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Energy-efficient and low- or zero-global-warming-potential technologies: outcomes of the workshop on energy efficiency (decision XXXIV/3, para. 4 (a))

Existing policies addressing interlinkages between phasing down hydrofluorocarbons and enhancing energy efficiency

Note by the Secretariat

I. Introduction

1. The present note has been prepared in accordance with subparagraph 4 (b) of decision XXXIV/3, on enabling enhanced access and facilitating the transition to energy-efficient and low- or zero-global-warming-potential technologies. In paragraph 4 of the decision, the Thirty-Fourth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer requested the Secretariat to:

(a) Organize a one-day workshop to share information, experiences and lessons learned, and assess challenges related to ways of improving availability and accessibility of energy-efficient equipment and equipment using low- or zero-global-warming-potential alternatives during the implementation of the Kigali Amendment;

(b) Prepare a report of existing policies addressing the interlinkages between phasing down hydrofluorocarbons (HFCs) and enhancing energy efficiency.

2. The present note focuses primarily on the refrigeration, air-conditioning and heat pump (RACHP) sector. In preparing it, the Secretariat sought information from the parties, requesting them to submit information pertinent to the request in subparagraph 4 (b) of decision XXXIV/3, focusing on policies that address energy efficiency and the transition to low- and zero-global-warming-potential alternatives in sectors using HFCs and other substances controlled under the Montreal Protocol.[1] The Secretariat also took into account the Technology and Economic Assessment Panel reports related to provision of information on energy-efficient and low- and zero-global-warming-potential technologies, the briefing notes for the workshop on energy efficiency opportunities while phasing down HFCs, organized by the Secretariat in 2018 in accordance with paragraph 4 of decision

* UNEP/OzL.Pro.35/1

[1] Five parties replied to the request; two of them were unable to compile and submit the information, owing to time constraints.

XXIX/10,[2] and background documents prepared for consideration by the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol in its discussion on cost guidance for energy efficiency, as well as a plethora of other publications and documents by organizations involved in this area.[3] In addition, the Secretariat consulted implementing and bilateral agencies of the Multilateral Fund and the United Nations Environment Programme (UNEP) specialized in energy efficiency and cooling programmes and requested them to provide information on policies and case studies. The note was also reviewed by a number of external experts, including from the energy efficiency task force of the Technology and Economic Assessment Panel. The Secretariat is grateful for all guidance and input received.

3. For the purpose of the present note, the Secretariat identified and summarized 15 case studies demonstrating how relevant policies have been introduced and tested in various countries, generally with the involvement of national ozone authorities. The case studies are presented in support of the goal of the workshop as set out in subparagraph 4 (a) of decision XXXIV/3. The case studies are listed in the annex to the note and presented in full in document UNEP/OzL.Pro/Workshop.12/INF/1–UNEP/OzL.Pro.35/INF/9, in English only. Most have been reviewed by their implementers, but parties may submit further corrections or summaries to the Secretariat should they wish to do so.

4. Section II of the note provides background information on the discussions and decisions of the Meeting of the Parties and funding provided by parties to the Montreal Protocol in relation to energy efficiency. Section III takes stock of the energy efficiency landscape in the RACHP sector, including barriers to policy adoption. Section IV maps out various possible policy options across the RACHP value chain, including interventions that could be undertaken directly during the HFC phase-out by national ozone authorities, and interventions necessitating collaboration and synergy with other line ministries and agencies. Section V provides some concluding remarks.

II. Background

A. Overview of energy efficiency discussions and decisions under the Kigali Amendment to the Montreal Protocol

5. In 2016, the parties to the Montreal Protocol adopted the Kigali Amendment through decision XXVIII/1, adding 18 HFCs to the list of controlled substances for their gradual phase-down by 2047. Parties' compliance with their HFC phase-down obligations under the Kigali Amendment is determined based on calculated levels (in carbon dioxide (CO_2) equivalent) of HFC consumption and production. Parties also have other obligations, including with respect to the establishment and implementation of export-import licensing systems covering HFCs, and data reporting. Parties also confirmed that the Multilateral Fund would continue to be used to provide financial and technical assistance to parties operating under paragraph 1 of Article 5 of the Protocol (Article 5 parties) to help them achieve the agreed phase-down targets of the Kigali Amendment. That and other important principles and the operational elements associated with the Kigali Amendment and its implementation are set out in decision XXVIII/2.

6. While the Kigali Amendment does not provide legally binding compliance targets or verification metrics relating to energy efficiency, during their consideration of the proposed amendment parties held extensive discussions on the importance of maintaining and enhancing energy efficiency while transitioning away from high-global-warming-potential HFCs to low-and zero-global-warming-potential alternatives in the RACHP and other relevant sectors. In addition to addressing energy efficiency in decision XXVIII/2, parties adopted decision XXVIII/3, where in the preambular paragraphs they:

(a) Recognized that a phase-down of HFCs under the Montreal Protocol would present additional opportunities to catalyse and secure improvements in the energy efficiency of RACHP products and equipment;

(b) Noted that the air-conditioning and refrigeration sectors represented a substantial and increasing percentage of global electricity demand;

[2] Briefing notes A, B and C are available at https://ozone.unep.org/meetings/workshop-energy-efficiency-opportunities-while-phasing-down-hydrofluorocarbons-hfcs/pre-session-documents.

[3] All pertinent sources have been referenced as necessary throughout the present note.

(c) Appreciated the fact that improvements in energy efficiency could deliver a variety of co-benefits for sustainable development, including for energy security, public health and climate mitigation;

(d) Highlighted the large returns on investment that had resulted from modest expenditures on energy efficiency, and the substantial savings available for both consumers and governments.

7. Since the adoption of the Kigali Amendment by the Twenty-Eighth Meeting of the Parties, the parties have discussed the energy efficiency issue under the following distinct but interrelated tracks:

(a) ***Continued provision of information on energy-efficient and low-global warming potential technologies by the Technology and Economy Assessment Panel***: The energy efficiency task force of the Technology and Economic Assessment Panel has been providing regular updates to the parties on various aspects of energy efficiency in the RACHP and other relevant sectors in connection with the HFC phase-down and addressing new developments, including with respect to the availability, accessibility and cost of energy-efficient technologies and relevant best practices, in accordance with requests in decisions XXVIII/3, XXIX/10, XXX/5, XXXI/7 and XXXIII/5. The parties' latest request of the Technology and Economic Assessment Panel is contained in paragraph 1 of decision XXXIV/3.

(b) ***The Executive Committee's development of cost guidance associated with maintaining and/or enhancing the energy efficiency of low- or zero-global-warming-potential replacement technologies and equipment when phasing down HFCs*** while taking note of the role of other institutions addressing energy efficiency when appropriate, as requested in paragraph 22 of decision XXVIII/2: In paragraph 3 of decision XXXIV/3, the Meeting of the Parties reiterated its request that the Executive Committee continue to support activities to maintain and enhance energy efficiency in countries wishing to do so while phasing down HFCs.

(c) ***Funding for the servicing sector*** pursuant to paragraph 16 of decision XXVIII/2 and paragraph 2 of decision XXX/5, in which the Executive Committee was requested to increase funding to the servicing sector when needed for the introduction of low- and zero-global-warming-potential alternatives to hydrochlorofluorocarbons (HCFCs) and HFCs and for maintenance of energy efficiency also in the servicing and end-user sector: The Executive Committee approved the funding principles for stage I of the Kigali HFC implementation plans in the servicing sector at its ninety-second meeting.[4]

(d) ***Additional resource mobilization and setting up of modalities for cooperation and co-funding arrangements*** with other funds and financial institutions for activities to maintain or enhance energy efficiency when phasing down HFCs, as called for in paragraph 22 of decision XXVIII/2, and paragraph 7 of decision XXX/5.

(e) ***Workshops related to energy efficiency*** organized by the Secretariat in accordance with decision XXIX/10, paragraph 4: The workshop to which the present note relates is the second such workshop. The first one took place in 2018 before the fortieth meeting of the Open-ended Working Group of the Parties to the Montreal Protocol. The outcomes of that workshop highlighted the importance of funding to support energy efficiency measures, especially to overcome upfront costs for the production and adoption of energy-efficient equipment with low- and zero-global-warming-potential alternatives, and the need to factor in life cycle costs because they are generally lower for equipment that has a high initial capital cost but is more energy-efficient. The discussion also highlighted the importance of further understanding the linkages between refrigerant choice and system efficiency.

B. Funding provided under the Montreal Protocol for activities and projects promoting climate-friendly and energy-efficient alternative technologies

8. It should be noted that improvements in energy efficiency might have occurred throughout the different phase-outs of ozone-depleting substances under the Montreal Protocol as new technology was developed and adopted in successive phases of the transition. The newly designed equipment was in principle more efficient than the equipment it replaced, even though energy efficiency improvement was not the main purpose. It made economic and business sense to pursue energy efficiency benefits from the phase-out of ozone-depleting substances, particularly in the RACHP sector.

9. In addition, in 2008, prior to the Kigali Amendment, the parties adopted decision XIX/6, in which they decided, for the first time, to take action to minimize impact on climate. In subparagraph

[4] Decision 92/37, set out in document UNEP/OzL.Pro/ExCom/92/56.

11 (b) of the decision, the parties agreed that the Executive Committee of the Multilateral Fund should give priority to cost-effective projects and programmes that focused on substitutes and alternatives that minimized other impacts on the environment, including on the climate, taking into account global warming potential, energy use and other relevant factors. Subsequent to that request, the Executive Committee allocated $18 million[5] to 14 demonstration projects for maintaining or enhancing energy efficiency during implementation of HCFC phase-out management plan projects involving conversion to alternative low-global-warming-potential technologies.

10. As a way to implement paragraph 16 of decision XXVIII/2, the Executive Committee, in decision 89/6, approved contingent funding for low-volume-consuming Article 5 parties to address emerging needs related to the introduction of low- and zero-global-warming-potential refrigerants to HCFCs and maintaining energy efficiency in the servicing sector. So far the Executive Committee has approved projects for seven low-volume-consuming countries and one global technical assistance project on twinning of national ozone officers and national energy efficiency policymakers to support Kigali Amendment objectives under this decision funding.

11. Pursuant to decision XXVIII/2, at its ninety-first meeting, in 2022, the Executive Committee adopted decision 91/65, establishing a $20 million funding window for pilot projects to maintain and/or enhance energy efficiency in the context of HFC phase-down. The activities could be related to technology conversions that enhanced energy efficiency during the transition away from HFCs in various sectors, including the servicing sectors, as well as the development of minimum energy performance standards (MEPS) and technical assistance to small and medium-sized enterprises. Document 91/63 of the Executive Committee sets out the criteria for developing, implementing and evaluating such pilot projects. At its 92nd meeting, the Executive Committee approved preparations for a pilot project on energy efficiency for India ($33,900) for funding from this funding window.

III. Policies addressing interlinkages between phasing down hydrofluorocarbons and enhancing energy efficiency

A. Energy efficiency landscape in relation to the refrigeration, air-conditioning and heat pump sector

12. According to the quadrennial assessment report of the Scientific Assessment of Ozone Depletion 2022, limiting the production and consumption of HFCs with high global warming potential is projected to avoid 0.3°C to 0.5°C of global warming over the current century.[6] Furthermore, improvements in the energy efficiency of equipment in the refrigeration and air-conditioning sectors during the transition to low-global-warming-potential alternative refrigerants could potentially double the direct climate benefits of the Kigali Amendment. Moreover, the combination of low-global-warming-potential replacement compounds, energy efficiency improvements and growth in renewable energy sources has great potential to minimize the direct and indirect contributions to climate forcing from global refrigeration and air-conditioning applications.[7]

13. High ambient temperatures in many regions, particularly in the last decade, have driven demand for the space cooling provided by air conditioners. According to the International Energy Agency,[8] sustained average daily temperatures at 30°C typically boost weekly air conditioner sales by approximately 16 per cent. In addition, with the current global heat wave, internet searches for air conditioners are up 25 per cent compared to averages for the past decade. While more than 90 per cent of households in the United States and Japan have air conditioners, only 15 per cent in Southeast Asia do, and the figure drops to 5 per cent in India and less than 1 per cent in Africa. Just one in ten individuals residing in the hottest regions of the world have access to indoor cooling. Aside from putting populations at risk of heat stress, such lack of access negatively affects their thermal comfort, which is important for productivity as well as health.[9]

[5] See document UNEP/OzL.Pro/ExCom/72/40.

[6] Ross J. Salawitch and others, *Twenty Questions and Answers about the Ozone Layer: 2022 Update*: *Scientific Assessment of Ozone Depletion* (World Meteorological Organization, United Nations Environment Programme, United States Department of Commerce, United States National Aeronautics and Space Administration and European Commission, 2023), p. 62.

[7] Ibid., p. 65.

[8] International Energy Agency, "Keeping cool in a hotter world is using more energy, making efficiency more important than ever" (2023).

[9] Ibid.

14. Since the adoption of the Kigali Amendment, the Technology and Economic Assessment Panel has been tasked to provide the parties with regular updates on progress made in developing energy efficient technologies and analysis of policy options, to advance the availability and accessibility of such technologies in the RACHP sector. To date, the Panel has presented nine reports containing the latest information for the consideration of the parties.[10] The key message from the most recent reports is that technologies using lower-global-warming-potential refrigerants are now widely available in key market sectors.[11] While accessibility to such technologies is improving, it is still limited in many countries, largely Article 5 parties but also some non-Article 5 parties.

B. Barriers and challenges

15. There are barriers to translating availability into accessibility and wider adoption, as extensively discussed in Technology and Economic Assessment Panel reports. A review of the Panel's reports as well as other relevant sources, including those that deal with market and policy dynamics and adoption of new technologies, indicates that the barriers can be grouped into the following categories:[12]

(a) ***Skill gaps.*** A notable challenge relates to lacking or limited expertise for absorption of a new technology by the market, and in the RACHP sector this relates to the lack of qualified engineers and technicians. Not only is there a shortage of technicians, but many lack the training required for safe installation and servicing of new, energy-efficient designs that rely on low- and zero-global-warming-potential refrigerants that are operationally challenging. Ensuring that professionals are competent is critical for the adoption of new technology.

(b) ***High upfront costs.*** Innovative products often start out at higher prices than the incumbent options, which can be a significant deterrent for manufacturers and consumers, even when equipment costs are recovered during use. Manufacturers face production challenges owing to the limited supply and high costs of specialized components, as well as limited expertise. The resulting additional costs are usually passed on to consumers. To help make such products more mainstream and address this economic imbalance, policymakers usually resort to financial incentives.

(c) ***Low demand and consumer awareness.*** Related to the above, consumers and end-users may either be unaware of such products or overlook the long-term benefits of options that are initially more expensive yet can yield cost savings in the long run. There can be scepticism about lower- global-warming-potential options or energy-saving potential and payback period, especially in the context of Article 5 parties, because of consumer price sensitivity. To significantly increase the market share of the new products, raising awareness about the total ownership cost – capturing both initial investment and lifetime energy savings – and incentivizing the initial uptake is critical. It should be noted that the running costs of equipment throughout its lifetime generally depend on the country, its climate and its energy mix for the electricity generation in a country.[13] It is also determined by the cooling capacity of the buildings where the equipment is used.

(d) ***Regulatory challenges and limitations.*** Existing policy frameworks can be fragmented and poorly coordinated during their development and implementation. Regulatory constraints, including building and transportation codes that can be restrictive in terms of safety aspects or lax and outdated in terms of energy efficiency, can inhibit the use of energy-efficient options based on low and zero-global-warming-potential refrigerants. Proliferation of varying energy efficiency standards can hinder the easy movement and acceptance of products across borders and fail to create the necessary economies of scale for manufacturers.

[10] All Panel reports are available at https://ozone.unep.org/science/assessment/teap.

[11] "Availability" is defined as the ability of the industry to manufacture products with new technologies of low-global-warming-potential refrigerants and higher efficiency and is controlled by the manufacturers. "Accessibility" is focused on the consumer side and implies the ease of access and extent to which such technologies can be used. Along the same lines, "adoption" can refer to how widely a technology is actually being used. See Report of the Technology and Economic Assessment Panel, May 2021, Volume 4: Decision XXXI/7 – Continued provision of information on energy-efficient and low-global-warming-potential technologies, p. 32.

[12] While the barriers are specific to the RACHP sector and its particular environmental challenges, many are also common to the adoption of any new technological innovations and practices. See Xavier Cirera and William F. Maloney, *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up* (Washington, DC, World Bank, 2017); Partnership for Action on Green Economy, *Green Industrial Policy and Trade: A Tool-Box* (2017); and UNEP, *Moving Ahead with Technology for Eco-Innovation* (2017).

[13] Richard Lowes and others, *A Policy Toolkit for Global Mass Heat Pump Deployment* (Regulatory Assistance Project, Brussels, 2022).

(e) ***Limited institutional capacity.*** Just having policies in place is not sufficient, as their implementation can stumble because of low institutional capacity and limited practical skills. It can be common to have a compartmentalized modus operandi in government, while addressing complex sectors requires effective communication, collaboration and coordination. Designing the right mix of policies calls for multidisciplinary knowledge and skills as well as resorting to funding options that go beyond traditional sources and explore new and innovative approaches, unlocking private sector finance.

(f) ***Market dynamics.*** There are certain market dynamics that need to be corrected to push the market to transition to and adopt new technologies. For example, in the context of RACHP, voluntary MEPS can inadvertently act as a trade barrier to wider conversion of industries, including the small and medium-sized enterprises prevalent in some supply chains and the assembly sector. Patent restrictions related to HFC alternatives and advanced energy-efficient, low-global-warming-potential technologies can also limit collaboration and spillover for wider uptake.

16. Barriers depend on the institutional dynamics and complexity in a specific national context. Their effects are also often interlinked and cannot be addressed in isolation or by a single solution. Understanding why these obstacles exist, and how they hinder intended goals, will help policymakers to design flexible, more effective policies. Addressing these multifaceted barriers requires a comprehensive approach that integrates regulatory reforms, targeted industrial support, skills development, financial incentives, consumer awareness and behaviour and stakeholder cooperation at the national level, as well as international collaboration.

17. The 2023 report of the energy efficiency working group of the Technology and Economic Assessment Panel states that "to decarbonize heating and cooling in a cost-efficient manner, energy efficiency needs to go beyond a pure product-based approach. Taking an integrated approach[14] to the energy system offers massive opportunities to reduce the need for energy generation, cost and emissions and to increase the resilience of the energy system".[15] It further cautions that focusing on product efficiency alone could eventually lead to a situation where the large incremental cost of super-efficient products could prevent their broad uptake in the market.[16]

IV. Policymaking process for energy efficiency in the refrigeration, air-conditioning and heat pump sector

A. Value chain of the sector

18. It is helpful to consider the complexity of the RACHP sector from the perspective of its value chain, meaning the full life cycle of a product or process, including material sourcing, production, consumption and disposal/recycling processes.[17] The value-chain approach allows the complexity of the sector to be broken down into phases and sequences of decisions and actions taken by different actors in the value chain while maintaining an integrated approach to the system as a whole. Policies generally aim to affect and direct the decisions of market players towards more sustainable choices. The value chain approach[18] has been central to the work of UNEP – as a leading normative organization for environmental sustainability – with industries and markets and has been embedded in the systems change approach.[19]

[14] Reports by the Technology and Economic Assessment Panel, UNEP, the International Energy Agency, the Kigali Cooling Efficiency Program, the Climate and Clean Air Coalition and other institutions all emphasize the need for integrated coordinated policies to mitigate global warming through climate-friendly alternatives and higher-efficiency cooling.

[15] See Technology and Economic Assessment Panel Progress Report, volume 1: supplementary report, Decision XXXIV/3 Energy Efficiency Working Group Report, p. 13. Available at https://ozone.unep.org/system/files/documents/TEAP-May2023-Progress-Report-Supplementary.pdf.

[16] Ibid., p. 40.

[17] World Business Council for Sustainable Development, *Collaboration, Innovation, Transformation: Ideas and Inspiration to Accelerate Sustainable Growth – A Value Chain Approach* (Geneva, 2011). For additional definitions and characteristics of a value chain, see https://www.cisl.cam.ac.uk/education/graduate-study/pgcerts/value-chain-defs.

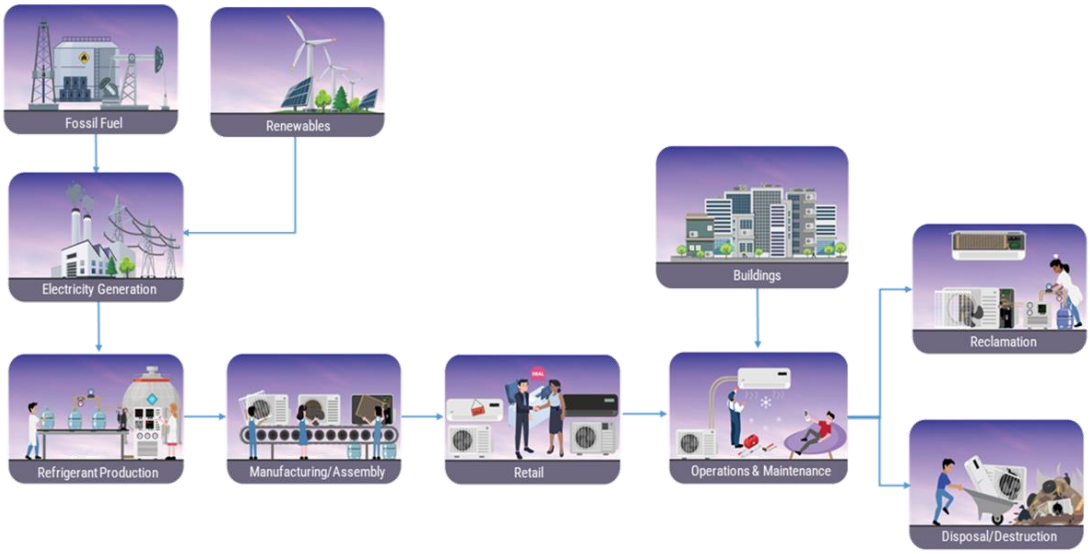
[18] UNEP, *Catalysing Science-Based Policy Action on Sustainable Consumption and Production: The Value-Chain Approach and Its Application to Food, Construction and Textiles* (Nairobi, 2021).

[19] The systems change approach has been discussed by the intergovernmental negotiating committee to develop an international legally binding instrument on plastic pollution. Systems change captures the idea of addressing the causes, rather than the symptoms, of a societal issue by taking a holistic (or "systemic") view. Systemic

19. The value chain perspective has been also helpful in determining what information to include in the present note, given that such information has already been provided in the Technology and Economic Assessment Panel reports and other sources[20] Looking at the whole value chain of the RACHP sector allows a more systematic review and presentation of the policy options.

20. The value chain of the RACHP sector can be divided into the following phases: refrigerant production, manufacturing and assembly, retail, operation and use, and end-of-life. As is shown in the figure below, the value chain also includes the energy sources and buildings that determine the cooling needs.

Value chain of an air conditioner



B. Policy options[21]

21. The policy options mentioned here are not meant to be prescriptive or exhaustive and are provided solely as information for the parties. Various policy instruments can be considered in developing and implementing a balanced and comprehensive strategy for an optimal and rapid transition to low-global-warming-potential-refrigerant-based equipment with enhanced energy-efficient features and the creation of a self-sustaining market for such equipment. The right combination of policy instruments and sequencing is important for producing the intended results. The policy options discussed here are not always within the direct mandate of the national ozone offices, but sharing information, engaging and coordinating with other line ministries and agencies will be essential for an integrated approach. The iterative process of policy design, implementation, review and adjustment should be based on communication and collaboration among those entities and with the groups targeted by such policies (e.g., industry, consumers etc).

22. Policy instruments are usually categorized by the type of incentives they provide, ranging from regulatory/command and control measures (e.g., bans, phase-out/down targets, standards) to market and economic instruments (e.g., licensing and permits, taxes, subsidies and loans, cooling as a service). Information-based instruments (e.g., certification, labelling, awareness campaigns, behavioural interventions) and voluntary initiatives (e.g., voluntary certification, environmental management systems, net zero commitments) comprise a range of policy instruments directly

change is generally understood to require adjustments or transformations in policies, practices, power dynamics, social norms or mindsets. It often involves a diverse set of players and can take place at a local, national or global level. Systems change requires modifications in many system structures, such as the mindset or paradigm that creates the system or the system's goals or rules. See document UNEP/PP/INC.1/7, p. 19.

[20] Other sources include documentation provided by the Multilateral Fund secretariat for the consideration of energy-related matters by the Executive Committee from its 83rd to its 92nd meetings, as well as sources considered in the preparation of the present note.

[21] This section draws from a plethora of existing resources that explain policy options for promoting cleaner technologies, including in the cooling space, such as the following: Partnership for Action on Green Economy, *Green Industrial Policy and Trade: A Tool-Box;* International Energy Agency, *Sustainable, Affordable Cooling Can Save Tens of Thousands of Lives Each Year* (2023); and Lowes and others, *A Policy Toolkit for Global Mass Heat Pump Deployment*.

implemented, indirectly promoted or facilitated by government. Each has specific purpose and associated strengths and limitations, with their effectiveness depending on context and timing.[22] The International Energy Agency maintains an online database providing access to information on past, existing and planned government policies and measures to reduce greenhouse gas emissions, improve energy efficiency, and support the development and deployment of clean energy technologies, including in space cooling and buildings.[23]

23. When considering policies that improve energy efficiency while phasing down HFCs, interventions during the ***manufacturing phase*** of the refrigeration and air-conditioning value chain are usually prioritized. Measures include design optimization and upgrades of the systems and their components, as well as adjustment of manufacturing lines to enable the use of low and zero-global-warming-potential refrigerants. High-energy-efficiency design options usually feature efficient compressors, high-efficiency heat exchangers, cabinet structures and gaskets with optimized thermal retention, and streamlined manufacturing processes. Variable capacity compressors that can adjust speed to meet the required cooling need and thus operating more efficiently than fixed capacity compressors can make systems more energy efficient.

24. Policy options such as setting and periodically revising MEPS can play a crucial role, incentivizing manufacturers to make RACHP appliances that are more energy-efficient and phasing less efficient products out of the market (see case study 1, from China). Based on the review conducted for the "Global Cooling Stocktake Report",[24] MEPS covering the cooling sector have been put in place in 128 countries, but stringency levels are regularly updated in only 14 per cent of those countries.

25. Mandatory MEPS reduce market uncertainty for industries and businesses and send clear signals to the market. MEPS should cover not only equipment design but also operating efficiency given patterns of prolonged use. Including refrigerant global-warming-potential values in the standards for RACHP equipment would also help with the transition to low and zero-global-warming-potential alternatives. For example, the UNEP 'Model Regulation Guidelines' for Energy-efficient and Climate-friendly Air conditioners suggest an ozone depletion potential value of 0 and a global warming potential of 750 for ductless split systems[25] (see case study 1, from China, and case study 5, from Brazil).

26. According to the International Energy Agency, in countries and regions with the longest-running programmes, such as the United States and the European Union, MEPS and labels have helped more than halve the energy consumption of air conditioners.[26] Coupled with labelling, MEPS are also designed to increase the uptake of these products by consumers, both individual and institutional (i.e., public-sector or corporate buyers).

27. At the regional level, to facilitate trade and reach economies of scale, ***MEPS harmonization*** can be considered. Manufacturers can produce a single version of a product for multiple markets rather than different versions to meet each country's MEPS. Given a larger potential market for their products, companies may be more willing to invest in new research and products to meet such standards and produce at a scale that brings down costs. In economic union regions such as the Association of Southeast Asian Nations (ASEAN) or the East African Community (EAC), the harmonization of standards is more feasible, as countries have similar climate conditions and energy needs (see case studies 3 and 4, from ASEAN, EAC and the Southern African Development Community). Harmonization is not always easy to achieve, however, owing to political and developmental differences between the countries. In such cases, interoperability – e.g., coordination of testing, verification and certification for mutual reconciliation – can help with trade facilitation and reaching economy of scales.

28. MEPS implementation can be supported by ***bans*** on the import, manufacturing or sale of products that fall below a certain efficiency level. For example, after the revision of the refrigeration and air-conditioning MEPS in 2020, the Government of China introduced a ban on the sale of sub-MEPS room air conditioning (with both cooling and heating function, i.e., heat pumps) as of

[22] Partnership for Action on Green Economy, *Green Industrial Policy and Trade: A Tool-Box*.

[23] International Energy Agency policies database. Available at https://www.iea.org/policies.

[24] Forthcoming, to be launched at the twenty-eighth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change.

[25] UNEP, "Supplement to the air conditioners policy guide: accelerating the global adoption of energy-efficient and climate-friendly air conditioners" (2019).

[26] International Energy Agency, "Keeping cool in a hotter world is using more energy, making efficiency more important than ever".

11 July 2021, which supported the rapid transformation of the domestic market. In one year, from 2020 to 2021, the market share for products below the lowest rating under the revised MEPS fell from 69 per cent to almost nil[27] (see case study 1, from China).

29. Owing to the novelty of equipment reliant on low- and zero-global-warming-potential options and energy efficiency features in some markets, industries still lack knowledge and practical experience, which translates into uncertainty. Such uncertainty can be addressed through supportive frameworks and mechanisms to foster learning and adoption. Targeted fiscal and financial incentives such as tax reductions and low-interest loans, loan guarantees and subsidies or grants to help offset the initial investment costs and mitigate financial risks (see case study 1, from China). The operationalization of the incremental cost principle of funding provided by the Multilateral Fund is based on this rationale.

30. ***Demonstrating and showcasing*** new best-in-class technologies can bring innovative technologies to market, with activities that aim to close the skills gap and ensure effective knowledge spillover (see case study 2, from Chile). ***Reward programmes*** support public- and private-sector investment in research and development to advance existing solutions and innovative ideas that go beyond incremental improvements on incumbent technologies. Examples include the Global Cooling Prize, the Lower-GWP Refrigeration and Air-Conditioning Innovation Award and the Beat the Heat: Nature for Cool Cities Challenge.

31. Beyond energy efficiency labels, there are other types of tools for informing consumers about the environmental sustainability of products. For example, Germany has been operating a third-party ***certified ecolabelling scheme***, "Blue Angel", that evaluates the sustainability of goods and services against set criteria based on their impact over their life cycle.[28] For single split unit air conditioners, for instance, the criteria cover not only energy efficiency and refrigerant type but also installation by certified technicians, ease of air filter cleaning, exclusion of hazardous substances in production, avoidance of composite materials in design and noise emissions, among other aspects.[29] The ecolabel is designed to differentiate top-performing products (usually targeting only 20–30 per cent of the market), thus serving as an attractive marketing tool for businesses, pushing them to aim higher than the minimum compliance levels and lead the market.

32. It is also important that technical and financial support for the manufacturing sector be distributed equitably to ensure a level playing field for different sized enterprises. ***Small and medium-sized enterprises*** occupy an important niche in the local commercial and small industrial refrigeration sector, making customized equipment for specific purposes. They are also vital for local economies, as they provide employment at the grass-roots level. Such enterprises usually wait for technology maturity and economies of scale before they switch to alternatives. They therefore require targeted technical assistance and capacity-building for product redesign or access to energy-efficient components and technology. One way to address that is to support a network of trained business intermediaries such as service providers, specifically targeting small and medium-sized enterprises and the installation and servicing sector of the refrigeration and air-conditioning value chain. For example, the centres of the Global Network for Resource Efficient and Cleaner Production have been created to act as service providers for small and medium-sized enterprises, to help them adopt environmentally friendly technologies and practices. The network currently includes more than 70 centres in 60 developing countries.

33. The ***installation, maintenance and servicing (operation and use) phase*** of the RACHP value chain is closely tied to refrigerant phase-out.[30] Improved installation quality through optimized wiring and control settings, and preventive maintenance such as regular cleaning of heat exchangers and airflow optimization can maintain equipment energy efficiency and lead to significant energy savings during the product's use phase. MEPS that regulate servicing practices are also important to sustain equipment energy efficiency during this phase.

[27] Lei (Steven) Zeng and others, "China's MEPS Lead to Major AC Market Transformation", Collaborative Labelling and Appliance Standards Programme, 2 June 2023.

[28] Life-cycle-based ecolabelling schemes have been established in 60 countries. See https://globalecolabelling.net/.

[29] The basic award criteria for stationary air conditioners are listed at https://www.blauer-engel.de/en/certification/basic-award-criteria#UZ204-2016.The Blue Angel ecolabel has been awarded, for example, to split-type room air conditioners manufactured by Midea.

[30] See "Desk study for the evaluation of the energy efficiency in the servicing sector" (UNEP/OzL.Pro/ExCom/88/10).

34. Enhanced installation quality can be achieved through ***certification and verification*** of installation skills. This involves third-party assessment and validation to confirm the skills of the installer. As many countries have done under the previous and ongoing phase-out programmes, rolling out regular good-practice training programmes for the servicing sector that also cover energy efficiency aspects is key to achieving leakage reduction and maintaining equipment energy efficiency (see case study 6, on the Refrigerant Driving Licence).

35. For example, the Energy Star energy efficiency programme administered by the United States Environmental Protection Agency offers the Verified HVAC[31] Installation programme, covering electricity, plumbing and natural gas systems. Such programmes empower technicians and contractors to ensure proper installations of residential RACHP systems and guide customers to certified professionals. Studies have indicated that nearly half of all heating, ventilation and air-conditioning (HVAC) systems in the United States are incorrectly installed, leading to unnecessary energy consumption and elevated peak loads.[32]

36. Mandating ***regular maintenance checks*** for refrigeration and air-conditioning systems in the commercial and industrial sectors can help to ensure that such systems run at optimal efficiency. For example, the European Union regulation on fluorinated greenhouse gases has provisions to prevent emissions from existing equipment by requiring regular checks, proper servicing, and recovery of the gases at the end of the equipment's life.[33] Subsidies or financial incentives accompanied by an effective information campaign on the benefits of having properly installed energy-efficient refrigeration and air-conditioning appliances can encourage users to get their systems checked and serviced regularly (see case study 7 on such programmes in California, United States).

37. As mentioned earlier, low demand and uptake owing to the higher costs of such equipment compared to incumbent technologies can hinder the ***widespread deployment*** of energy-efficient refrigeration and air-conditioning models relying on climate-friendlier refrigerants. To address this barrier and ***foster demand***, a set of well-designed approaches can be considered.

38. ***Product registration systems*** are tools for sustainable product management that governments can use to oversee products entering the market. They are part of a broader monitoring, verification and enforcement system, beneficial in addressing challenges related to managing appliances placed on the market; ensuring compliance with regulations, such as MEPS; understanding the use of controlled substances; and data collection. Product registry serve to create a comprehensive database that provides valuable insights into the implementation of policies and their adjustment (see case study 8, on product registration systems in Australia, ASEAN, EU and the Philippines).

39. Governments can introduce tax breaks, rebates or subsidies for consumers to stimulate demand. These financial instruments can be tied in with energy efficiency standards or conditions for maintaining operational efficiency, which in turn need to be accompanied by end-user awareness and education campaigns highlighting the reasons for and benefits of switching to cleaner technologies. To avoid shifting the burden of refrigerant and technology transition to the end of life by creating banks of unwanted refrigerants and stockpiles of obsolete equipment, such schemes should ideally incorporate the provision of proper recycling and/or disposal facilities for refrigerants and equipment (see case study 9, on an incentive scheme in Ghana).

40. Targeting ***lower-income consumers and households*** is important as they tend to opt for the least efficient air conditioner models, which are cheaper but require more power to operate, rendering them both more climate-warming and more expensive in the long run[34] (see case study 7).

41. Collaboration with local banks to diversify their banking products and provide sustainable finance that factors in long-term energy savings can make such appliances more accessible to a broader group. Banks are the primary source of capital allocated in the economy. By offering tailored ***financial packages*** or lower interest rates for environmentally friendly appliances, banks can reduce the upfront cost barrier, enabling more consumers to invest in sustainable technologies. Their engagement would facilitate the long-term sustainability of any initial public seed funding. Banks may perceive investment in less established technologies as risky, however, because of a lower potential return on green investments against a background of their low uptake and lack of expertise in creating

[31] HVAC stands for heating, ventilation and air-conditioning.

[32] See https://www.energystar.gov/saveathome/heating_cooling/esvi.

[33] See https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/eu-legislation-control-f-gases_en.

[34] Economist Intelligence Unit, "The cooling imperative: forecasting the size and source of future cooling demand" (2019).

financial products in this area. Regulatory frameworks are also often not fully suited to supporting sustainable financing.[35]

42. The provision of ***cooling as a service*** (or heating, in the case of heat pumps) is seen as a promising innovative solution that changes the traditional approach to purchasing.[36] It is a business model that helps with the economics of energy efficient and low and zero-global-warming-potential-based RACHP equipment by tackling some of the barriers mentioned earlier in the present note. The initial cost "hump", a significant impediment for many consumers, is reduced or eliminated, as instead of buying and owning a piece of equipment, end-users pay for cooling or heating that the refrigeration, air conditioning or heat pump delivers. Also, the responsibility for proper installation, servicing and safe substance handling lies with the service provider, who retains ownership of the equipment and disposes of it at the end of its life. Because the customer pays a fixed price per period that is agreed before the contract is signed, the service provider has a vested interest in deploying the most efficient systems, to reduce its operational costs and increase its profit margin (see case study of 10, on cooling-as-a-service models in India, Singapore and South Africa).

43. In most cases, cooling as a service has been provided business-to-business (e.g., where building or facility owners are the client). The government can also be the client, buying such service for a hospital[37] or other public space. This also works for ***equipment leasing***, and has seen some uptake with small, off-grid portable and solar-powered applications in the context of developing countries. For example, small-scale farmers, fishermen and businesses[38] that otherwise could not afford to pay for permanent cold-chain equipment can rent it for a certain period on a "pay-as-you-go" basis. The deployment of such business models benefits from supportive policies, including clear regulation enforcing concepts such as performance-based contracts as well as access to finance.[39]

44. Another way to boost demand for more efficient equipment with low- and zero-global-warming-potential refrigerants is through ***government or bulk procurement***. When governments prioritize buying energy-efficient appliances with low- and zero-global-warming-potential refrigerants for public buildings and facilities, they create direct demand and set an example for the private sector and the general public, showcasing the government's commitment. Buying in bulk can also drive prices down significantly. In practice, when implementing sustainable public procurement, MEPS can be embedded as a reference tool for providing technical specifications in bulk procurement, for easier identification and verification of RACHP-related products[40] (see case study 11, on bulk procurement in Morocco).

45. Electricity consumption during the equipment ***use phase*** is the source of a substantial climate impact in the RACHP sector. As highlighted by IEA in 2023, extreme weather events have led to record-breaking electricity demand for cooling.[41] In addition to the measures mentioned in previous paragraphs on maintenance and installation, a set of incentives can be employed to prompt users to change their behaviour.[42] In general, ***behaviour change***, whereby people make energy-efficient choices when purchasing products or take action in their in everyday activities to reduce their carbon emissions (e.g., by adjusting temperature set points for space heating and cooling) is one of the most significant and cost-effective measures for achieving significant energy and carbon savings.[43] In Japan, for instance, the government has led the Cool Biz, Warm Biz, Cool Share and Warm Share campaigns, depending on the season, to change lifestyles (e.g., by setting an upper limit of 28°C as a guide for

[35] The UNEP Sustainable Finance Initiative offers a range of tools for the banking sector to engage banks and direct their operations towards more sustainable investment. See, for example, the online course entitled "Getting Started in Responsible Banking" of the Principles for Responsible Banking Academy.

[36] International Energy Agency, *The Future of Heat Pumps* (2021).

[37] See, for example, https://www.caas-initiative.org/casestudies/a-leading-hospital-chain-in-india-turns-to-cooling-as-a-service/.

[38] See, for example, the Koolboks Ice Thermal Storage-Freezer, at https://ozone.unep.org/coldchainexhibition/exhibition-detail-022.html, or the Eja-Ice Chest Freezer, at https://ozone.unep.org/coldchainexhibition/exhibition-detail-033.html.

[39] Lowes and others, *A Policy Toolkit for Global Mass Heat Pump Deployment;* section 9.3 discusses the benefits and potential issues involved in heat-as-a-service business models.

[40] UNEP, *Sustainable Public Procurement: 2022 Global Review* (2022); UNEP, *Sustainable Public Procurement: How to "Wake the Sleeping Giant"* (2021).

[41] International Energy Agency, *Sustainable, Affordable Cooling Can Save Tens of Thousands of Lives Each Year*, p. 43.

[42] The Behaviouralist, "Applying behavioural insights to energy policy: toolkit for practitioners".

[43] International Energy Agency, "Residential behaviour changes lead to a reduction in heating and cooling energy use by 2030", in *Technology and Innovation Pathways for Zero-Carbon-Ready Buildings by 2030* (Sept. 2022).

room temperature).[44] The Net Zero campaign, one of the many strategies promoted by the International Energy Agency, suggests that space heating temperatures be limited to 19–20°C and space cooling temperatures to 24–25°C by 2030.[45]

46. Providing information is a fundamental initial step. ***Public awareness campaigns*** can illustrate benefits, emphasize the feasibility of reducing electricity bills over a product's lifespan and encourage environmental stewardship by the public. New equipment should feature easily accessible and understandable features for setting thermostats temperatures to support user behaviour change. Public information can also demonstrate the positive impact of regular maintenance on energy consumption.

47. Each advancement and replacement of RACHP equipment inherently shifts the environmental burden to the ***end-of-life stage*** of its value chain. It is therefore important to have in place sound waste management systems prioritizing recovery, recycling, reclamation of refrigerants and reuse of equipment relying on them along with safe destruction options. Doing so can help reduce direct emissions of RACHP systems, but also foster the culture of sustainability in the sector and stimulate innovation in designing more efficient equipment. Japan's life cycle management of refrigerants provides a paradigm, emphasizing integrated approach from production to disposal, to mitigate the environmental impact and ensure material and energy efficiency[46].

48. Strategies aimed at improving thermal efficiency of buildings and thus reducing their overall ***cooling/heating load*** also play important role in determining the ***running costs*** of RACHP equipment. Building energy codes can promote high energy performance design or retrofitting of buildings and mandate the use of energy-efficient heating, ventilation and air-conditioning systems based on low-and zero-global-warming-potential refrigerants. Restrictive safety codes for buildings have been seen as a barrier to the adoption of the low and zero-global-warming-potential alternatives. According to the *Global Cooling Stocktake* report to be published by UNEP, at least 151 countries have building codes in place to ensure a minimum standard of efficiency. Their actual implementation and enforcement, however, remains low overall (see case study 12, on buildings energy efficiency and cooling in the Middle East and North Africa region).

49. ***Passive cooling***[47] through natural ventilation, sun-reflective surfaces, better insulation and windows and shading can effectively minimize the need for mechanical cooling.[48] As mentioned in earlier paragraphs, putting in place incentives, rebates and grants and promoting innovation while also specifically targeting lower-income communities can support the transition in the building sector.

50. Centralizing the provision of cooling through ***district cooling*** systems is another effective strategy for improving efficiency in the RACHP sector and an example of sustainable urban planning and infrastructure. It precludes the need for individual cooling units and helps with faster and wider adoption of low-and zero global-warming-potential alternative refrigerants that are more readily available for larger applications and that can be handled safely by skilled, certified personnel. The Multilateral Fund has provided funding or co-funding for a number of demonstration projects that included district cooling and that have generated a number of useful lessons[49] (see case study 13, on district cooling in Colombia).

51. Sustainable ***urban planning*** and architectural design that promote nature-based solutions are cost-effective solutions for building city heat resistance, reducing building cooling loads and decreasing the effects of the urban heat island. For example, tree shading and vegetation transpiration can provide a significant cooling effect by reducing the energy use of the adjacent buildings by up to 15 per cent.[50] There are other effective strategies[51] in this respect that have gained attention in recent years because of record-breaking high temperatures and extreme weather events around the world.

[44] Yoshifumi Nakashima, "Climate Change Policies in Japan/What are COOL BIZ and WARM BIZ?", *Japan Environment Quarterly*, vol. 3, Oct. 2013.

[45] International Energy Agency, "Net Zero by 2050: A Roadmap for the Global Energy Sector" (2021).

[46] Climate and Clean Air Coalition, *Resource Book for Life Cycle Management of Fluorocarbons* (UNEP, 2022).

[47] International Institute of Refrigeration, "Passive cooling technologies. 47th Informatory Note on Refrigeration Technologies" (Paris, 2022).

[48] International Energy Agency, *Sustainable, Affordable Cooling Can Save Tens of Thousands of Lives Each Year*.

[49] See document UNEP/OzL.Pro/ExCom/72/40.

[50] Chun-Ming Hsieh and others, "Effects of tree shading and transpiration on building cooling energy use", *Energy and Buildings*, vol. 159, 15 Jan. 2018.

[51] UNEP, *Beating the Heat: A Sustainable Cooling Handbook for Cities* (Nairobi, 2021) and World Economic Forum, "From Phoenix to Abu Dhabi, here's how cities around the world are building heat resilience", 31 July 2023.

52. As outlined in this section, the policy options for managing the availability and accessibility and promoting the use of energy-efficient RACHP equipment that uses low- and zero-global-warming-potential alternatives are many (the list presented here is by no means exhaustive) and work most effectively in a well-designed mix dealing with the supply and demand and the energy needs of such equipment, to ensure their sustainable adoption by the market. This approach will need to be built on a long-term vision, joint planning and coordinated implementation.

53. Since India launched its India Cooling Action Plan, which encompasses many of the ideas presented here, that plan has become a blueprint for integrated policy planning and coordination, showing how to go about it, what to aim for and how stakeholders can do it together. The ***national cooling action plan methodology*** is also available and has now been applied to a varying extent by at least 40 countries around the world, yielding many useful lessons and generally demonstrating the usefulness of such a Montreal-Protocol-centred umbrella framework for policy coordination, coherence and effectiveness (see case study 14, on national cooling action plans).

V. Concluding remarks

54. The Kigali Amendment mandates the phase-down of high-global-warming HFCs and offers an opportunity to tackle energy efficiency concurrently, for additional climate benefits. This elevates the role of the Montreal Protocol in sustainable development.

55. There is a need to enhance the sustainability of incumbent solutions in RACHP equipment and systems, which are vital for various sectors of the economy. From the perspective of the Montreal Protocol, this is primarily achieved by replacing refrigerants with more climate-friendly alternatives. At the same time, the RACHP sector is a component of the existing infrastructure that continues to contribute to the climate problem, mainly due to its electricity consumption. The Parties to the Montreal Protocol in their decisions have recognized the importance of energy efficiency and its significant potential for climate change mitigation, and have aimed to identify actionable opportunities to enhance energy efficiency when phasing down HFCs.

56. As is highlighted in the present note, however, the introduction of new RACHP technologies and equipment to the market for their wider deployment requires considerable effort. Moreover, each technological transition will shift the environmental burden to the end of the life of the equipment if attention is not paid to the sound environmental management of refrigerants and equipment waste.

57. The need for cooling, especially through the use of air conditioning, is projected to rise in response to global warming. Consequently, the challenge extends beyond the supply and uptake of energy-efficient equipment with low- and zero-global-warming-potential refrigerants. Reducing the demand for cooling equipment overall becomes an important factor for cutting energy demand and addressing environmental impacts. Still, many countries lack access to refrigeration, air-conditioning and cold-chain facilities, which are essential for food security, health, productivity and development. Decision-making for the implementation of the Kigali Amendment therefore also needs to consider the implications of those complexities.

58. The policy options explored in this note are already being implemented by many parties. They lay the ground for an integrated approach that addresses the RACHP equipment supply and demand and associated energy requirements, interlinkages and implications throughout the value chain. The cooperation of various stakeholders, including governments, industry and financial institutions, is also important for success.

59. Financial support for activities that focus on the manufacturing side as well as the servicing sector can be made available through the Multilateral Fund from the funding window for pilot projects to maintain and/or enhance energy efficiency in the context of HFC phase-down. As is demonstrated in the case studies compiled for the present note, other sources of funding have also always been sought and utilized. Through the Executive Committee of the Multilateral Fund, the parties to the Montreal Protocol are exploring modalities for collaboration with financial institutions, recognizing that the implementation of the Kigali Amendment also requires an integrated approach to financing in order to realize the estimated overall climate mitigation potential of the Kigali Amendment.

Annex

List of case studies[1]

No.	*Policy approach*	*Location*	*Name of initiative*
1	MEPS and labelling, National Cooling Action Plan, other approaches for uptake	China	Refrigerant transition and energy efficiency policies in China
2	Introduction of new technologies (demonstration, promotion, technical assistance)	Chile	Transcritical CO_2 refrigeration systems for supermarkets
3	Harmonization of minimum energy performance standards	ASEAN	ASEAN Cool Initiative for MEPS harmonization
4	Harmonization of minimum energy performance standards	EAC and SADC	Regional EAC-SADC project on energy-efficient cooling appliances
5	Minimum energy performance standards	Brazil	MEPS for commercial refrigerating appliances in Brazil
6	Certification of servicing technicians	Global	Refrigerant Driving Licence
7	Incentive schemes for uptake by individual consumers and household	California, United States	Supporting adoption of sustainable heating and cooling equipment in low-income and disadvantaged communities
8	Product registration systems	Global, Australia, the European Union, and the Philippines	Product registration systems
9	Incentives schemes, business models	Ghana and Senegal	Ecofridges initiative: Green on-wage financing in Ghana
10	Cooling as a service, business models	Global, India, Singapore and South Africa	Cooling as a Service Initiative
11	Bulk procurement	Morocco	Air Conditioners Buyers Club
12	Building energy efficiency	MENA, and Jordan	Energy efficiency in buildings in the MENA region
13	District cooling	Colombia	District cooling systems in Colombia
14	Integrated planning	Global, India and Rwanda	National Cooling Action Plans
15	MEPS	Iran	Review and updating of MEPS

Abbreviations: ASEAN – Association of Southeast Asian Nations; CO_2 – carbon dioxide; EAC – East African Community; MENA – Middle East and North Africa, MEPS – minimum energy performance standards; SADC – Southern African Development Community.

[1] The case studies are set out in information document UNEP/OzL.Pro/Workshop.12/INF/1–UNEP/OzL.Pro.35/INF/9