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Briefing to the 41st Open-  
Ended Working Group of the  
Montreal Protocol

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# High Stakes:

Implementing and strengthening climate  
and ozone commitments under the  
Montreal Protocol

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## ABOUT EIA

We investigate and campaign against environmental crime and abuse.

Our undercover investigations expose transnational wildlife crime, with a focus on elephants, pangolins and tigers, and forest crimes such as illegal logging and deforestation for cash crops like palm oil. We work to safeguard global marine ecosystems by addressing the threats posed by plastic pollution, bycatch and commercial exploitation of whales, dolphins and porpoises. Finally, we reduce the impact of climate change by campaigning to eliminate powerful refrigerant greenhouse gases, exposing related illicit trade and improving energy efficiency in the cooling sector.

## OUR CLIMATE WORK

EIA has almost three decades of experience working with international bodies, governments, enforcement agencies and industry to tackle illegal trade in refrigerants. It began in the 1990s when we exposed the illegal trade of chlorofluorocarbons (CFCs) in Europe.

EIA's pioneering investigations shone a light on the illegal trade in Ozone-Depleting Substances (ODS) across the globe. Our exposés and advocacy helped increase awareness of the illegal trade among Parties to the Montreal Protocol on Ozone-Depleting Substances and spur action to curtail it, including through the adoption of ODS licensing systems.

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# Introduction

After more than three decades of undeniable success, earning it the title of the world's most successful multilateral environmental agreement, the Montreal Protocol is now being tested.

Following revelations of unexplained CFC-11 emissions in 2018, legitimate questions have been raised as to whether the Montreal Protocol's institutions and controls are fit for purpose, not only to ensure the sustained phase-out of ozone-depleting substances (ODS) but also to address new challenges unique to the HFC phase-down under the Kigali Amendment.

The failure to detect ongoing production and use of CFC-11 prior to its scientific discovery necessitates a very serious look at the current monitoring, reporting, verification (MRV) requirements and procedures of the Montreal Protocol. The ability of Parties to effectively enforce Montreal Protocol commitments must also be reviewed.

Some very specific issues have surfaced due to the illegal CFC-11 production and use, including: the inadequacy of the verification procedures used in projects funded by the Multilateral Fund (MLF) to ensure sustained reductions of phased-out controlled substances; the lack of full geographic coverage of atmospheric monitoring of controlled substances; and the difficulties in monitoring the trade in ODS-containing pre-blended polyols and, in future, HFC-containing polyols.

While some MLF-funded project management issues should be tackled directly by the Executive Committee (ExCom) of the MLF, EIA believes many other issues can only be addressed at the Montreal Protocol level. The Parties to the Montreal Protocol must take primary responsibility for setting a clear path to review, assess and make recommendations on actions to strengthen the current MRV regime in order to ensure effective implementation of Montreal Protocol decisions.

These actions must take into account the additional complexities and challenges that the Montreal Protocol faces with the ongoing HCFC phase-out in parallel with the Kigali Amendment. For example, the HCFC phase-out is just under way in Article 5 Parties, with the first significant reduction of 35 per cent set for 2020 followed by reductions of 67.5 per cent in 2025, 97.5 per cent in 2030 and 100 per cent in 2040.

To achieve the HCFC phase-out schedule will require A5 Parties to reduce their HCFC production and consumption to close to zero within the next decade, in particular the pervasive HCFC-22. Unlike CFC-11, HCFC-22 is also widely used as a feedstock to manufacture other fluorochemicals, such as HFC-32, and to produce synthetic polymers, such as polyvinyl chloride (PVC) and

polytetrafluoroethylene (PTFE), also known as Teflon.<sup>1</sup> The Montreal Protocol places no controls on the production and consumption of feedstocks, subjecting them only to basic reporting.<sup>2</sup> This creates a loophole that could lead to significant illegal use and trade, exacerbated by the fact that HCFC-22 is a less expensive drop-in for many HFC applications. Moreover, it is difficult to imagine how atmospheric monitoring and modelling would be similarly effective in overseeing compliance with the HCFC phase-out as it was with the CFC phase-out, given that the emissions from illegal use of HCFC-22 would be dispersed and time-delayed, compared to emissions from the use of CFC-11 in foams.

The HFC phase-down presents more unique challenges. In particular, the HFC phase-down is a phase-down, not a phase-out, meaning there will be a tail of allowable consumption and emissions into the future. Unlike most CFCs and HCFCs, HFCs are used as both a pure substance and in countless HFC blends. Since the HFC phase-down is based on carbon-dioxide equivalence (CO<sub>2</sub>e), an unknown mix of HFC blends will be emitted to the atmosphere as the phase-down progresses, with reporting only indicating the constituent HFCs in Annex F. It will therefore be difficult if not impossible to identify illegal HFC production or the use of specific HFC blends through atmospheric monitoring and modelling alone.

The CFC-11 experience has been informative and still requires significant additional efforts to ensure this specific issue is fully understood and addressed. However, it has also triggered overviews of some of the Montreal Protocol's institutions and controls, highlighting a broad set of shortcomings that must be addressed as well as foreshadowing several new issues that will arise.<sup>3</sup> These insights provide a solid foundation to build upon but much more is required. A broader examination of the institutions and processes of the Montreal Protocol as a whole is warranted, in order to ensure it is ready to take on the growing challenges of the ongoing HCFC phase-out and the new controls under the Kigali Amendment.

It is time to reinvest in the Montreal Protocol. Parties should use the 41st meeting of the Open-Ended Working Group (OEWG) to prepare to initiate a comprehensive fitness check at the 31st Meeting of the Parties (MoP31) in Rome, one with clear timetables for consideration and adoption of needed improvements, whether via decisions, adjustments or future amendments.

# Illegal production and use of CFC-11

Immediately after scientists revealed unexpected and high emissions of CFC-11, EIA investigations provided evidence of widespread illegal use of CFC-11 in China's polyurethane (PU) foam insulation sector. EIA provided two reports to the Parties to the Montreal Protocol detailing the findings and information gaps yet to be addressed.<sup>4</sup> The Parties to the Montreal Protocol unanimously responded with urgency to the crisis and agreed to a decision at the 30th Meeting of the Parties in Quito, Ecuador (MoP30) with vital next steps to address this issue.<sup>5</sup>

In May 2019, a new scientific paper confirmed the origin of large-scale emissions of CFC-11 in eastern China, primarily in the north-eastern provinces of Hebei and Shandong. Rigby et al. showed that CFC-11 emissions from eastern mainland China were around 7,000 tonnes (range of 4,000-10,000) higher in 2014-17 than 2008-12. This increase accounts for at least 40-60 per cent of the global emissions increase since 2012. The study notes that, given the global emissions increase may be over-estimated owing to unaccounted for changes in atmospheric dynamics, the fraction of the global emission increase accounted for by eastern mainland China may be substantially higher.<sup>6</sup>

At MoP30, Parties requested the Technology and Economic Assessment Panel (TEAP) to provide them with relevant information on potential sources of emissions of CFC-11 and related controlled substances.

In response, TEAP formed a Task Force, combining expertise from TEAP and its Technical Options Committees (TOCs) with outside expertise, to address the requirements of this decision.

The detailed report identifies closed cell rigid foams as a primary sector for further investigation and analysis after exploring a number of speculative hypotheses regarding the large-scale use and emissions of CFC-11. The TEAP Task Force rules out a number of applications of CFC-11 as likely causes for the sudden increase in global emissions, including: in chillers, aerosols, as a solvent, as a process agent in the manufacture of synthetic fibre sheet, in uranium processing, in tobacco expansion and MDIs.<sup>7</sup> The Task Force also rules out CFC-11 stockpiles as a likely source of the emissions.<sup>8</sup>

The TEAP Task Force states it is "likely that any new CFC-11 production has occurred is completely independent of CFC-12 use in all R/AC sub-sectors."<sup>9</sup> EIA supports this statement as our evidence strongly suggests that the driver of illegal CFC-11 production is demand for CFC-11 in the foam sector. However, it is possible that significant quantities of CFC-12 have been illegally co-produced. As the use of CFC-12 as a replacement refrigerant for HFC-134a is technically possible, it is important for Parties to explore this further, in particular with respect to the mobile air-conditioning



**Above:** a cylinder of illegal CFC-12 seized in India in 2001

sector, which was the main sub-sector that used CFC-12 in the 1990s. EIA is aware of a number of large CFC-12 seizures in 2018 that have not been reported to the Ozone Secretariat and has recently heard anecdotal information from two Parties regarding the unintentional import of CFC-12 mislabelled as HFC-134a.

The TEAP Task Force also concludes that, although the sudden emissions increase cannot be explained by a similar, sudden increase in emissions from banks, additional exploration of CFC-11 emissions from installed foams, dismantling activities and from landfills are necessary to refine estimates of emissions from new production and use.

## Potential PU foam scenarios and use of CFC-11

The report provides calculations for several scenarios estimating the amount of PU rigid foam production theoretically required to produce 13,000 tonnes of CFC-11 emissions annually, as per the Montzka et al. estimate. High end ranges of overall emission rates combined from CFC-11 production (up to 10 per cent), polyol production (5-15 per cent), moulded foam production (up to 10 per cent), and spray foam application (20 per cent or more) indicate that lower than previously estimated levels of rigid foam production could result in the estimated atmospheric increases. While technically feasible, the Task Force questions the use of CFC-11 in flexible foams given the lack of economic incentive.

With respect to PU rigid foam in appliances, TEAP calculates that 343,915 tonnes of PU rigid foam for domestic appliances would have to be produced to result in 13,000 tonnes of CFC-11 emissions. This would require annual production of 42,005 tonnes of CFC-11 and leave a bank of 29,004 tonnes of CFC-11 in the foam. With respect to a spray foam scenario, the total foam production would be slightly less – 312,000 tonnes – and a smaller bank of 13,000 tonnes of CFC-11 would remain in the foams (see Table 1). This is due to the lower amount of CFC-11 required as blowing agent in spray foam

compared to moulded foam.<sup>10</sup> The Task Force scenario analysis is purely a theoretical scenario, however it reinforces the need to continue to explore PU foam manufacturing as an important potential source of the unexpected CFC-11 emissions.”<sup>11</sup>

According to the Task Force report, an estimated 1.8 million tonnes of rigid PU foam was produced in China in 2017, almost 33 per cent of the global total. Around 710,000 tonnes were produced for construction and just over a million tonnes for refrigeration. The potential for 312,000-343,915 tonnes of PU rigid foam production to be responsible for the unexpected CFC-11 emissions is therefore entirely plausible, in particular considering EIA's investigations which indicated widespread use of CFC-11 in the PU foam construction sector.

The Task Force reports that spray foam constitutes a small proportion (80,000 tonnes) of China's rigid foam production. Table 1 shows that TEAP estimates production of 312,000 tonnes of PU spray foam would be needed to cause CFC-11 emissions of 13,000 tonnes, therefore it seems unlikely that CFC-11 use in spray foams could be uniquely responsible for all of the CFC-11 emissions. Mixed use of CFC-11 in spray foams and moulded PU foams (a scenario not modelled by the Task Force) remains feasible. Based on the TEAP calculations for moulded foam emissions, the 7,000 tonnes of CFC-11 identified to originate from eastern China by Rigby et al. would require approximately 185,185 tonnes of moulded PU foam to be blown with CFC-11, more than 10 per cent of China's total annual rigid PU foam production.

**Table 1:** TEAP simulation of PU foam and CFC-11 required to produce 13,000 tonnes of CFC-11 emissions in rigid technology

Components	PU Rigid - Foam Appliances (moulded foam)		PU Rigid - Spray (calculated)	
	Parts by weight	Wt%	Parts by weight	Wt%
	CFC-11 net released = 30.95%		CFC-11 net released = 50%	
Polyol	131,265.40	38.17	130,000.00	41.67
Required CFC-11	42,004.93	12.21	26,000.00	8.33
Isocyanate, PMDI	170,645.02	49.62	156,000.00	50
Total Foam Required to produce 13,000 tonnes of CFC-11 emissions	343,915.31	100.00	312,000.00	100.0
Bank of CFC-11 in foam remaining	29,004.93		13,000.00	

**Right:** application of spray foam



## CFC-11 production and linkages with CTC

The TEAP Task Force considered 20 potential CFC-11 production routes, with production ranging from small-scale production ( $\leq 2,000$  tonnes per year) to large-scale production in a dedicated CFC plant ( $\geq 50,000$  tonnes per year). According to the Task Force, the most likely production routes are carbon tetrachloride (CTC) to CFC-11 on micro-scale plants using minimal equipment (to make 100-2,000 tonnes low grade CFC-11 for foam blowing) and CTC to CFC-11/12 on a large scale (30,000-50,000 tonnes) in an existing HCFC-22 plant.

EIA is aware of Chinese enforcement efforts which have uncovered what appear to be small-scale CFC-11 production facilities. However, information relating to the exact scale and methods of production is lacking. TEAP suggests that if such plants were to exist their location would be determined by the availability of raw materials such as CTC.

The notion that HCFC-22 production lines could be swung to produce CFC-11 and CFC-12 is supported by TEAP's analysis of spare HCFC-22 capacity in China, which has grown steadily since 2012 and currently amounts to greater than 50,000 tonnes per annum.

The rate at which CTC has declined in the atmosphere remains slower than expected from its reported use as a feedstock, indicating ongoing emissions of around 35 Gg/yr. Although the CTC discrepancy has been significantly reduced by recent estimates of uncontrolled CTC emissions from China, the 2018 MCTOC Assessment Report states that "much of the apportionment of sources is uncertain and subjective, and most of the emissions appear to arise from unregulated sources."<sup>12</sup> A scientific paper published in 2018 provided compelling evidence linking elevated levels of CTC to the same region in China as the increased emissions of CFC-11.<sup>13</sup> Given the strong likelihood that CTC is being used as a feedstock for CFC-11, a more thorough investigation of CTC production in China is required.

The TEAP report shows that, regardless of the percentage of CFC-12 co-production, the amount of CTC required is within a similar range.<sup>14</sup> EIA believes that this is an area that warrants further exploration. Given that it takes a week for a plant to swing back from CFC-11/12 production to HCFC-22 production, unannounced inspections may help shed light on this issue and potentially rule out this production route.

## Response by China

Since the discovery of unexpected CFC-11 emissions and EIA's information regarding the use of CFC-11 in China's foam sector, China has responded with nationwide enforcement action. China has destroyed two illegal CFC-11 production facilities located in Liaoning and Henan Provinces, seized 177.6 tonnes of various raw materials and 29.9 tonnes of illegally produced CFC-11 and has investigated 1,172 companies in China. CFC-11 was identified after testing in products from 10 foam systems houses.<sup>15</sup>

From 2010 to the first half of 2018, China reports 14 cases involving illegal production of CFC-11, with about 84 tonnes of illegal CFC-11 destroyed. China also reports

that between 2012-18 the General Administration of Customs investigated and made seizures in 17 cases of ODS smuggling, involving more than 1,500 tonnes of ODS. However, China's report does not provide details of these cases and whether any CFCs were involved. This information should be provided, including details of the destination countries involved. This information should also be routinely reported to the Ozone Secretariat according to Paragraph 7 of Decision XVI/7.

China has additionally provided an overview of its system for monitoring and managing ODS, its enforcement efforts to date, challenges in enforcement, as well as plans for further initiatives to strengthen ODS monitoring and management, including establishing new atmospheric monitoring systems and ODS product testing for the information of the parties.<sup>16</sup>

However, very little is still known and understood about the production methodology, raw materials and their routes, production capacity, location and sales markets of those facilities producing CFC-11 that have already been identified in China. It is also unclear whether any of the illegal CFC-11 production facilities were previously producing HCFC-22.

## Conclusions and recommendations for next steps

Further validation of CFC-11 emissions rates during production of the gas, transport for use, production of polyol systems, shipping to foaming companies, during production of the different types of foam, from installed foams, during shredding before landfills and from landfills is critical in determining the magnitude of this issue and prioritising action. A thorough analysis specific to each of these aspects is required to refine accuracy of the emissions rates that will in turn inform a better understanding of the scale of the issue on the ground. EIA agrees with the areas for further assessment outlined by the Task Force in Chapter 7 and recommends additional efforts to be undertaken.

In particular, different scenarios should be modelled to account for the following uncertainties:

1. Emissions during production of CFC-11 differ based on the level of sophistication of the production facility. The Task Force states that well managed facilities can have ODS emission levels as low as 0.05 per cent of the ODS amount produced. However, it is possible that a rate of 1.5 per cent may more closely resemble realistic conditions, while TEAP has suggested up to five per cent may be possible for unsophisticated small batch production facilities and as much as 10 per cent for unregulated illegal production.<sup>17</sup> Additional emissions in the supply chain (e.g. loading cylinders) may add 1-3 per cent emissions.
2. The IPCC estimates emissions of 86-100 per cent of the blowing agent during the foaming process for flexible foams and four per cent (appliance foams) to 25 per cent (spray foam) in the manufacture of rigid foams.<sup>18</sup> The Task Force suggests these are "more sophisticated technologies and application techniques" since earlier literature describes emissions rates of 98 per cent (flexible foams) and up to 30 per cent (closed cell foams) during installation.



3. FTOC noted a range of 5-15 per cent of the blowing agent is emitted during the production of polyol systems in drums for shipping to foaming companies.

In addition, EIA urges China to undertake large-scale testing of existing moulded and sprayed PU foams in the construction and refrigeration industry (for example in new constructions and products), to categorically identify the market for CFC-11 blown foams. This should be informed by intelligence gathered from ongoing enforcement efforts, including the markets supplied by the systems houses already identified using CFC-11. In addition to the presence of CFC-11, mass spectrometry analysis of foam samples can identify other chemicals that can give important indications of the production process used to produce the CFC-11 gas. The new data from Rigby et al regarding the regional source of significant emissions provides an opportunity for Chinese authorities to conduct more targeted follow-up investigations and sampling efforts in these regions to better understand these elements.

Further information on the supply chain of pre-blended polyols will also be critical to understanding and addressing this issue. Given the volume of trade in polyols from China, it is clear that there is a possibility that CFC-containing pre-blended polyols have been imported by other Montreal Protocol Parties.

It is also vital to further examine the potential unregulated sources of CTC emissions with a view to increasing the understanding of those emissions and their potential linkages to unaccounted CFC-11 emissions. EIA encourages China and other Parties to further explore ways in which CTC production and sales can be better monitored.

EIA supports the additional information on illegal trade requested by the Task Force but urges that consideration of illegal shipments of CFC-12 is also included. Information on suppliers of CFC-12 can help identify the market drivers of the CFC-11/12 production as well as the actual illegal producers.

Finally, EIA notes that only China responded in a limited way to the request in paragraph 3 of Decision XXX/3 to provide relevant data to the TEAP. EIA cautions Parties not to treat the issue of CFC-11 emissions as an isolated enforcement issue limited to one Party. All Parties should report any illegal trade involving CFCs, and Parties importing pre-blended polyols from China should undertake testing to ensure they do not contain CFC-11.

**Top:** illegal CFCs seen in Chinese foam company in 2018

**Below:** image taken in 2018 in China of raw material used to produce blowing agent





**Above:** Very little has been done thus far to improve management and disposal of banks

## Managing and destroying ODS and HFC banks

The potential mitigation from preventing emissions of ODS and HFC banks has been estimated at 89.7-96.5 Gigatonnes CO<sub>2</sub> equivalent (GtCO<sub>2</sub>e) between 2020-50, similar to the expected impact of the HFC phase-down.<sup>19</sup> The size of current recoverable ODS and HFC banks in 2019 is estimated to be about 12GtCO<sub>2</sub>e.<sup>20</sup> This may be an underestimate as illustrated by the recent discovery of illegal CFC emissions and use. Based on the example of moulded foam calculated by TEAP, a new CFC-11 foam bank of more than 820 million tCO<sub>2</sub>e could have been created over six years between 2012-18.<sup>21</sup> Addressing ODS and HFC banks represents a massive but time limited opportunity to increase the climate benefits of the Montreal Protocol, consistent with a 1.5°C warming scenario.<sup>22</sup> Substantial HFC banks are expected to persist after completion of the HFC phase-down.

Very little has been done thus far to improve management and disposal of banks. In response to Decision XX/7, TEAP produced several reports on the potential benefits and costs of ODS management and disposal and a small number of pilot projects on ODS disposal were implemented with funding from the Multilateral Fund.<sup>23</sup> A recent synthesis report by the MLF Secretariat on these projects shows considerable variation in results and a wide range of cost-effectiveness related to project design and existing national regulations.<sup>24</sup> The outcomes of some projects, including lower than expected destruction rates, and therefore lower cost-effectiveness, were observed

to be related inter alia to incorrect assumptions of functioning ODS waste collection and storage systems in the countries. The synthesis report noted that existing strong national regulations that mandated ODS and other waste collection efforts and standards such as extended producer responsibility (EPR) schemes or waste electrical and electronic equipment (WEEE) recycling management programmes facilitated implementation of the projects. Lessons from the pilot demonstration projects should be translated into a more comprehensive approach focused on increasing sustainable recovery and collection of banks, as well as disposal.

Decision XXVIII/2 requests the ExCom to develop new guidelines on methodologies and cost calculations on both “[r]ecycling and recovery of hydrofluorocarbons” as well as “the cost-effective management of stockpiles of used or unwanted controlled substances, including destruction.”<sup>25</sup> As an immediate next step, Parties should request that TEAP undertake a comprehensive evaluation of the costs, mitigation benefits and approaches to comprehensive management of ODS and HFC banks, including recovery, reclamation and disposal. The evaluation should include a review of national legislation and best management practices in countries with high recovery and destruction rates, such as EPR including deposit-refund schemes, take-back obligations, technician training and awareness programs and bans on non-refillable cylinders.



# 2018 and future quadrennial assessment reports

EIA offers the following comments and recommendations related to the Scientific Assessment of Ozone Depletion (2018) and the 2018 Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee (RTOC) Quadrennial Assessment Report and subjects for the next quadrennial assessment.

## 1. Additional Montreal Protocol controls can have a significant climate impact

The Montreal Protocol is working: the Antarctic ozone hole is recovering and ODS controls have contributed to avoiding additional global warming to the extent that several centimetres of future global sea level rise have been avoided.<sup>26</sup>

In the baseline scenario, assuming compliance with the Kigali Amendment, projected cumulative HFC emissions from 2020-60 are approximately 60 GtCO<sub>2</sub>e (about half of those that would result in a scenario without HFC controls). The SAP assessment estimates that a faster phase-down, through elimination of high-GWP HFC production from 2020 onwards, could avoid an additional 53 GtCO<sub>2</sub>e during 2020-2060 (see Fig 1).

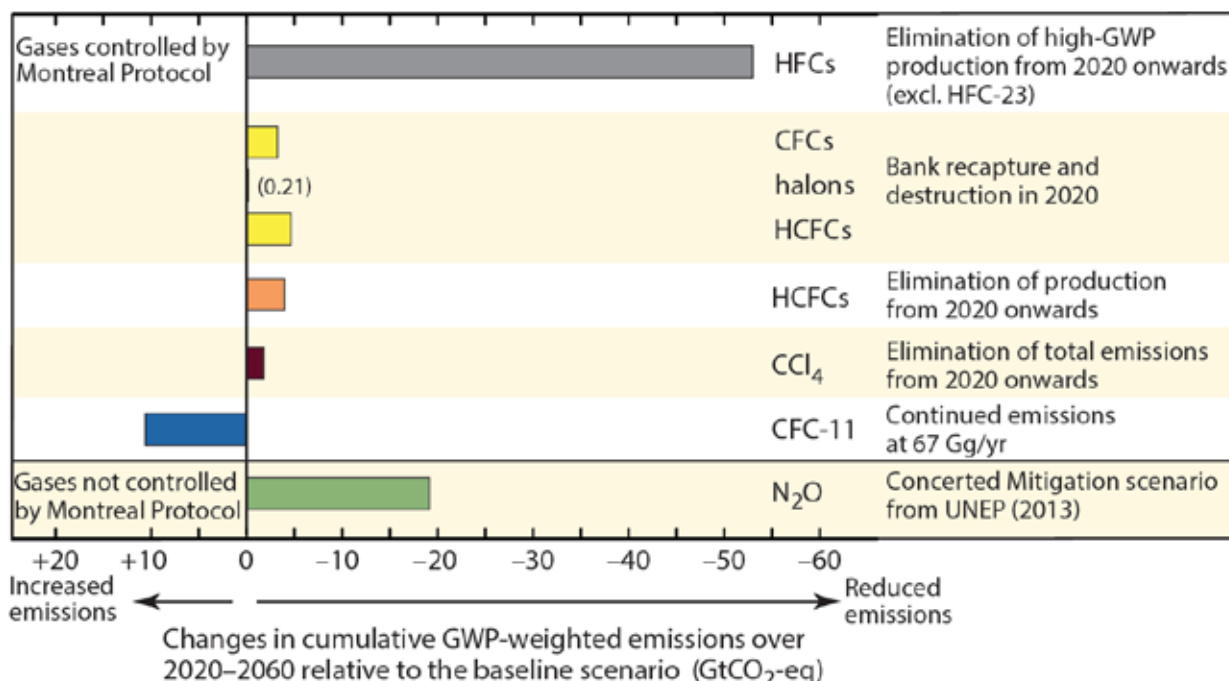
However, it is not clear in the SAP assessment what GWP level is indicated by 'high-GWP'. In fact, it seems that the terms high-GWP, medium GWP, lower GWP, low-GWP and very low-GWP are used without any clear definitions, and sometimes interchangeably. For example, the report states that "some HFCs such as HFC-23 (GWP = 12,400), HFC-143a (GWP = 3,170), and HFC-125 (GWP = 4,800), and to a lesser extent

HFC-134a (GWP = 1,300), have high GWPs"<sup>27</sup> but also refers to "Low-GWP refrigerant blends of HFC/HFO/hydrochlorofluoroolefins (such as R-448A, R-449A, R-449B, R-450A, and R-513A)".<sup>28</sup> The latter 'low-GWP' HFO blends R-448A, R-449A and R-449B have GWPs ranging between 1,370 and 1,390, higher than the 'high-GWP' HFC-134a, which has a GWP of 1,300. EIA recommends that all GWP levels are clearly annotated in all reports and assessments.

**EIA recommends** that the TEAP and SAP jointly analyse a set of ambitious fast-action scenarios in order to inform the Parties on the potential for capturing additional climate mitigation from a strengthening of the Kigali Amendment. These should not only include various adjustment scenarios but also novel targeted measures, such as a global high-GWP HFC ban.

The SAP report also highlights the inadequacy of current reporting of HFC consumption, production and emissions, something that needs to be swiftly rectified. For example, total global emissions derived for HFC-134a from atmospheric observations are over two times larger than total emissions reported to UNFCCC from Annex 1 countries, and this emission gap has become larger over time,<sup>30</sup> likely reflecting increasing use in developing countries and the need for immediate reporting by all countries.<sup>31</sup> The recent CFC-11 crisis has underscored the importance of strong reporting and monitoring in order to enable early warnings of unexpected emissions; without strong top down and bottom up data it will be impossible to determine future non-compliance.

Fig 1: Change in GWP-Weighted Emissions in Response to Alternative Scenarios<sup>29</sup>





Above: some groundwater samples are already showing higher than permitted TFA levels

## 2: Review the use of the 20-year GWP and how it relates to the need for climate action in the coming decades

The RTOC 2018 assessment report provides both 20-year GWP and 100-year GWP values for refrigerants, noting that an “advantage of the 20 year GWP over the 100 year GWP is that a 20-year time horizon is more relevant when discussing global warming over the next decades; it is also better for differentiating between substances with short lifetimes.”<sup>32</sup> The average lifetime of HFCs in use today is 21.7 years, therefore most HFCs in use have lifespans more appropriate to a 20-year time frame.<sup>33</sup> The SAP report provides revised lifetimes for gases and states that HFC lifetimes may change towards 2100 due to changes in temperatures and hydroxyl radical (OH) abundances. Most models show a decrease in lifetime by 5–10 per cent in 2100 relative to 2000.<sup>34</sup>

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) issued a Special Report on Global Warming of 1.5°C in which the co-chair observed that “[e]very extra bit of warming matters, especially since warming of 1.5°C or higher increases the risk associated with long-lasting or irreversible changes.”<sup>35</sup> Given increased recognition of the pivotal role short-term warming will have on the future climate system and increased scientific understanding of climate-

tipping points – positive feedback processes which further exacerbate warming – EIA believes that now is an important time for the Montreal Protocol to consider using the 20-year GWP in addition to the 100-year GWP.

## 3: Improving sustainability of refrigeration

Cooling lies at the nexus of the Montreal Protocol controls, the Paris Agreement and the Sustainable Development Goals (SDGs). Cooling is essential for food, vaccines, comfort, productivity, data centres, hospitals and much more; however, the growth in cooling demand is a significant threat to the climate and the world’s power grids.

With the recognition in Decision XXVIII/2 that the Montreal Protocol will address energy efficiency during the HFC phase-down, it is vital that Parties have access to clear information to assist in making the right policy and implementation decisions. EIA therefore welcomes the broader holistic look at energy efficiency and sustainability as applied to refrigeration systems in the 2018 RTOC assessment and recommends it is revisited in the next assessment. A number of important issues are raised in the 2018 assessment:

### (a) The need to understand TFA and other HFC and HFO breakdown products and by-products

The RTOC assessment highlights our inadequate knowledge of trifluoroacetic acid (TFA) pollution impacts and calls for more in-depth research. TFA is a degradation product of some HFCs and HFOs and is also produced in nature; however, sources are not well understood. It is a persistent toxic pollutant and accumulates in the hydrosphere.<sup>36</sup>

HFO-1234yf yields five times more TFA than equivalent quantities of HFC-134a and given its shorter atmospheric lifetime, its TFA emissions are deposited near the point of emissions.<sup>37</sup> EIA is therefore concerned at the potential impact of TFA degradation, given the predicted widespread use of HFO-1234yf in the mobile air-conditioning and other sectors.

The SAP assessment states that: “There is increased confidence that trifluoroacetic acid (TFA) produced from degradation of HFCs, HCFCs, and HFOs will not harm the environment over the next few decades.”<sup>38</sup> It also acknowledges “[p]otential impacts beyond a few decades of this TFA source could require future evaluation due to the environmental persistence of TFA and uncertainty in future emissions of HFC-1234yf and other HFCs that produce TFA upon degradation.”<sup>39</sup>

In contrast, the 2018 RTOC assessment raises a number of more immediate concerns:

- TFA is produced as a degradation product from other industrial processes and there are unknown sources and pathways<sup>40</sup>
- A significant increase of TFA levels in rainfall on glaciers and in ground and drinking water has been measured and some groundwater samples are already showing higher than permitted TFA levels

- HFO emissions relevant for TFA formation are estimated to reach 90,000 tonnes by 2030
- Despite a large number of studies, adequate knowledge of HFO decomposition to TFA and TFA pollution is lacking.

RTOC therefore concludes that the high rate of TFA from a number of HFOs, especially HFO-1234yf, is a critical issue and “may be of considerable environmental relevance in view of the expected future HFO production expansion.”<sup>41</sup> EIA agrees with RTOC that there is an urgent need to clarify whether TFA limits in basic and drinking water could be exceeded from the accumulation of all chemicals that result in TFA production.”<sup>42</sup>

EIA also notes that the SAP assessment refers to emissions of the compounds HCFC-133a and HCFC-31 in atmospheric measurements, for which no current intentional use is known.<sup>43</sup> Research to date suggests that these gases are unintentional by-products of HFC-32, HFC-134a, and HFC-125 production. Most medium-GWP and lower-GWP HFC blends contain HFC-32 and often HFC-125,<sup>44</sup> while HFC-32 is increasingly being used in air-conditioning to replace HCFC-22 and HFC-410A. EIA recommends a full examination of the unintentional by-products and atmospheric degradation compounds of all new and commonly used refrigerants and their impact under various scenarios to ensure that their use is not creating an additional environmental problem.

#### **(b): Sustainability in the servicing sector**

The RTOC calls on the need to enhance servicing activities, including refrigerant recovery, recycling and reclamation techniques in order to ensure the sector is ready to handle flammable refrigerants, including those classified as A2L. For example, venting of small charges of hydrocarbons may be legal due to minimal environmental impacts, however RTOC warns of the dangers of venting flammable HFC-based refrigerants given that “hydrogen fluoride and other chemicals that are all highly toxic, will be produced when HFC, HCFC, CFC and HFO refrigerants burn or decompose, even at temperatures below ignition temperature.”<sup>45</sup>

The phase-in of flammable refrigerants is already well under way in both Article-5 and non-Article 5 countries. There is an urgent need for investment in the servicing sector to ensure they are handled correctly. In addition, RTOC calls for a revision in the way safety standards for flammable refrigerants are developed, calling for an “Improved understanding of the actual risks of refrigeration systems based on common principles (e.g. IEC 60079-series) rather than being based on the chemical nature of a refrigerant (e.g. ASHRAE refrigerant classification, ISO 817).”<sup>46</sup>

#### **4: Illegal trade/counterfeiting in HFO-1234yf in the MAC sector.**

RTOC highlights the history of illegal trade in the mobile air-conditioning sector during the move away from CFCs to HFC-134a and how the increased cost of HFC-134a compared to CFCs lead to a surge

in counterfeit HFC-134a. The counterfeit HFC-134a was found to contain CFCs and toxic and flammable components which pose serious treats to the environment and human safety when used.

As EIA has warned previously, the RTOC report notes that the large price differential between HFC-134a and the replacement HFO-1234yf being phased in in some parts of the world may lead to even more significant problems for illegal trade and counterfeiting. HFC-134a can be purchased for around \$11/kg whereas HFO-1234yf costs approximately 8-9 times more than this.<sup>47</sup>

Europe is already witnessing significant illegal HFC use in the mobile air-conditioning sector, as the F-Gas Regulation is rapidly cutting HFC use and raising prices.<sup>48</sup> Unless strong measures are taken to improve enforcement and close regulatory loopholes, the shift to HFO-1234yf will undoubtedly result in widespread counterfeiting with significant environmental and human safety impacts.

#### **Below: HVACR servicing and maintenance**



# Updates on safety standards key to implementation of Kigali Amendment

Decisions XXVIII/2 and XXVIII/4 recognised timely updates to safety standards as critical to enabling market uptake of low- and zero-GWP refrigerants and leap-frogging HFCs.<sup>49</sup> The Ozone Secretariat has introduced a new interactive website to help Parties keep track of key safety standards.<sup>50</sup> While there is progress in a key refrigeration standard, there remains an urgent need to update standards for air conditioning equipment to limit the uptake of medium-GWP transitional substances.

A significant breakthrough was reached with the recent final approval of an update to IEC 60335-2-89 which has now been published.<sup>51</sup> The updated standard, Edition 3, will allow for increased charge sizes of flammable low-GWP refrigerants in stand-alone commercial refrigeration equipment such as display cases, self-service counters and walk-in freezers. The charge limit increase from 150-500g of A3 refrigerant will enable more widespread uptake of energy efficient low-GWP hydrocarbons across the commercial refrigeration sector. Under the updated standard, equipment using more than 150g of flammable refrigerant must comply with certain safety tests to ensure any risks are mitigated. In countries following a corresponding

national or regional standard, or that have adopted a previous version of the IEC standard into national law, the provisions of the updated IEC standard will need to be adopted nationally. Parties should actively engage with their respective national and regional standards bodies to ensure that the IEC 60335-2-89 Edition 3 update is taken up for consideration as a priority.

Updates are still needed for air conditioning and heat pump equipment under IEC 60335-2-40. While the standard has been amended to allow increased charge limits of A2L refrigerants, further updates to IEC 60335-2-40 would allow A5 countries to bypass medium-GWP refrigerants directly for more efficient low-GWP hydrocarbons in the room air conditioning sector. Work is ongoing to update IEC 60335-2-40 with a formal proposal, or "Committee Draft for Vote" (CDV). The CDV is anticipated by the end of 2019 and may result in publication of a new edition of the standard by 2021, provided it is approved in two rounds of voting. Active support and engagement by Parties, particularly from member countries in IEC SC61D<sup>52</sup> will be critical to enabling effective implementation of the accelerated HCFC phase-out and the Kigali Amendment.

**Below:** commercial refrigeration system using hydrocarbons



# Energy efficiency

Three years after the adoption of the Kigali Amendment, it is time to take stock of the progress made and consider what additional actions could be taken by the Parties at the upcoming MoP31 in Rome to implement decisions taken on energy efficiency. The Parties should also consider advancing the energy efficiency agenda in ways responsive to the urgency of the climate crisis.

To date, the Parties have adopted several decisions on energy efficiency with directives to the Ozone Secretariat, TEAP and ExCom, summarised in Table 2. The Parties continue to deliberate on how to promote energy efficiency under the Montreal Protocol, with particular focus on the development of cost guidelines under paragraphs 16 and 22 of Decision XXVIII/2.

**Table 2:** Summary of decisions on energy efficiency taken by the Parties

Decision	Summary	Progress
<b>Ozone Secretariat</b>		
<b>Decision XXIX/10</b>	<b>Paragraph 4:</b> Ozone Secretariat to organise a workshop at OEWG-40	<b>Completed</b>
<b>Technology and Economic Assessment Panel (TEAP)</b>		
<b>Decision XXVIII/3</b>	<b>Paragraph 1:</b> TEAP to review energy efficiency opportunities in the RACHP sectors	<b>Completed</b>
	<b>Paragraph 3:</b> TEAP to prepare a report on energy efficiency for MoP29, including information from the Parties	
<b>Decision XXIX/10</b>	<b>Paragraph 1:</b> TEAP to assess several specific energy-efficiency aspects including technology options, capacity-building and servicing-sector requirements and related costs	<b>Completed</b>
	<b>Paragraph 2:</b> TEAP to review inter alia activities and funding provided by other institutions and financing modalities	
	<b>Paragraph 3:</b> TEAP to prepare a report on energy efficiency for MoP30	
<b>Decision XXX/5</b>	<b>Paragraph 3:</b> TEAP to prepare a report on the cost and availability of low-GWP technologies and equipment that maintains or enhances energy efficiency for MoP31	<b>Advance copy submitted to OEWG 41</b> <sup>53</sup>
<b>Executive Committee of the Multilateral Fund (ExCom)</b>		
<b>Decision XVIII/2</b>	<b>Paragraph 16:</b> ExCom to increase servicing sector funding under ExCom Decision 74/50 (i.e. for the HCFC phase-out) when needed for maintaining energy efficiency in the servicing/end-user sector	<b>Ongoing</b>
	<b>Paragraph 22:</b> ExCom to develop cost guidance associated with maintaining and/or enhancing the energy efficiency of low-GWP or zero-GWP replacement technologies and equipment, when phasing down HFCs, taking note of the role of other institutions addressing energy efficiency, where appropriate.	
<b>Decision XXX/5</b>	<b>Paragraph 1:</b> ExCom to consider flexibility of enabling-activity financial support for energy-efficiency policy and training	<b>Ongoing</b>
	<b>Paragraph 2:</b> ExCom to consider increasing servicing sector funding to LVC countries for the HCFC phase-out to assist with energy-efficiency policy and training (i.e. para 16 Dec VIII/2)	
	<b>Paragraph 5:</b> ExCom requested to review servicing projects to identify best practices, lessons learned and opportunities	
	<b>Paragraph 6:</b> ExCom requested to take account of information provided by HFC demonstration and stand-alone projects in order to develop energy efficiency cost guidance	
	<b>Paragraph 7:</b> ExCom, in dialogue with the Ozone Secretariat, requested to liaise with other funds and financial institutions to explore mobilizing additional resources and set up modalities for cooperation, as appropriate	

The activities undertaken by the Ozone Secretariat and TEAP have provided the Parties with greater awareness and information on energy-efficiency issues and considerations, most recently in the advance version of the TEAP Task Force's Report on Cost and Availability of Low-GWP Technologies/Equipment that Maintain/Enhance Energy Efficiency. So far, however, the Parties have not taken concrete action at the Montreal Protocol level to advance the energy-efficiency agenda, beyond using this information to inform further requests to ExCom under Decision XXX/5.

For its part, ExCom continues deliberations on how to implement paragraphs 16 and 22 of Decision XXVIII/2, with the former further along than the latter. With respect to paragraph 16, ExCom will consider a draft decision at its next meeting to increase funding for future HCFC phase-out management plans (HPMPs) in LVC countries to undertake additional activities, including pilot projects, training-material updates, cooling sector emission-reduction strategies, certification scheme development and awareness and outreach programmes. With respect to paragraph 22, ExCom has struggled with implementing this paragraph, in part due to the scope of potential measures, departure from historical MLF practice and the funding implications, as well as the roles of other national authorities and institutions in this space. In some limited instances, ExCom has also initiated processes to generate certain cost information.<sup>54</sup> In light of this, the Parties should consider whether additional direction to ExCom is required to facilitate the development of cost guidelines under paragraph 22, for example:

### External Funding.

ExCom remains undecided on whether MLF should accept external funding.<sup>55</sup> This indecision seems at odds with the underlying assumption behind paragraph 7 of Decision XXX/5, which requests the ExCom, in dialogue with the Ozone Secretariat, to liaise with other funds and financial institutions to explore mobilizing additional resources and, as appropriate, set up modalities for cooperation, such as co-funding arrangements. Maximising the energy efficiency co-benefits of the Kigali Amendment will require external funding and this issue should be progressed without further delay. The Parties could consider directing ExCom to accept external funding, in principle, and to establish modalities for receiving it by a certain timeframe.

### Avoidable Technology Upgrades.

ExCom remains undecided on whether avoidable technology upgrades enhancing energy efficiency should be eligible for funding. Under historical MLF practice, avoidable technology upgrades (those not strictly required for compliance with control measures) are not eligible for financial support from MLF, which precludes some of the most important energy efficiency-related technology improvements in the manufacturing sector.<sup>56</sup> The Parties could consider directing ExCom to adopt a cost-effectiveness threshold in carbon-dioxide equivalence (CO<sub>2</sub>e) under which avoidable technology upgrades enhancing energy efficiency would become eligible under paragraph 22 of Decision XXVIII/2.

In tandem with these ExCom-focused actions, the Parties should consider what additional concrete actions could be taken at the Montreal Protocol level to promote energy efficiency with other relevant venues. For example, over the next four years, the United Nations Framework Convention on Climate Change (UNFCCC) presents a series of opportunities to advance energy-efficient low-GWP cooling practices worldwide. As Parties to the Paris Agreement begin to revise and potentially strengthen their nationally determined contributions (NDCs), it will be critical for them to include initiatives related to the cooling sector, including phasing down HFCs and maximising the energy efficiency of appliances:

- In 2019-20, Parties submit new or updated Nationally Determined Contributions (NDCs) for the first time since adoption of the Paris Agreement, allowing alignment with actions undertaken subsequently in related venues, including the Kigali Amendment
- In 2023, the UNFCCC will undertake a Global Stocktake to assess the collective progress towards achieving the long-term goals of the Paris Agreement, with significant implications on the design of the next round of NDC submissions in 2024-25, coinciding with the first two years of the HFC phase-down under the Kigali Amendment for most A5 Parties.<sup>57</sup>

The UNFCCC continues to offer opportunities to raise awareness about issues important to the Montreal Protocol and to help place sustainable coordinated strategies in the cooling sector squarely among the top climate priorities of Parties to the Paris Agreement. The Ozone Secretariat could be tasked with creating a joint Montreal Protocol-UNFCCC working group to promote synergies and secure policies in future NDC submissions as it relates to sustainable strategies in the cooling sector.

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