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Open-ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer
Forty-fourth meeting
Bangkok, 11–16 July 2022
Items 4, 6, and 8 (a) of the provisional agenda*

Issues for discussion by and information for the attention of the Open-ended Working Group of the Parties to the Montreal Protocol at its forty-fourth meeting

Note by the Secretariat

Addendum

I. Introduction

1. The present addendum to the note by the Secretariat on issues for discussion by and information for the attention of the Open-ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer at its forty-fourth meeting (UNEP/OzL.Pro.WG.1/44/2) contains information that has become available since the preparation of that note. Section II of the addendum sets out a progress report by the Ozone Secretariat on the identification of gaps in the global coverage of atmospheric monitoring of controlled substances and options for enhancing such monitoring in relation to agenda item 4, and new information provided by the Technology and Economic Assessment Panel in its 2022 report in relation to agenda items 6 and 8 (a).

2. Further information, expected to be provided by the Panel in relation to agenda items 8 (b)–(d) and 9 of the provisional agenda, will be included in a second addendum to the note by the Secretariat, along with any other issues of relevance for the parties' information.

3. The 2022 report of the Technology and Economic Assessment Panel consists of three volumes:[1]

(a) Volume 1: 2022 progress report of the Technology and Economic Assessment Panel;

(b) Volume 2: Interim report of the Methyl Bromide Technical Options Committee – Evaluation of 2022 critical-use nominations for methyl bromide and related issues;

(c) Volume 3: Decision XXXIII/5 task force report – Continued provision of information on energy-efficient and low-global-warming-potential technologies.

* UNEP/OzL.Pro.WG.1/44/1.

[1] Available on the Ozone Secretariat meeting portal for the forty-fourth meeting of the Open-ended Working Group at https://ozone.unep.org/meetings/44th-meeting-open-ended-working-group-parties/pre-session-documents.

II. Summary of issues for discussion by the Open-ended Working Group at its forty-fourth meeting

4. The issues covered in the present addendum are set out below in the order of the respective agenda items in the provisional agenda of the meeting.

Agenda item 4

Identification of gaps in the global coverage of atmospheric monitoring of controlled substances and options for enhancing such monitoring (decision XXXIII/4)

5. As is mentioned in the note by the Secretariat (UNEP/OzL.Pro.WG.1/44/2, paras. 13–16), in decision XXXIII/4, on enhancing the global and regional atmospheric monitoring of substances controlled under the Montreal Protocol, the Ozone Secretariat, in consultation with relevant experts from the Scientific Assessment Panel, the Technology and Economic Assessment Panel and the Ozone Research Managers, was requested to report to the parties at the forty-fourth meeting of the Open-ended Working Group on progress made on the issue, in particular on options for the regional monitoring of atmospheric concentrations of controlled substances and the challenges for operationalizing relevant recommendations; the identification of suitable locations for possible high-frequency measurements and flask sampling for regions with no or insufficient atmospheric monitoring coverage; and options for possible means of establishing new monitoring capacity and related costs, taking into account existing monitoring infrastructure. The progress made so far is summarized in the following paragraphs.

6. In 2021, the Ozone Secretariat, with support from the European Union, developed a pilot project entitled "Regional quantification of emissions of substances controlled under the Montreal Protocol".[2] The purpose of the project is to identify the regions where emissions are likely to occur, the locations of potential observation stations, the protocols for measurements and analyses that best provide the required information; to assess the capabilities of the locations and types of measurements for installing one or more stations; and to initiate new measurements at those stations. The implementation of the pilot project is managed by the Ozone Secretariat and overseen by a steering committee established in November 2021.

7. As a first step in the implementation of the pilot project, the steering committee, with support from the Ozone Secretariat, organized a three-hour virtual discussion forum on 16 March 2022 to share the latest information from the scientific community on the development of an improved monitoring network and discuss ideas with a wider audience including participants at the eleventh meeting of the Ozone Research Managers, experts in atmospheric monitoring and interested party representatives. Such a network could in the long-term identify and quantify emissions of substances controlled under the Montreal Protocol. A concept note including the agenda of the discussion forum was posted on the website of the World Climate Research Programme Stratosphere-Troposphere Processes and their Role in Climate.[3]

8. The discussion forum, attended by 159 participants from 29 different countries, focused on understanding emission sources, the future evolution of controlled substances and other compounds of importance to the Montreal Protocol, observational systems and techniques, and the siting and development of new stations to improve regional coverage. The main points that emerged during the discussion are summarized below:

(a) Assessing where emissions may occur in the coming decade is critical in the setup of new measurement sites. Four speakers provided diverse approaches to assessing emission regions:

(i) Economic modelling;

(ii) Trade data analyses;

(iii) Locations and capabilities for the manufacture of controlled substances;

[2] An outline of the pilot project is available on the Ozone Secretariat website at: https://ozone.unep.org/eu-funded-project-regional-quantification-emissions-substances-controlled-under-montreal-protocol.

[3] https://www.sparc-climate.org/wp-content/uploads/sites/5/2022/03/RegionalMonitoringVirtualDiscusson_Agenda_titlesabstracts_27Feb.pdf.

(iv) Use of nightlight satellite data with artificial intelligence to predict regional emissions. Past production and consumption, the evolution of banks, and the accuracy of bottom-up emission estimates were also considered to be crucial factors in determining emissions.

(b) The emissions from North America, large parts of Europe, and regions around Japan and the Korean peninsula are expected to continue. However, as monitoring in these areas is currently much better than in the rest of the world, focusing on regions with insufficient or no station coverage was deemed to be a good starting point for filling gaps in the atmospheric monitoring of controlled substances. Based on the information presented, it became clear that the focus for the establishment of new stations should be on the regions of southern Asia, including the Indian subcontinent; the Middle East, including Turkey; Mexico and nearby locations; eastern Europe and eastern Asia.

(c) Focusing on the above-mentioned regions, two speakers provided information on potential locations for monitoring, based on scientific analyses (Observing System Simulation Experiments, (OSSE)) for optimal emissions detection at a host of locations. Even though no locations were found to provide year-round optimal coverage for all the potential emission regions, some locations were found to provide such coverage for much of the year, including sites in Asia, the Middle East, and Europe.

(d) The best way to carry out measurements, i.e., by flask sample collection and analyses in one or two central analytical facilities or by installing automated high-frequency in-situ measuring instruments, was thoroughly discussed. Recognizing the need for high-frequency sampling in the long run, the participants were of the view that it would be helpful to start by using flask samples from a few identified locations for over a year to better assess the feasibility and efficacy of the selected measurement locations. Such an approach was also preferable in the light of funding constraints.

(e) Regarding standards and the metrology of the appropriate measurement systems, it became clear that having transferrable standard calibration scales and archiving data for analyses by a community of scientists would be important.

9. In terms of the approach to be followed to further the implementation of the pilot project, participants highlighted the importance of:

(a) The role of the Technology and Economic Assessment Panel in continuing and enhancing its crucial work on assessing emission sources;

(b) Starting the monitoring with flask sampling at one or more collection sites, and analysis of those flasks at one or two central established laboratories;

(c) Continuing to examine the suitability of proposed sampling locations using OSSEs;

(d) Using, in the near term, the standards already developed by the Advanced Global Atmospheric Gases Experiment (AGAGE) and National Oceanic and Atmospheric Administration (NOAA) networks, and encouraging a metrology institution to take on calibration scale establishment and maintenance for the longer term;

(e) Archiving data from the initial flask sampling sites to ensure their inclusion in global analyses and enable regional emission estimates;

(f) Working towards enhancing sampling sites and expanding sampling locations.

10. The first phase of the pilot project, involving the identification of suitable locations for carrying out measurements of controlled substances, is expected to be concluded soon. Enhancing capacity-building in parties operating under paragraph 1 of Article 5 (Article 5 parties) by including personnel from those countries in carrying out relevant parts of this work is also being considered. Updated information on the implementation of the project will be included in the Secretariat's report to the parties at the forty-fifth meeting of the Open-ended Working Group in 2023, as requested in decision XXXIII/4.

Agenda item 6

Energy-efficient and low-global-warming-potential technologies

(a) Report by the Technology and Economic Assessment Panel (decision XXXIII/5)

11. In response to decision XXXIII/5, the provisions of which are outlined in the note by the Secretariat (UNEP/OzL.Pro.WG.1/44/2, para. 21), the Technology and Economic Assessment Panel established a new task force to prepare a report on energy-efficient and low-global-warming-potential

(low-GWP) technologies and on measures to enhance and maintain energy efficiency during HFC transition in equipment for the consideration of parties at the current meeting. This is the fourth task force report on energy efficiency-related issues prepared by the Panel since the adoption of the Kigali Amendment in 2016.[4] It is set out in volume 3 of the 2022 Panel report and is available on the portal of the current meeting.[5]

12. While previous reports had restricted their scope to the domestic air conditioning and commercial self-contained refrigeration sectors, the Panel notes that the new task force includes members with the expertise required to address additional sectors (heat-pump, large commercial refrigeration, larger air-conditioning systems), installation and servicing, as well as assessing the integration of energy enhancements with hydrofluorocarbon (HFC) phase-down, as requested in decision XXXIII/5. It also notes that the report is intended as an update to previous reports with new information in additional refrigeration, air-conditioning and heat pump (RACHP) market sectors. To that end, the task force includes in its report an outline of some consistent key messages that had been provided in the 2018, 2019 and 2021 task force reports.

13. The report consists of seven chapters and five annexes providing specifications and further details on certain issues and case studies. The executive summary of the report presents the key messages of each chapter, including on the availability and costs of low-GWP and medium-GWP technologies and equipment that maintain or enhance energy efficiency; a short-term road map for the adoption of energy-efficient technologies while phasing down HFCs; options to maintain and enhance energy efficiency through best practices in installation, servicing, maintenance, refurbishment and repair; and information on how the benefits of integrating energy efficiency enhancements with the HFC phase down can be assessed. It is included in the annex to the present addendum as received by the Secretariat, without formal editing.

14. The task force report is also available in the online forum to enable parties, should they wish to do so, to submit comments and questions about the report prior to the meeting in order to facilitate adequate preparation by the Panel and its task force of responses to be provided during the discussion of the report at the meeting.

15. The Open-ended Working Group may wish to discuss the task force report and make any recommendations on the way forward.

Agenda item 8

Technology and Economic Assessment Panel 2022 report and related issues

16. Under this agenda item, the parties will consider information provided by the Technology and Economic Assessment Panel in volumes 1 and 2 of its 2022 report. The Panel's progress report (volume 1) is expected to include progress reports by its technical options committees, updates on the Panel's response to decision XXX/7 on future availability of halons and their alternatives, and other matters, including membership.

17. The interim report of the Methyl Bromide Technical Options Committee (volume 2), available on the meeting portal,[6] provides information on the evaluation of critical-use nominations for methyl bromide for 2022 and related issues. A summary of the Committee's evaluation is set out in the following paragraphs.

(a) Nominations for critical-use exemptions for methyl bromide for 2023 and 2024

18. As is indicated in the note by the Secretariat (UNEP/OzL.Pro.WG.1/44/2, paras. 34–35), the Methyl Bromide Technical Options Committee evaluated a total of three nominations for critical-use exemptions that were submitted in 2022. One Article 5 party, South Africa, submitted one nomination for 2023, and two parties not so operating (non-Article 5 parties), Australia and Canada, submitted one nomination each, for 2024 and 2023, respectively.

19. Another Article 5 party which has nominated critical-use exemptions in recent years, Argentina, has advised the Committee that it will not put forward any nominations in 2022.

[4] After an initial scoping report prepared by an internal working group of the Panel in 2017 in response to decision XXVIII/3, three task force reports were presented to the parties in 2018, 2019 and 2020/2021 in response to decisions XXIX/10, XXX/5 and XXXI/7, respectively.

[5] https://ozone.unep.org/system/files/documents/TEAP-EETF-report-may-2022.pdf.

[6] https://ozone.unep.org/system/files/documents/TEAP-CUN-interim-report-may-2022.pdf.

20. The total amount of methyl bromide nominated for 2023 and 2024 by the three parties mentioned above is 39.507 metric tons, representing a 26 per cent increase from the total amount requested by three parties in 2021. After reviewing the nominations, the Committee made an interim recommendation for only one of those nominations as it was unable to assess the other two pending the availability of further information. The table below presents a summary of the nominations of the parties and the interim recommendations by the Committee, with brief comments in the footnotes to the table where the recommendations differ from the amounts nominated.

Summary of the nominations for 2023 and 2024 critical-use exemptions for methyl bromide submitted in 2022 and the interim recommendations of the Methyl Bromide Technical Options Committee

(Metric tons)

Party	*Nomination for 2023*	*Interim recommendation for 2023*	*Nomination for 2024*	*Interim recommendation for 2024*
Non-Article 5 parties and sectors				
1. Australia				
Strawberry runners			14.49	Unable to assess[a]
2. Canada				
Strawberry runners	5.017	Unable to assess[b]		
Subtotal	**5.017**	**Pending**	**14.49**	**Pending**
Article 5 parties and sectors				
3. South Africa				
Structures	20.00	[19.00][c]		
Subtotal	**20.00**	**[19.00]**		
Total	**25.017**	**Pending**	**14.49**	**Pending**

[a] The Methyl Bromide Technical Options Committee is unable to assess the nominated amount at this stage. According to the party, the registration authority requested additional data to assess methyl iodide (MI), as an alternative to methyl bromide, and this resulted in a delay in the date for a decision on its registration from 17 January 2022 to 17 July 2022. Given the contingent nature of this use and the fact that the party has put forward a transition plan for phasing out methyl bromide, the Committee finds it reasonable to wait until after July 2022 to assess the nomination.

[b] The Methyl Bromide Technical Options Committee is unable to assess the nominated amount at this stage. However, it will be able to do so in its final 2022 assessment upon receipt of an updated national management strategy with timelines for the complete phase-out of methyl bromide.

[c] The nominated amount covers the fumigation of residential houses and industrial premises for the control of wood-destroying insect pests. The recommended amount represents a 5 per cent reduction from the nominated amount for 2023, as the Methyl Bromide Technical Options Committee considers that alternatives are available for 1 metric ton of the nomination that is therefore not recommended.

21. In addition to the interim recommendations on parties' critical-use nominations, the report of the Methyl Bromide Technical Options Committee recalls the reporting requirements under relevant decisions and includes information on trends in methyl bromide critical-use nominations and exemptions for all nominating parties to date, as well as on the reported accounting frameworks for critical uses and stocks of methyl bromide, and on the submission of national management strategies for the phase-out of critical uses of methyl bromide.

22. Based on the accounting framework information received from the nominating parties in 2022, at the end of 2021 Australia and Canada reported no available stocks, while South Africa reported the availability of 6.1 tons.

23. The Committee reiterates that the accounting information does not show accurately the total stocks of methyl bromide held globally for controlled uses by Article 5 parties, as some parties have no formal mechanism to account accurately either for such stocks or for stocks used in quarantine and pre-shipment applications, and there is no requirement for parties under the Montreal Protocol to report pre-2015 stocks. According to the Committee, such stocks may be substantial (approximately 1,200 metric tons).

24. Recent decisions[7] have reiterated that Article 5 parties requesting critical-use exemptions are required to submit their national management strategies for the phase-out of critical uses of methyl bromide in accordance with paragraph 3 of decision Ex.I/4. The Committee reports that in this round

[7] Decisions XXXI/4, XXXII/3 and XXXIII/6.

of nominations no detailed management plan was received from South Africa, but notes the continued progress made by the party in reducing its nominated amounts and its intention to phase out methyl bromide use by 2024.

25. The nominating parties and the Methyl Bromide Technical Options Committee are expected to hold further bilateral discussions on the interim recommendations and additional information that may be provided to the Committee for its final evaluation and recommendations. The final report of the Committee will be available prior to the Thirty-Fourth Meeting of the Parties.

26. The interim report of the Methyl Bromide Technical Options Committee is also available in the online forum to enable parties to submit comments and questions about the report prior to the meeting.

27. The Open-ended Working Group may wish to consider the report and interim recommendations of the Methyl Bromide Technical Options Committee.

Annex*

Report by the Technology and Economic Assessment Panel (May 2022) Volume 3

Decision XXXIII/5 – Continued provision of information on energy-efficient and low-global-warming-potential technologies

Executive Summary

Under **Decision XXXIII/5 on "Continued provision of information on energy efficient and low-global-warming-potential technologies",** parties requested the Technology and Economic Assessment Panel to prepare a report on energy efficient and lower- global- warming- potential technologies and on measures to enhance and maintain energy efficiency during hydrofluorocarbon transition in equipment for consideration by the Open-ended- Working Group at its forty-fourth meeting. Parties requested TEAP in the report to:

(a) Update information in the decision XXXI/7 report where relevant, and address additional subsectors not previously covered such as the heat-pump, large commercial refrigeration and larger air-conditioning system sub-sectors;

(b) Assess potential cost savings associated with adoption of lower global warming potential energy efficient technologies in each sector, including for manufacturers and consumers;

(c) Identify sectors where actions could be taken in the short term to adopt energy efficient technologies while phasing down hydrofluorocarbons;

(d) Identify options to enhance and maintain energy efficiency in equipment through deploying best practices during installation, servicing, maintenance, refurbishment or repair;

(e) Provide detailed information on how the benefits of integrating energy efficiency enhancements with the hydrofluorocarbon phase-down measures can be assessed.

Key Messages from each Chapter

Chapter 1: Introduction: Context of the Report

- The urgency of the need to mitigate global warming has been emphasised in 2021 and 2022 by both The Intergovernmental Panel on Climate Change (IPCC) and the COP-26 meeting. IPCC Working Group II highlighted vulnerability and limits to adaptation, while Working Groups I III showed the need to make strong and sustained emissions reductions immediately to limit global warming.
- The phaseout of ozone depleting substances through the Montreal Protocol has already avoided 1.1 degrees of warming over the Arctic by 2021, and projected to be 3-4 degrees by 2050, equivalent to ~25% of the mitigation of global warming
- Future HFC Phasedown through implementation of the Kigali Amendment can further mitigate global warming by 0.3 to 0.5 degrees. Synchronous improvements in energy efficiency of Refrigeration Air Conditioning and Heat Pump (RACHP) equipment could double this climate benefit.
- The major HFC use worldwide is in the RACHP sector. Most of this HFC use is for comfort cooling and heating and the remainder is for refrigeration, although the proportion varies by country and region. A large proportion of RACHP GHG emissions are related to the energy used. The ratio of "indirect" energy-related emissions to "direct" refrigerant emissions varies between countries depending on factors such as the carbon intensity of power generation, the leakage rate from different RACHP applications, and the GWP of the refrigerants used.
- Continued use of high GWP HFCs will result in an accumulation of a large stock of high GWP HFCs in RACHP equipment in A5 parties. This increasing stock of equipment containing high GWP HFCs has the potential to delay by 20-30 years (the lifetime of RACHP equipment in developing countries) the climate benefits through reduced direct emissions. In addition, if the

* The annex is reproduced without formal editing.

high GWP HFCs were contained within inefficient RACHP equipment, this would create excess energy demand (indirect emissions) over the same period.

- In all sectors it is now possible to significantly enhance energy efficiency. The overall energy benefits from HFC phasedown depend on the RACHP application, sector and the HFC alternatives used. Incentives would encourage and support transition in the RACHP sector and enhanced energy efficiency benefits would be realised. There is excellent potential to synchronise the reduction in energy-related emissions with the phasing down the use and emissions of HFCs, for example by integrating with energy efficiency standards and labelling policy.

Chapter 2 "Availability of Low and Medium GWP Technologies and Equipment that Maintain or Enhance Energy Efficiency"

- RACHP equipment using low and medium GWP refrigerants with enhanced energy efficiency, is now available in all the sectors defined in this report, but not necessarily accessible in all countries. Technology developments are proceeding at pace. Early action through the Kigali Implementation Plans can enable their transition to this new generation of RACHP equipment.
- Country-specific incremental improvements in energy efficiency are being driven by MEPS, developed with the consideration of seasonal, full, and part load performances. Such MEPS are either being adopted or progressively enhanced. Technologies including variable speed drives (for compressors and fans), brushless DC motors, and electronic expansion valves are used to achieve seasonal performance requirements.
- Heat pumps are available with low and medium GWP refrigerants with energy efficiency measures implemented for the refrigeration cycle, the selection of ancillary components, and the integration of heat pumps with the building controls.
- Large commercial refrigeration equipment operates throughout the year which compels the need for higher efficiency to reduce energy costs. This is measured by the annual power consumption, which can be reduced by considering component selection and evaporative condensers.
- In larger AC systems, safety considerations limit the application of flammable refrigerants. However, large AC systems of all capacity ranges are available with low and medium GWP refrigerants with comparable efficiencies to the baseline high GWP refrigerants which can be further optimised for higher efficiency. Compressors designed to work with a range of refrigerants including baseline refrigerants as well as low and medium GWP refrigerants are now available.
- Not-In-Kind (NIK) technologies that do not utilise mechanical vapour compression can offer lower operational lifetime costs (OLC) than in-kind systems, in some circumstances. Some examples of NIK technologies include solar energy driven absorption systems, hybrid evaporative cooling and deep-sea cooling are some examples of these NIK technologies.

Chapter 3 "Cost of Equipment Using Low and Medium GWP Refrigerants whilst Maintaining or Enhancing Energy Efficiency"

- There is a wide range of RACHP equipment and a diversity of refrigerant options (low and medium GWP), which makes it necessary to evaluate material cost impact on a case-by-case basis.
- Refrigerant characteristics play an important role in the design of RACHP equipment in specific relation to maintaining or enhancing energy efficiency. The two main factors which influence the material cost of equipment are refrigerant thermodynamic characteristics (pressure, density, cycle COP etc.) and refrigerant safety characteristics (e.g., flammability/toxicity/pressure). Other factors may also play a role such as material compatibility.
- Flammability and/or toxicity characteristics may limit the acceptable amount of refrigerant for safety reasons and thus limit the cooling or heating capacity and/or energy efficiency that can be achieved. Reducing the refrigerant charge may be possible using different technologies such as microchannel heat exchangers but these can also bring technical and application challenges.

Chapter 4 "Cost Benefit Analysis of Low GWP Technologies and Equipment that maintain or enhance energy efficiency"

- The Parties to the Montreal Protocol have agreed to maintain or enhance energy efficiency while phasing down HFCs under the Kigali Amendment to the Montreal Protocol. However, in practice, it is difficult to decide what level of energy efficiency is optimal in any specific case, both at a project level and at an economy wide level, for example when setting minimum energy performance standards for equipment.
- Parties may choose to conduct economy-wide or project-specific cost-benefit analyses to maximize benefits to consumers and society from energy efficiency improvement as has been done historically in many economies.
- The US Department of Energy and EU Ecodesign typically conduct in-depth cost-benefit analyses to optimise the level of energy efficiency of equipment.
- Such studies vary in their depth, analytical rigor, and cost from multi-year studies with detailed engineering analysis to short market studies. However, such studies are crucial for understanding the value of energy efficiency particularly in the context of considering investments that may have varying benefits to consumers and manufacturers as well as varying environmental benefits.
- Regardless of the level of energy efficiency invested in, it is very likely that co-ordinated investment in energy efficiency and refrigerant transition will cost manufacturers and consumers less than if such investments are made separately.
- In order to conduct an in-depth cost-benefit analysis of concurrent refrigerant transition and energy efficiency improvement, detailed data is necessary including incremental capital and operational costs.
- General lessons from previous case studies suggest that:
    - Energy Efficiency is more valuable under cases with high hours of use and high electricity prices
    - Lifecycle CO_{2eq} savings are higher in cases with high hours of use and high grid CO_{2eq} intensity
    - Lifecycle cost savings can far outweigh higher first cost of more efficient equipment
    - In the case of large investments an in-depth analysis is essential.
    - Manufacturers may find higher cash flow and revenue through efficiency improvement

Chapter 5 "Short Term Roadmap for Adoption of Energy-Efficient Technologies While Phasing Down HFCs

- Roadmaps for adopting energy-efficient technologies while phasing down HFCs will vary based on national circumstances. These approaches can benefit from a common set of policies that would support these technology transitions. These include sector-specific and cross--cutting policies like integrated energy and refrigerant performance standards and labelling, best practice performance metrics and test procedures, enabling building energy and safety standards, support for ongoing service sector training, and monitoring, compliance, and enforcement. Several country specific case studies are provided in Annex 9.5
- The technology transition would be supported by coordination between National Ozone Units and national energy and climate authorities especially through the integration of lower GWP HFC standards into energy efficiency standards and labelling policies
- Raising awareness across government institutions and community-based consumer programmes can speed adoption of energy-efficient and low-GWP equipment, and increase access to additional financing mechanisms, such as through electricity utility efficiency programs and bulk procurement programs.
- Where A5 parties do not have the capacity to prescribe and enforce laws to prohibit shipping of obsolete products, the local and global harms inflicted as a result of increased environmental dumping in these most-vulnerable jurisdictions necessitate that non-A5 exporting parties share responsibility with A5 recipient countries to prevent the environmental dumping of obsolete products.

Chapter 6 "Options to Maintain and Enhance Energy Efficiency through Best Practices in installation, servicing, maintenance, refurbishment and repair".

- Design upgrades to meet energy efficiency levels require a higher level of knowledge and training for safe and effective installation and servicing. These new topics include units with variable speed drives, controls with self-diagnostics, and remote-control features which all require improved skills including knowledge of electronics.
- Energy efficiency degradation is affected by the severity of use and operating conditions, as well as corrosive environments. Improper installation and maintenance accentuate the loss of EE, and high quality and frequent planned maintenance minimise the loss of EE.
- Refrigerant leakage impacts EE. Reducing leakage continues to be a service priority for optimised systems using low-GWP refrigerants with reduced refrigerant charge.
- End-user environmental awareness is driving them to demand lower CO2-eq emissions from the operation of their systems. Preventive and eventually predictive maintenance are becoming a priority for both operators and service providers.
- Rigorous service requirements drive higher training, certification, and specialisation with improved rewards. This will tend to lower technician turnover and consolidate/spread good practices.

Chapter 7 "How to Assess the Benefits of Integrating Energy Efficiency Enhancements with the HFC phase-down"

Modelling tools can support the analysis of the potential to reduce energy related indirect GHG emissions from RACHP at the same time as phasing down use of HFCs and reducing direct HFC emissions.

Some important insights from modelling are discussed – these include:

- The relative importance of direct and indirect GHG emissions can vary considerably in different countries. This has an impact on the choice of policy to support an integrated approach. For countries with high electricity generation carbon factors, reducing energy use is the key priority. For countries with low carbon factors, a greater focus on reducing HFC emissions is beneficial.
- The relative importance of direct and indirect GHG emissions can also vary considerably across the wide range of different RACHP technologies and applications.
- There are many different pathways available to achieve the Kigali Amendment targets. Combining early action for HFC mitigation actions with simultaneous energy efficiency actions can lead to significant reductions in cumulative GHG emissions between now and 2050 and at the lowest cost. Grid decarbonisation also makes a vital contribution to reduced emissions.
- Using heat pumps in place of fossil-fuels for space, water and process heating will be essential for heating decarbonisation. The avoided fossil fuel emissions from the use of heat pumps will massively outweigh any direct and indirect emissions from the heat pumps.
- Ensuring that new RACHP equipment is as efficient as possible, and that existing equipment is operated and maintained for high efficiency makes a very cost-effective contribution to the path to net zero GHG emissions.
- There is a significant lack of reliable data on refrigerant banks and equipment stocks by sector which is needed optimise the outputs of modelling. Better data would improve modelling at national and regional levels.