutes for ODS; PFCs, which are ozone-safe substitutes for very minor uses of ODS but which have significant other uses; and SF_6, which is ozone-safe but is not a substitute for ODS. There are therefore clear policy justifications for some degree of joint, rather than separate, responsibility under the two regimes.

Moreover, in legal and substantive terms, there is no conflict or incompatibility between the two regimes; on the contrary, their aims are complementary and mutually reinforcing. Nonetheless, the

[27] IPCC/TEAP (2005), 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.

fact remains that HFCs are currently included under the climate change regime, and the climate change parties are subject to substantive commitments on them, notably with regard to reporting. The climate change regime is also responsible for the overall attainment of its ultimate objective – i.e. to avoid dangerous climate change – for which action on HFCs will make an important contribution. Some reflection, at the very least, is therefore needed to ensure legal and institutional clarity should the Montreal Protocol adopt measures on HFCs.

Even if not legally mandatory, it appears logical that the climate change COP should take a decision inviting, encouraging, or otherwise lending its blessing to moves to adopt control schedules under the Montreal Protocol. Indeed, at the UNFCCC COP 19, in Warsaw in 2013, the EU put forward a proposal for a very brief COP decision to urge 'all parties to pursue the adoption, under the Montreal Protocol [...] of appropriate measures to progressively reduce the production and consumption of hydrofluorocarbons, in a manner that would complement the efforts under this Convention to minimise emissions of hydrofluorocarbons to the environment'. Although not deemed legally necessary by the EU, this approach was intended to send a strong political signal from the climate community to the ozone community that urgent action on HFCs was both an environmental imperative and best handled through an amendment to the Montreal Protocol. The proposal did not command consensus, and thus was not adopted.

If the Montreal Protocol parties did adopt measures on HFCs, a subsequent COP decision acknowledging and welcoming those measures would be appropriate. Such a decision could then include complementary provisions, for example establishing an agenda item regularly to review developments under the Montreal Protocol on this issue, to which a representative of the ozone secretariat (or another ozone body, as appropriate) would be invited to report.

How would responsibilities on HFCs be shared in practice? There are several issues to consider. A key question concerns the individual commitments of parties. If HFCs were subject to control schedules under the Montreal Protocol, would meeting such control schedules also count towards emission commitments under the climate change regime? The answer appears to be yes: the G20 Declaration has, for example, argued that HFCs should continue to be included 'within the scope of UNFCCC and its Kyoto Protocol for accounting and reporting of emissions'. How, then, would the two compliance regimes coordinate in the event of non-compliance?

A related question is that of emissions trading. If emissions trading continues under the climate change regime post-2020, several parties have insisted that HFC reductions should not be eligible, because of the dangers of flooding the market with cheap credits.

The provision of finance is obviously key. As discussed above in the section on finance, judicious coordination between the funding bodies of the climate and ozone regimes could prove fruitful.

A further question concerns reporting. All parties are already required to report disaggregated data on HFC emissions under the climate change regime. Admittedly, such reporting has been patchy, especially in developing countries, which are only just starting to report biennially. The completeness and quality of reporting, however, has improved over time. Among developing countries, China, India and other large producers and/or consumers have reported on their HFC emissions. None the less, there is scope for deepening and expanding data-gathering. For example, under the climate change regime, only emissions are reported, and not the detailed production and

consumption data on which the emissions estimates are based. An arrangement could be envisaged whereby countries would report their detailed production and consumption data under the Montreal Protocol, and their emissions under the climate change regime. The more detailed data would then be useful for the implementation of effective measures (e.g. management plans and country programmes) to reduce HFC use under the Montreal Protocol.

The existing mechanisms for information-sharing and technical cooperation, for example between the two regimes' secretariats, could be extended and strengthened. One option might be for the parties to the two regimes to set up a more formal liaison arrangement, enabling more structured and in-depth exchanges. One model might be the joint liaison group that has operated between the UNFCCC and the two other Rio Conventions (see above). Such a joint liaison group between climate and ozone might include, at a minimum, representatives of the relevant secretariats, the IPCC and the TEAP, chairs of the relevant working bodies (e.g. SBSTA, OEWG), and possibly also geographically balanced representatives of interested parties. This could provide a useful forum for exploring issues surrounding new forms of cooperation between the two regimes.

The new climate agreement

The ongoing negotiations on a future agreement under the climate change regime provide a window of opportunity to develop a new approach on HFCs (although there is also the danger that parties may be distracted, and may not want to address HFCs until the 2015 agreement is adopted). Whatever its legal nature, the new, 2015 text could be drafted so as to be legally consistent with any sharing – or transfer – of responsibilities for HFCs with the Montreal Protocol that might be agreed. Collaboration between the two regimes could be established, in the climate context, in a number of different ways:

- Any new arrangements on HFCs could be included as legal text in the 2015 agreement, if this takes the form of a new legal treaty. This could have a similar form to the wording in the Kyoto Protocol on aviation and marine bunker fuel emissions.

- A simple COP decision (which could, if appropriate, be part of the 2015 agreement) could set out the new arrangements, in whatever detail was deemed necessary. An MOP decision would be needed to acknowledge and mirror the COP decision.

- A memorandum of understanding could be established between the COP and the MOP. This might be particularly useful if parties preferred to set out the new arrangements in some detail.

- Such a memorandum of understanding might be especially useful if collaborative funding arrangements between the MLF and the climate change funding bodies were established.

In addition, there are many other ways that national and regional action could be motivated through the climate regime:

- A COP decision could encourage parties to take accelerated action on HFCs at the domestic and regional levels.

- A political declaration, adopted at a COP, could do something similar; a register of pledges of action on HFCs could be initiated, including funding pledges to assist developing countries with phase-down.
- The UN secretary-general's scheduled 2014 Climate Summit also provides an opportunity for countries and regions to make such political declarations.

Designing a way forward: issues and options under the Montreal Protocol

As most parties to the Montreal Protocol have recognized, there are strong arguments for adding HFCs to the protocol, with their own control schedules and access to finance from the MLF. The climate regime controls emissions of GHGs, a sensible approach in cases where the gases, such as CO_2, are essentially by-products of processes (burning fossil fuels, deforestation, etc.). The Montreal Protocol controls production and consumption, a sensible approach when the chemicals can be replaced by other chemicals or by not-in-kind alternatives – as is the case with HFCs. (It is, of course, perfectly possible to leave both obligations in place, while searching for synergies between them, as discussed in the previous section.)

Furthermore, developing specific international control schedules for HFCs sends a clear signal to industry, encouraging the development of alternatives. Such a signal is unlikely to be delivered by the climate regime, under which controls extend over a wide basket of gases and are not substance-specific. Unlike the climate regime, the institutions of the Montreal Protocol have considerable experience of dealing with exactly those sectors, such as refrigeration and air-conditioning, in which HFCs are being used – unsurprisingly, as they are replacements for the chemicals being phased out under the terms of the protocol. Also, as discussed in the section on finance, the MLF, with its narrower focus and stable basis of funding, is more likely to be able to deliver targeted financial assistance than the climate funds. The Montreal Protocol also possesses an effective compliance regime.

How, then, could HFCs be included under the Montreal Protocol? Although they are not currently controlled under the agreement, and are not themselves ozone-depleting substances, the flexible nature of the protocol provides scope for their inclusion.

The substances controlled by the Montreal Protocol are defined by their inclusion in the annexes to the treaty (Article 1.4, which has been amended on four occasions over the past 15 years). In principle, therefore, the protocol could control *any* substance, although the title of the treaty (Montreal Protocol on *Substances that Deplete the Ozone Layer*) and its preamble's references to 'control equitably total global emissions of substances that deplete it [the ozone layer]' indicates its primary focus on ODS. However, Article 2.2(b) of its parent Vienna Convention has been cited as providing a legal mandate for action on HFCs:

> 2. […] the Parties shall, in accordance with the means at their disposal and their capabilities […]
>
> (b) Adopt appropriate legislative or administrative measures and co-operate in harmonizing appropriate policies to control, limit, reduce or prevent human activities under their jurisdiction or control *should it be found that these activities have or are likely to have adverse effects resulting from modification or likely modification of the ozone layer*. [emphasis added]

It may be interesting to discuss whether HFCs should be considered as controlled substances at all in the meaning of the Montreal Protocol. For all current controlled substances, the aim is to achieve a total phase-out, thus eliminating all emissive uses except for a few exemptions. This is not necessarily the objective for HFCs: current proposals contain only a phase-*down* and not a total

phase-*out*. This opens the possibility of differentiating between controlled substances and 'other substances', the latter of which would be subject to similar control measures but which would continue to be emitted.

An important issue to consider is the strong linkage between any new controls on HFCs and the existing HCFC control schedules. Several developing countries have pointed to the difficulties already facing them in meeting their HCFC commitments, and fear that new restrictions on HFC use could jeopardize compliance with those schedules. Although adjusting the existing HCFC control schedules to give more time to develop low-GWP substitutes would, in principle, be a logical solution, concerns about the potentially negative signals sent to industry, and the generally worrisome precedent of 'backtracking' on commitments, outweigh any theoretical benefits.

Current amendment proposals

Recent debates have focused on two amendments, both proposed annually since 2009: one by the North American parties (Canada, Mexico and the United States); the other by the Federated States of Micronesia (and, in the past, Mauritius). The 2014 versions of each amendment proposal share similar features, setting out phase-down targets for total consumption and production of HFCs, weighted by their GWP, creating an incentive to phase down fastest those HFCs with the highest GWP.

Recognizing that alternatives to HFCs do not yet exist for all uses, both amendments aim at a phase-down, not a total phase-out. For developed countries, the North American amendment contains a target of an 85 per cent phase-down by 2035, with interim steps starting in 2017. The baseline level for the phase-down is the average of HFC consumption and production plus 85 per cent of HCFC consumption and production over the period 2008–10 (North American amendment); or the average of HFC plus HCFC consumption and production over the period 2014–16 (Micronesian amendment).

Each amendment proposes slower phase-down schedules for Article 5 parties. The North American amendment introduces the first step for Article 5 parties two years later than for non-Article 5 parties, in 2020, and this is a freeze rather than a 10 per cent reduction. Two further interim steps end at an 85 per cent reduction by 2045. The Micronesian amendment leaves the grace period to be defined. The baseline level for Article 5 parties is the average of HFC consumption and production plus 40 per cent of the average of HCFC consumption and production over the period 2011–12 (North American amendment); or over a period to be defined (Micronesian amendment). Each amendment also puts strict limits on the volume of HFCs that can be emitted as a by-product of the manufacture of HCFCs or other HFCs – a reference primarily to HFC-23.

The main opposition to the proposed amendments has rested on the following arguments:

- The limited availability of alternatives to HFCs, particularly for some uses, including those in very hot countries;
- Lack of clarity over the adequacy of funding for the MLF to cope with the additional control commitments, and of effective mechanisms for technology transfer to developing countries;

- The impact on the phase-out of HCFCs in developing countries – currently under way – of future controls on HFCs, which are in some cases the main substitutes for HCFCs;
- Uncertainty on the part of developing countries over exactly what they might be signing up to, given the lack of knowledge on current HFC use and future anticipated use in their countries;
- Uncertainty over the inter-relationship between the Montreal Protocol, if amended, and the UNFCCC and Kyoto Protocol;
- The fact that HFCs represent only 0.7 per cent of current GHG emissions, and therefore that the focus on them is misplaced; if countries want to control them, they could adopt national regulations to do so.

Options for action

The amendments described above address many of the key issues, although there is of course room for debate over the details. Given the persistent opposition to these existing proposals, there is a case for exploring how they could be modified to address the concerns raised by some countries. This section presents some ideas for reflection on how the current situation of HFC use in developed and developing countries could be addressed under the Montreal Protocol.

Overall, the geopolitical and economic contexts in which new controls for HFCs would be negotiated are very different to those in play when controls on ODS were initially established under the Montreal Protocol. For example, at least half the total global HFC production takes place in Article 5 parties (mainly in China); and new technologies are being developed in Article 5 as well as non-Article 5 parties. For this reason, there have been suggestions that the Article 5/non-Article 5 classification is no longer appropriate, and other ways of categorizing countries and their commitments on HFCs could be devised. Although this may make logical sense, it would be highly risky. Attempting to apply new classifications would inevitably generate considerable controversy – especially among the emerging economies, the support of which is so vital for controls on HFCs to be agreed and to succeed. It may therefore be best to stick to existing, and accepted, forms of country classification. Of course, there are ways of recognizing the special circumstances of particular groups of parties, such as low-volume consuming countries, or countries with high ambient temperatures. This has already been done in the ozone regime – and indeed in the climate change regime, where the special circumstances of LDCs, small island developing states (SIDS) and others are recognized and acted on – and would continue.

Consumption in non-Article 5 parties

Developed countries have largely already phased in HFCs, so a phase-down schedule as proposed by the existing amendments would seem to be fully appropriate, although of course the details remain to be negotiated. A joint HCFC/HFC baseline, considering that HCFC consumption is still allowed under the Montreal Protocol, in line with the agreed HCFC phase-out schedule, seems a plausible way forward for these countries, aiming for a significant reduction by 2030 – i.e. similar to some existing national regulations. These measures would drastically reduce the existing consumption, and hence emissions, of HFCs.

Consumption in Article 5 parties

Article 5 parties have always been treated differently, with financing of agreed incremental costs and long grace periods before the implementation of controls: 10 years for HCFCs and methyl bromide; 14 years for CFCs and carbon tetrachloride; 16 years for halons; and 19 years for methyl bromide. (There was no grace period for hydrobromofluorocarbons and bromochloromethane, which always had limited global use.)

In the early years of the Montreal Protocol, companies from non-Article 5 parties manufactured ODS and most products made with or containing ODS. Today, however, as noted above, companies in Article 5 parties account for much of the global production of HCFCs and HFCs, together with the production of almost all room air-conditioners (sales are split evenly between customers in Article 5 and non-Article 5 parties). Similarly, a third of global car manufacture or assembly takes place in Article 5 parties, for domestic use or for export to customers in non-Article 5 parties. (The exception is foams: due to the cost of transporting bulk thermal insulating foam, manufacture tends to be closer to the point of use.)

The implication of this new dominance of products being manufactured in Article 5 parties is that a long grace period may not be so appropriate. On the one hand, it would ensure that technology would have been demonstrated in non-Article 5 parties well in advance of Article 5 phase-down. On the other hand, it could allow a long period of growth of HFC use in Article 5 parties even in applications where there are already mature and proven alternatives; and companies operating in Article 5 parties might have to raise their own capital to service non-HFC export markets – only gaining access to MLF financing years later, when domestic Article 5 markets began the transition. One possible solution is to adopt a grace period but to make full financing available to Article 5 parties wishing to phase down HFCs in advance of the Article 5 control schedule.

It is also the case that many Article 5 parties, particularly the smaller ones, do not always have a good overview of future consumption, and may find it difficult to sign up to a fixed schedule, even with a long grace period (hence the argument, made in the section on finance, for funding of HFC inventories). Another possible solution, therefore, could be to adopt an initial binding commitment of avoiding an increase in climate impact as a result of their existing HCFC phase-out efforts. In view of the rapidly growing markets in many of these countries, this could be a significant step towards climate protection. This approach would build on existing practice under the MLF today, rewarding countries for their action to phase out HCFCs by giving them the credit for taking climate action simultaneously. The determination of a future reduction schedule could be deferred to a later date when information on HFC consumption would be fully available. Another option would be for Article 5 parties to agree to a freeze in HFC consumption and leave the future reduction schedule to be determined when better information becomes available.

Production

Production of HFCs is now taking place in both non-Article 5 and Article 5 parties, with a large share of substances for use in equipment for non-Article 5 parties now being produced in some Article 5 parties (mainly in China). This changed market situation has to be considered when deciding on grace periods for Article 5 HFC production; possibly, there should be no grace period for a production phase-down.

The option of dividing HFCs into groups for tailored controls

By design, and as a consequence of the evolution of the Montreal Protocol, ODS were divided into groups of controlled substances, each with their own baselines and phase-out schedules, and with each group of substances separately evaluated for technical feasibility of accelerated phase-out. These groups of substances fortuitously allowed parties to control specific applications at the pace at which technology became available. For example, with few exceptions, halons were only used as fire protection agents; methyl chloroform and carbon tetrachloride were only used as solvents; and methyl bromide was only used as a pesticide.

Parties could consider the advantage of dividing HFCs into groups to allow tailored control of each application, now or in the future. This strategy allows each sector to do its part in protecting the climate, protects companies from HFC price increases when alternatives are not available, and avoids sheltering of HFC uses where alternatives are easily available but other sectors are more easily satisfying the phase-down.

For example, for parties with vehicle manufacturing, the transition from HFC-134a (GWP = 1,370) to HFO-1234yf (GWP <1) in MAC could satisfy even an ambitious control schedule, while parties without such an industry would have to phase down HFCs in other sectors where the costs might be higher. Companies in countries with vehicle manufacturers might enjoy unrestricted access to HFCs at low cost and therefore unfairly compete with products made in countries where the HFC phase-down would increase the HFC price or prohibit HFC use.

To avoid this situation, an HFC amendment could divide HFCs into groups for the purpose of controls. For example:

- Group 1: HFC-134a
  - Rapid phase-down reflecting availability of alternatives in MAC and other RAC applications
  - Global exemptions for RAC service, MDIs and national security uses
  - Essential-use exemptions available from the start
- Group 2: HFC-125 (ingredient in HFC-410A, 407A and 407C)
  - Rapid phase-down of high-GWP refrigerants in RAC
  - Global exemption for RAC service
- Group 3: HFC-32 (next-generation RAC in equipment requiring a refrigerant charge larger than would be safe with HC-290)
  - No control schedule, unrestricted use until alternatives emerge and parties agree to adjust the control schedule
- Group 4: HFC-152a (next-generation MAC refrigerant without intellectual property constraints and complications)
  - No control schedule, unless later adjusted by parties

  - A decision by the parties could discourage use of HFC-152a in aerosol cosmetic and convenience products such as aerosol dust blowers

- Group 5: All other HFCs
  - Control schedule with essential-use exemptions

Conservative phase-downs could be agreed at the time of the amendment, and be strengthened, through the protocol's adjustment procedure, as technology emerges and becomes more affordable. Further consideration would obviously have to be given to how HFC blends could be treated.

Allowance for special situations

The Montreal Protocol has always made available a wide range of exemptions. **Accounting exclusions** are allowed for feedstock and process agents where ODS emissions are *de minimis*, and for methyl bromide quarantine and pre-shipment uses. **Global exemptions** are allowed for laboratory and analytical uses (with some exceptions). **Essential-use exemptions** are allowed for CFCs, halons and methyl chloroform, and **critical-use exemptions** for methyl bromide. **Emergency-use exemptions** are allowed for most ODS. (Note that feedstock, process agent, quarantine and pre-shipment global exemptions are implemented by accounting rules in the protocol, while laboratory and analytical use global exemptions were implemented – and amended to exclude certain uses – by decision of the MOP.)

Under an HFC amendment, the case could be made for similar allowances such as exemptions or service tails. However, the amendments debated to date propose only a phase-down rather than a complete phase-out – unlike for ODS – so the rate of phase-down and the ultimate reduction can be set to allow for those applications where low-GWP alternatives may not be available, and to ensure the servicing of installed equipment.

Ensuring the adequate supply of HFCs for MDIs is necessary for the immediate future because of the increasing incidence and treatment of asthma and COPD; and because access to drugs varies among countries, and suitable alternatives are not readily available at affordable prices or are not suitable for all patients.

Conclusions

Rising HFC use poses a significant threat to intergovernmental efforts to combat climate change and to keep global temperature rise below 2°C. The current high growth rate in HFCs can be attributed almost entirely to the Montreal Protocol, and its success in dramatically scaling back the production and consumption of CFCs, HCFCs and other ODS. For many, it is therefore clearly incumbent on the Montreal Protocol to focus now on reducing HFC use, replacing these with low-GWP alternatives.

However, HFCs are already included – by default as GHGs – under the UNFCCC, and are listed by name under the Kyoto Protocol. But because of the very different, economy-wide, approach taken by the climate change regime, the introduction of specific controls targeting HFCs is unlikely in that regulatory context. At the same time, measures to reduce HFCs are generally highly cost-effective and, in many cases, would be relatively easy to introduce, compared with other climate change mitigation options. Although there is no such thing as a 'wonder chemical', low-GWP alternatives to HFCs are available in many sectors, and indeed many countries are already taking early action to reduce HFC use. This is an area with considerable potential for large environmental gains from coordinated action, and yet the intergovernmental arena is failing to seize the opportunity.

The rationale for introducing a phase-down schedule for HFCs under the Montreal Protocol is strong. The protocol has the technical expertise to address issues raised by the HFC sector, given its strong similarities to the other fluorinated gases that the ozone regime has already successfully phased out. The linkages with the existing HCFC phase-out again suggest that the Montreal Protocol would be best placed to oversee the control of both groups of substances.

Legally, the fact that HFCs are already included under the scope of the climate change regime should not pose any barriers, given that the aims of the two regimes are entirely compatible. There are no legal impediments to the climate change parties – which, after all, are the same as the ozone parties – requesting the Montreal Protocol to assist in the fulfilment of the UNFCCC's ultimate objective by addressing the rise in use of HFCs. Of course, there are many practical issues to be ironed out, and there is considerable scope for fruitful cooperation to be exploited, not least in the areas of finance and reporting.

The specific provisions of any new control schedules will also need careful negotiation, so that the usual safeguards and exemptions for special circumstances and uses can be applied. The majority of parties to the ozone regime – once again, bearing in mind that these are also the climate change parties – broadly support the initiation of negotiations on HFCs under the Montreal Protocol, and, presumably (although this has not yet been fully tested), also support providing a mandate for doing so from the climate change regime.

Discussions, however, remain all but stalled in both forums. Some participants even claim that the ozone regime has been 'infected' by the climate change regime, in that its usually cordial atmosphere has deteriorated to the extent that the HFC issue can only be discussed under the code term 'high-GWP alternatives'. This link to the climate change regime, and its politics, lies at the heart of the problem. Some countries are clearly concerned that moving substantive responsibility for HFCs into the ozone regime would mean that they would be subject to stronger commitments

on those substances. Even if the Montreal Protocol does explicitly recognize equity, its implementation of that principle is different to that under the climate change regime, arguably placing greater expectations to act on developing countries.

The fact that the climate change regime is in the midst of landmark negotiations throws up both opportunities and extra challenges: opportunities because agreement to 'carve out' HFCs could form part of – and indeed provide an easy win for – the 2015 deal; extra challenges because, at present, there is very little attention being paid to HFCs in the climate change area, and the negotiations may simply be too complex and too full to incorporate another dimension. Time, however, is of the essence, if developing countries are to avoid a damaging widespread introduction of HFCs as they phase out HCFCs.

None the less, there are practical ways of moving forward to address the remaining concerns and try to unblock the politics. Key among these is for donor countries to provide solid assurances on the availability of finance. The current MLF replenishment negotiations, and the process of operationalizing the GCF, provide ideal opportunities for doing this. At the same time, a request to the ozone and/or climate change secretariats to prepare a (joint) paper on issues of cooperation should also help to allay any legal concerns and explain how, in substance, a joint approach to HFCs would work, especially in terms of finance and reporting. Continued analysis by the TEAP on alternatives to HFCs is, of course, always helpful.

The issue of HFCs provides a stark example of how the global atmosphere scorns legal divisions. As MEAs advance in their implementation phases, it is perhaps inevitable that more cases of crossover between different regimes would emerge. Although challenging, there is no reason why the international community cannot come together to address this new problem of coordination and ensure that legal regimes support each other rather than get in each other's way, especially when the potential gains to be made are so great. All that is needed is the political will – and political courage – to do so.

About the authors

Dr Stephen O. Andersen is Director of Research at the Institute for Governance & Sustainable Development (IGSD), where he focuses on technology and policy to rapidly reduce ozone-depleting and hydrofluorocarbon greenhouse gases and other climate forcers. From 1986 to 2009 he worked for the US Environmental Protection Agency in a variety of positions, including Director of Strategic Climate Projects and Deputy Director of the Stratospheric Protection Division. He was Co-Chair of the Montreal Protocol's Technology and Economic Assessment Panel from 1988 to 2012, and has also been a senior manager and author of reports for the Intergovernmental Panel on Climate Change.

Duncan Brack is an independent environmental policy analyst, working on issues including international environmental crime, deforestation and climate change, bioenergy, ozone depletion and the Montreal Protocol, international environmental regimes and institutions, and the interaction between environmental regulation and international trade rules. In the mid-1990s he was one of the first researchers to study illegal trade in ozone-depleting substances. He is an Associate Fellow of Chatham House, and has also been a special adviser at the UK Department of Energy and Climate Change.

Dr Joanna Depledge is affiliated lecturer at the Department of Politics and International Studies, University of Cambridge, where she teaches and examines on the international climate change regime. She has worked on climate change and ozone issues for the past 20 years, including for the UN Climate Change Secretariat and the Earth Negotiations Bulletin. She has published widely on the climate change negotiations, and is Deputy Editor of the journal *Climate Policy*.

Acknowledgments

Funding for the production of this paper is gratefully acknowledged from the Children's Investment Fund Foundation. Funding for the workshop at which an earlier draft of this paper was discussed is gratefully acknowledged from the Children's Investment Fund Foundation and the European Commission (DG Climate Action).

The authors are grateful to Nathan Borgford-Parnell, Marco Gonzalez, Nancy Sherman, Xiaopu Sun, Jake Werksman and Durwood Zaelke for substantive input.

Independent thinking since 1920

The Royal Institute of International Affairs
Chatham House
10 St James's Square, London SW1Y 4LE
T +44 (0)20 7957 5700 F +44 (0)20 7957 5710
contact@chathamhouse.org www.chathamhouse.org
Charity Registration Number: 208223