Alternatives to High-GWP Hydrofluorocarbons

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This report is a continuous work in progress that will be updated frequently. Corrections and additions are welcome. Please contact Dr. Nancy J. Sherman, Director of Technical Assessment (nsherman@igsd.org).

[1] The views expressed in this report are those of the authors and team members and not necessarily the views of the organizations where they are employed. Affiliation is for identification only.

0 Executive Summary

This assessment report aims to give a concise and accessible picture of the current availability of alternatives to high-global warming potential (GWP) hydrofluorocarbons (HFCs) in their main uses, with elaboration of their efficacy, cost-effectiveness, safety, environmental impacts and technical performance, as well as their applicability at high ambient temperatures, with the goal of better informing decision making about the future of HFCs in a fast-evolving market and regulatory context.

This report builds on the findings of the Chatham House/Institute for Governance & Sustainable Development (IGSD) Workshop and Report (Andersen, Brack, and Depledge, 2014) and the IGSD Primer on Hydrofluorocarbons (Zaelke and Borgford-Parnell, 2014) and is a continuous work in progress, which will be updated frequently; corrections and additions are welcome.[2]

A wide choice of alternatives to HFCs are now available, with more under development, but many of these are very new. Not surprisingly, many Article 5 Parties (A5 Parties) have expressed concerns over factors such as availability, cost-effectiveness, safety, applicability in high-ambient-temperature environments, and maintenance requirements particularly because, in many cases, these countries are just beginning the process of phasing out hydrochlorofluorocarbons (HCFCs).

This report summarises: 1) the latest state of knowledge of the availability and characteristics of current alternatives to HFCs in the key sectors, 2) a discussion of barriers to their uptake and how the barriers can be overcome, 3) the crucial issue of the energy efficiency of HFC-using systems and their alternatives and 4) the potential for accessing financial support for the replacement of HFCs.

The objective is to provide information that will allow decision makers, and particularly ozone officers, to tackle the growing global threat to the Earth's (atmosphere).

The Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) has organizations in place to assess science, environmental effects, and technology; to educate the public and policy-makers; to build regulatory capacity and train service technicians; and to select, finance, and implement next-generation alternatives to most remaining uses of HCFCs and HFCs.

The case studies presented in the report show that high-GWP HFCs can be and are being successfully replaced in a wide range of uses in both A5 and non-A5 Parties. Given the progress of the introduction of energy-efficient lower-GWP HFC alternatives and the gradual spread of national and regional regulations and voluntary industry commitments, more and more countries committed to mitigating climate change will need to address the question of how to phase down the use of HFCs, regardless of whether the Montreal Protocol is amended to control HFCs.

Opportunities exist for both A5 and non-A5 Parties to reduce high-GWP HFCs used to manufacture new refrigeration, air conditioning, fire protection, aerosol, and miscellaneous products at the same time as HCFCs are phased out. Once the production of new products depending on high-GWP HFCs is halted, use can be limited to servicing existing equipment. The cost of retrofitting or replacing existing equipment may be too high to be cost-effective in the short term, although energy savings and increased reliability can offset enough cost to make replacement of obsolete equipment worthwhile.

The report finds that in product manufacturing, technology is already available to phase down high-GWP HFCs in most applications in the foam, domestic, commercial and industrial refrigeration, and solvents sectors.

Many technologies exist to replace high-GWP alternatives in stationary air conditioning, especially in the commercial and industrial sector. However, domestic air conditioning may present challenges that require immediate attention. It is expected that A5 parties will want to demonstrate the

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feasibility and ascertain local costs of new hydrofluoroolefins (HFOs) and blends, and, in the case of flammable solutions, A5 countries would need to first set new standards and train technicians, even for small air conditioning charges. Some countries, including China, India, Indonesia, and Japan, are championing the safe use of flammable hydrocarbon (HC)-290 and HFC-32 refrigerants in room air conditioners (A/Cs).

0.1 Specific alternatives to high-GWP HFCs suitable for A5 Parties

A5 Parties—if adequately financed for the added first cost, training and safety requirements (and, in some cases, the ongoing added cost of servicing)—have a wide choice of immediately available technologies that can eliminate, with few exceptions, high-GWP HFCs in MACs, domestic and commercial refrigeration, building air conditioning chillers, and thermal insulating foam. A5 Parties will want to implement next-generation choices that achieve high energy efficiency and reliability at local ambient temperatures.

A5 Parties can be market leaders in the safe use of flammable solutions by setting appropriate safety standards and properly training technicians, while non-A5 Parties may be followers because existing standards prohibiting all flammable refrigerants are entrenched in standards organizations where change comes only slowly (though clearly, appropriate safety standards are needed in every market).

A5 Parties, including China and India, with the ability to train and enforce safe practices in the manufacture, installation, service and disposal of room air A/Cs using flammable refrigerants, and with the technical and administrative ability to put safety regulations in place rapidly, can move quickly to replace room A/Cs containing HCFC-22 and HFC-410A with room A/Cs manufactured with HC-290, HFC-32, and HFC/HFO blends. Because HC-290 and HFC-32 refrigerants are flammable, installation should only occur in cases where the charge is large enough to cool the room on the hottest days, but small enough to be safe if discharged into the occupied room.

The vast majority of A5 Parties do not manufacture HCFCs or HFCs or products containing these substances. For these Parties, high-GWP HFCs are mostly contained in new imported equipment or are used for servicing new and existing equipment. The opportunity exists to import only energy-efficient low-GWP products; thereby avoiding the infrastructure and training that would otherwise be necessary to support already obsolete high-GWP HFC technology. Actions such as prior informed consent, environmental trade barriers and strong customs controls and regulations may be necessary to prevent the dumping in A5 Parties of obsolete high-GWP HFC products that require expensive new infrastructure.

A5 Parties can make a second transition and replace HFC-134a in the manufacture of new MACS with HFO-1234yf, the cost of which is marginal when compared with the cost of the car, or can wait for HFC-152a or carbon dioxide (CO_2) systems to be commercialized and proven energy efficient and reliable. Because HFO-1234yf systems can be recharged at service with HFC-134a, the full life-cycle climate benefits are only realized if vehicle owners, service technicians, and government authorities insist that the systems be recharged only with HFO-1234yf. It is not currently technically feasible to retrofit automobiles with HFC-134a systems to use HFO-1234yf.

0.2 Specific alternatives to high-GWP HFCs suitable for non-A5 Parties

Non-A5 Parties—with the advantages of easily-available financing and well-trained, equipped and disciplined service sectors—have a wide choice of immediately available technology that can eliminate, with few exceptions, high-GWP HFCs in motor vehicle air conditioning (MACs), domestic and commercial refrigeration, building air conditioning chillers, and thermal insulating foam. The European Union (EU) HFC phase-down schedule is indicative of the reductions all non-A5 regions can take.

Although the additional cost of HFO-1234yf vehicle air conditioning is small compared to the cost of new automobiles, it may be fair and reasonable to provide incentives such as rebates or sales tax reductions at the time of purchase or to secure agreements from chemical suppliers and automobile manufactures to provide extended warranties for A/C service.

0.3 Flexible manufacturing facilities allow rapid future transition

Room A/C manufacturers in both A5 and non-A5 Parties can design their facilities to safely use a wide range of possible future refrigerants by anticipating that next-generation refrigerants will be either more flammable and/or require higher operating pressures than HCFC-22. For example, room A/C manufacturers in A5 Parties that choose to convert initially from HCFC-22 to HFC-410A, due to strict Montreal Protocol compliance needs, and then later make a second transition to lower-GWP options, can insist that the Multilateral Fund (MLF) finance appliance filling facilities and refrigerant storage areas to be suitable for all of the foreseeable technical options. Chemical manufacturers and safety authorities can cooperate with OzonAction, the MLF and Montreal Protocol implementing agencies to specify the factory designs.

0.4 Stringent environmental screening and safety precautions

Parties will want to choose technology that has satisfied stringent environmental screening for toxicity and acceptable atmospheric fate and will want to implement appropriate safety precautions for flammable and/or toxic substances. It will be prudent to check the technologies listed as acceptable by the US Environmental Protection Agency (EPA) Significant New Alternatives Policy Program (SNAP) and the EU's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation. It will be prudent to implement only technology proven safe, energy efficient, and affordable in case studies and reports of demonstration projects published by reputable independent organizations such as the Climate and Clean Air Coalition (CCAC) to Reduce Short-lived Climate Pollutants, the MLF and its implementing and bilateral agencies, UNEP, and the Montreal Protocol Technology and Economic Assessment Panel (TEAP) and its Technical Options Committees (TOCs). Parties and companies may consider contacting the experts listed on the case studies to ask if superior alternatives have emerged and to request advice on suppliers, installations, and service.

0.5 Best proof of technical and economic feasibility and market acceptance

Some of the best technical and economic information on alternatives and substitutes to high-GWP HFCs will come from projects undertaken for Parties by the MLF and its implementing and bilateral agencies where the actual costs, including those for refrigerant and foam blowing substances, will be transparently listed and where experience with the new technology will be faithfully and honestly shared through the networks.

0.6 Financial solutions

With additional funding to expeditiously restructure the HCFC phase-out to enable a leapfrogging of high-GWP HFCs, A5 Parties could have wider choices in foams, refrigeration, air conditioning, and other uses. National, regional, and international regulations, industry leadership, voluntary agreements, and technical innovation are driving change. The research and development pipeline is full and new alternatives are rapidly being commercialized.

However, costs beyond those normally financed by the MLF would be incurred, and therefore, additional funds will be necessary to build capacity, to train technicians to maintain and service products that contain flammable alternatives, to set new standards to allow for the introduction of new technology, to cover the operational costs of the new technologies (HFOs and blends), and to strengthen networks linking chemical companies, appliance manufacturers, technicians, and end-users. It will also be necessary to demonstrate and report the performance of next-generation technology when applied to A5 Parties, particularly in locations with long seasons of high ambient temperatures.

The simplest solution to financing 'agreed incremental costs' is replenishment of the MLF to take on 1) the added cost of leapfrogging high-GWP HFCs in the phase-out of HCFCs; 2) the added cost of a second transition from HFCs in applications like MACs that already use HFCs; and 3) the added cost of a two-stage transition, first from HCFCs to HFCs and then from HFCs to next-generation technology in applications where implementing HFCs is too far along to turn back. Parties could decide to make financing available immediately for A5 Parties choosing to go beyond compliance.

A second solution is to establish an expanded source of financing from non-A5 contributions as grants, provided the MLF Executive Committee welcomes and approves this co-financing and eases any administrative requirements that would prevent A5 Parties and enterprises from adopting measures justified by the climate, clean air, and natural resource benefits of higher energy efficiency.

A third solution is for A5 Parties to separately seek financing from sources other than the MLF for the HFC phase-down and energy efficiency improvements and to coordinate that funding with the HCFC phase-out schedule. However, the national ozone units in most A5 Parties are accustomed to having a 'one-stop window' for international financing that relates to ozone depletion, and are not well prepared (given, in general, their lack of knowledge of other financing institution or mechanisms) to access funds from the international financial institutions or funds that support energy-efficiency investments and clean energy projects, which are described in the full report. Some A5 parties have shown a preference to use government and private sector finance at the national level for the non-eligible portion of Montreal Protocol projects, rather than seek co-finance from international climate and aid organizations.

Unlike the ozone-depleting substance (ODS) phase-out, where transition costs were mostly in the manufacturing sector, products such as MACs built with the current choice of HFO-1234yf refrigerant, will increase the cost of new air-conditioned cars and the cost of service over the lifetime of the vehicle. It should also be borne in mind that some technologies are already cost effective for MLF finance, while other technologies have not yet achieved economies of scale or competitive cost.

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