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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Ninety-eighth Meeting
Montreal, 22–26 June 2026
Item 9 of the provisional agenda¹

**UPDATED REPORT ON THE ISSUE OF ALTERNATIVES IN POLYURETHANE FOAM
MANUFACTURING WITH A FOCUS ON SMALL AND MEDIUM-SIZED ENTERPRISES,
IN PARTICULAR FOR SPRAY AND INSULATING FOAM APPLICATIONS
(DECISION 96/53(c))**

Introduction

1. At its 93rd meeting, the Executive Committee requested a paper on alternatives in the polyurethane (PU) foam manufacturing sector, which the Secretariat presented at the 94th meeting.² The paper covered HCFC phase-out projects assisted by the Multilateral Fund, implementation experience and best practices, adopted alternatives with low global-warming potential (GWP), blowing agent prices and availability, identified challenges and regional feedback. Discussions at the 94th meeting highlighted concerns over the limited availability and high cost of hydrofluoroolefins (HFOs), suitability of alternative technologies for certain applications and economic implications for Article 5 countries, including risks of non-compliance and potential penalty payments, with small and medium-sized enterprises (SMEs) facing particular difficulties and uneven progress across regions.

2. Consequently, the Committee requested the Secretariat to prepare, in cooperation with the implementing agencies, an updated paper for the 95th meeting, covering technology availability, alternative prices in ongoing projects, access programmes, and barriers faced by local systems houses; and to further update the report for the 96th meeting with focus on SMEs in spray and insulation foam applications (decision 94/58(b) and (c)). Following the 95th meeting update,³ members acknowledged improved access to alternatives, while noting persistent challenges for SMEs, uneven progress across countries, and ongoing concerns on pricing and sustainability, with several members calling for continued follow-up to determine whether additional Committee action would be needed.

¹ UNEP/OzL.Pro/ExCom/98/1

² UNEP/OzL.Pro/ExCom/94/58

³ UNEP/OzL.Pro/ExCom/95/85

3. At the 96th meeting, the Secretariat presented an updated report on low-GWP alternatives in the PU foam sector with focus on SMEs, particularly for spray and insulation foam applications, based on input from UNDP, UNIDO, and the World Bank.⁴ The Committee welcomed progress on availability and pricing, while some members expressed interest in supercritical carbon dioxide (CO₂) technology for spray foam, noting its performance advantages despite currently limited access given that the supplier rents rather than sells the modified equipment. Other members raised concerns over the technical stability, safety, and sustainability of HFOs, requested further information on risk-assessment mechanisms, and reaffirmed the Committee's technology-neutral approach and countries' flexibility under the Kigali Amendment. Acknowledging the uneven progress and ongoing challenges, the Committee requested the Secretariat to further update the report for consideration at the 98th meeting (decision 96/53).

Update on HCFC phase-out and HFC phase-down projects in the polyurethane foam manufacturing sector assisted by the Multilateral Fund

4. Paragraphs 4 to 8 of document UNEP/OzL.Pro/ExCom/94/58 present detailed information on all projects approved up until the 94th meeting in the PU foam sector under both the HCFC phase-out management plans (HPMPs) and the Kigali HFC implementation plans (KIPs) and the associated consumption addressed. Since then, the following projects have been approved:

- (a) At the 95th meeting, as part of the KIP for Nigeria, a technical assistance project to phase out 472.50 mt or 375,165 CO₂-equivalent (CO₂-eq) tonnes of HFC-365mfc at two PU foam enterprises to adopt cyclopentane, HFO, and other low-GWP alternatives; and
- (b) At the 96th meeting, as part of the KIP for Egypt, a PU foam sector plan to phase out 161.17 mt or 166,579 CO₂-eq tonnes of HFCs pure and contained in pre-blended polyols to adopt cyclopentane, HFOs and other low-GWP alternatives.

5. Furthermore, PU foam sector plans for the Plurinational State of Bolivia and Ecuador have been submitted to the 98th meeting in line with decision 96/52, to phase out the use of HFCs contained in pre-blended polyols, primarily by SMEs, through the adoption of HFO-based technology.

Update on the availability and prices of alternatives with low global-warming potential and related challenges faced by spray foam manufacturers, including small and medium-sized enterprises

6. To update the reports contained in documents UNEP/OzL.Pro/ExCom/94/58, UNEP/OzL.Pro/ExCom/95/85 and UNEP/OzL.Pro/ExCom/96/60, the Secretariat requested information from the implementing agencies involved in PU foam projects. Specifically, agencies were asked to provide their overall assessment of how the availability and prices of low-GWP technologies in the PU foam sector in Article 5 countries had evolved since this information was first collected prior to the 94th meeting, including any regional differences identified; any additional (not previously reported) challenges to the adoption of low-GWP technologies by SMEs in the PU foam sector, in particular for spray and insulating foam applications (including technical issues, safety or environmental concerns, and other barriers to the adoption of the technology), and how those have been addressed; and an update by the currently assisted countries. The information provided by the implementing agencies is presented below.

UNDP

7. UNDP reported that the availability and pricing of low-GWP technologies in the PU foam sector in Article 5 countries remained largely unchanged from those described in the previous report, with persistent regional disparities and technology-specific cost barriers. In some countries, temporary logistical issues have been observed, including delays in HFO supply linked to tank returns from the main manufacturer. These

⁴ UNEP/OzL.Pro/ExCom/96/60

issues are being monitored through regular coordination among suppliers, systems houses, and national ozone units (NOUs) and have not resulted in structural supply constraints. Market uncertainty has been noted following one supplier's corporate transition of its blowing agent manufacturing to a different brand, although no concrete impact on substance availability or pricing has been observed to date.

8. The prices of HFO-based systems continue to be the main challenge for SMEs, affecting both the blowing agents and formulated systems, and limiting uptake where other alternatives are not technically viable. Additional barriers include logistical and supply-chain constraints, such as volume-dependent procurement and longer delivery times, particularly in markets relying on regional rather than local distribution networks.

9. Technical challenges related to foam performance, density, and formulation optimization for some enterprises are being addressed through ongoing technical assistance. Safety and environmental considerations also influence technology choices, with SMEs often favoring pre-blended systems that reduce on-site handling risks and require fewer modifications.

10. Overall, unresolved challenges relate primarily to the affordability and long-term competitiveness of HFO-based technologies for SMEs. Potential ways forward include further market consolidation and increased volumes to reduce prices, continued technical assistance to lower the operating costs, and closer engagement with suppliers to clarify future supply strategies and customer support following recent market restructuring.

11. UNDP also provided updates on PU foam projects implemented in 10 countries. In five of those (Brazil, Chile, Costa Rica, Egypt and Panama), as confirmed in previous reports, PU foam projects have been completed and low-GWP alternatives, such as hydrocarbons (HCs), HFOs and methyl formate, are now available in respective local markets. One country (Mexico) is starting its conversion from HFCs to HFOs with a confirmed availability of the blowing agent. Regarding the remaining four countries:

- (a) In Colombia, the situation following completion of the PU foam project remains consistent with that described in the previous report, with HFOs available but continuing to face pricing challenges. One systems house has reported temporary delays in HFO supply due to logistical constraints related to the return of tanks. To monitor and address these issues, periodic coordination meetings are being held among the main HFO supplier, the systems houses, and the NOU;
- (b) In India, the situation following completion of the PU foam project remains consistent with that described in the previous report. HFO-based technologies continue to face barriers to widespread adoption due to their high cost, with prices of approximately US \$24/kg for pure substances and 30–50 per cent higher costs for fully formulated systems, compared with HFC-based alternatives. In contrast, pre-blended HCs and methyl formate have achieved broader market acceptance, supported by consolidated supply chains and significantly lower prices (approximately US \$2.00/kg for HC-based systems and US \$2.10/kg for methyl formate), making them more attractive options for SMEs;
- (c) In Malaysia, the PU foam project has been completed, but HFO availability remains limited. Most enterprises supported under the HPMP selected pre-blended HCs to avoid significant capital investments, while non-assisted enterprises continue to rely largely on HFC-based systems. HFOs are supplied mainly on a quotation-based, business-to-business basis, with limited local supplier presence and prices dependent on volumes (US \$18–30/kg for pure substances and US \$25–40/kg for formulated systems), resulting in their continued perception as niche products; and

- (d) In Uruguay, the PU foam project was cancelled at the 94th meeting.⁵ The Executive Committee requested UNDP to provide, at the 98th meeting, an update on the technology selected by foam-manufacturing SMEs and the availability of HFO-based technology in the foam sector (decision 94/13(b)). Accordingly, UNDP reported that two systems houses present in the region were now offering HFO-based systems, although their higher cost and limited shelf life still limited widespread adoption.

12. It was further indicated that in June 2025, an international systems house in Argentina announced that it had started the formulation of HFO-based PU systems for distribution in the region, but that higher costs than HFC-based systems were still a barrier.

UNIDO

13. UNIDO reported general improvement in the availability of low-GWP technologies in the PU foam sector in Article 5 countries, with most alternatives now technically accessible through imports or systems houses, and fewer cases of complete unavailability than previously reported. Pre-blended polyol systems continue to be critical in ensuring access for SMEs that lack in-house formulation capacity. However, widespread adoption of low-GWP technologies continues to be constrained by economic, logistical and practical barriers, especially for smaller enterprises.

14. Price remains the main limiting factor, with HFO-based technologies being consistently more expensive than HCs or water-based alternatives across all regions, despite some gradual cost reductions. HC technologies are generally affordable and widely available, but their uptake is often restricted by safety requirements and need for upfront investment. Clear regional differences persist: Latin America still faces high HFO prices, limited suppliers and long delivery times, with some enterprises postponing or abandoning conversions due to those constraints; in Asia, large enterprises are transitioning to HCs more rapidly than SMEs that tend to transition to other technologies; in the Middle East and North Africa, there is heavy reliance on HCs wherever safety investments are feasible, given the irregular and costly HFO supply; and in Africa, access to technologies has improved, although import dependence, foreign exchange limitations and limited technical capacity continue to impede widespread adoption by SMEs.

15. Some of the issues that enterprises assisted by UNIDO continue to face are the high capital and safety investment needed for HC technologies, especially for SMEs; and persistent supply-chain fragility for HFOs, characterized by reliance on few suppliers, long lead times and price volatility, along with market uncertainty and concerns about future regulatory changes. Potential ways forward proposed by UNIDO include stronger and sustained technical support, aggregated or long-term procurement approaches, targeted financing for safety investments, and additional demonstration projects to reduce risk perception and build confidence in long-term viability of low-GWP solutions.

16. UNIDO provided the following updates on PU foam projects implemented /to be implemented in five countries:

- (a) In Argentina, adoption of HFO-1233zd(E) is currently transitioning from a trial phase to a more regular supply arrangement. Supply disruptions were avoided in the second quarter of 2025. The sole supplier is exploring alternative supply-chain configurations to reduce reliance on ton tanks, the return and rotation of which continues to create logistical challenges. Discussions are ongoing regarding the establishment of a local fractionation scheme, which could improve short-term availability but raises concerns about intermediation costs and lack of competitive pricing in a single-supplier scenario. UNIDO

⁵ As described at the 94th meeting, out of the 21 enterprises included in the plan, one converted to cyclopentane, three to HFO, and 17 did not complete conversions due to the lack of availability of HFO-based systems; unused balances were returned to the Fund.

also reported uncertainty surrounding international regulatory frameworks, particularly the potential classification of some HFOs as per- and polyfluoroalkyl substances (PFAS), which could affect the transition pathway of SMEs in applications where no other viable alternatives currently exist;⁶

- (b) In Ecuador, HFC-based pre-blended polyol systems are readily available through established import channels, and HFO-1233zd(E)-based systems are increasingly sourced from Colombia, Panama, and Asia, with several enterprises already conducting or preparing validation trials for spray foam and discontinuous panels. Unlike countries with local systems houses, Ecuador relies on specialized importers and regional distributors, which has facilitated access to HFO-based formulations and improved delivery times compared to previous years. While cost differences still challenge SMEs, supply conditions and technical support have improved since the HCFC phase-out. Ecuador has submitted to the 98th meeting, under decision 96/52, a sector-wide PU foam plan to phase out HFC-based polyols and adopt HFOs. Cyclopentane-based systems remain limited for SMEs due to safety, infrastructure, and high capital investment required;
- (c) In Nigeria, commercial refrigeration enterprises continue to use HFO-based technologies; however, prices and exchange rates have fluctuated in recent years, prompting enterprises to adopt various strategies to maintain operations;
- (d) In Pakistan, the PU foam conversion project in thermoware plants has been completed, with beneficiary enterprises adopting pre-blended cyclopentane, supported in part through co-financing; no issues related to availability or price were reported; and
- (e) In Tunisia, the conversion to cyclopentane that was completed in 2021 remains operational and generally stable, with only minor delivery delays attributed to the international situation and no significant impact to date. The average price of cyclopentane is approximately US \$3.35/kg. In addition, one other enterprise completed its conversion to HFO-1233zd(E) in January 2025; however, availability and pricing challenges persist. Direct commissioning from the technology supplier is expected to substantially reduce prices compared to those obtained from intermediaries.

World Bank

17. The World Bank provided updates on PU foam projects implemented in four countries. With regard to the availability of HFO blowing agents, consultations with producers in China indicated that there were currently no plans to establish additional production capacity. Prices for HFO-1233zd(E) and HFO-1336mzz(Z) remain high, with foam formulations based on HFO-1336mzz(Z) being particularly costly.

18. Systems houses in China are continuing research and development efforts to improve foam performance and reduce thermal conductivity, including work on gas composition within foam cells, radiative heat transfer, and optimization of the PU matrix. One area of research involves the combined use of blowing agents, with cyclopentane as the primary blowing agent supplemented by a low-boiling-point agent, while other efforts focus on optimizing raw materials (such as polyols and catalysts) and cell structure through improved control of the foaming process. Overall, previously reported challenges persist, notably the high cost of HFOs and limitations related to their physical properties.

⁶ Also discussed in document UNEP/OzL.Pro/ExCom/98/6 on projects with specific reporting requirements.

Additional information obtained by the Secretariat

19. The Secretariat held discussions with several suppliers in the margins of other meetings. Information provided by one supplier indicates that global HFO production continues to improve with capacity growth in North America and Asia. HFO availability in Article 5 countries also depends on local logistics and commercial infrastructure, packaging formats, customs and regulatory processes, country and segment/sector specific phase-down programmes, and the presence of trained, compliant downstream operators and local technical support. Larger Article 5 countries could serve as supply and knowledge hubs for neighboring countries, but their national supply chains would also need to be strengthened.

20. HFO costs and pricing are market- and segment-specific, driven by feedstock and energy input, production scale and location, logistics, freight fares, duties, taxes, and compliance and technical-support requirements. In countries without local production, delivered costs are often determined by logistics, local infrastructure, fiscal regimes, and permit-issuing rather than by molecule economics, especially where quota systems, import licensing, or fragmented distribution channels exist. Prices are typically higher during early adoption phases, declining over time as scale improves.

21. In the case of Argentina, supply infrastructure, ban enforcement, and user engagement are in place. Coordination with the Government, NOU, and industry has defined a viable transition pathway and ensured technical feasibility. HFO supply has been successfully introduced, with the first import validating the country's technical, regulatory, and logistical readiness. Logistics remain critical, as complex supply chains involving specialized assets, international transport, customs processes, and return cycles influence availability and timelines. Broad adoption is expected in 2026, transitioning from project-based supply to a stable, self-sustaining market. Over time, additional suppliers may appear, strengthening long-term market sustainability.

22. Key lessons include the importance of strong government and industry engagement, and sufficient, predictable demand to reduce supply risks and improve logistics. Developing in-country capabilities (e.g., storage and downpacking) is essential to broader-scale adoption. Training and technical support across the value chain are critical for the safe and compliant adoption of new technologies. Supply-chain constraints must be addressed early to avoid delays, and robust regulatory enforcement is necessary to sustain the transition, including preventing illegal trade and ensuring a transparent, rules-based market.

Observations

23. Regarding the availability of low-GWP alternatives, HCs, methyl formate, methylal and water-based technology continue to be available and used by many PU foam enterprises, varying with their size, characteristics, and applications. HFOs have become available in an increasing number of countries for which information was reported (e.g., Brazil, Colombia, Costa Rica, China, Chile, Ecuador, Egypt, India, Indonesia, Panama, Thailand, and Viet Nam). In Argentina, the adoption of HFO-1233zd(E) is currently transitioning from a trial phase to a more regular supply arrangement, with local systems houses maintaining sufficient operational inventories, and the supplier exploring alternative supply-chain configurations to improve medium-term continuity.

24. Significant price variations of alternative technologies persist both within countries and internationally. Based on the updated information, several countries have seen a gradual decrease in HFO-1233zd(E) prices, with some reporting prices below US \$20.00/kg (e.g., Brazil, China, Colombia, Ecuador, Indonesia, Thailand and Viet Nam).

25. Challenges to the adoption of low-GWP alternatives by SMEs continue to include high capital investment and safety constraints associated with the use of HCs, particularly for spray foam applications, as well as the high cost and limited commercial availability of HFOs in several countries.

26. Global HFO production capacity has increased in recent years, but availability in specific countries depends also on local logistics, supply chains, customs and regulatory processes, country and segment/sector specific phase-down programmes, as well as other variables.

RECOMMENDATION

27. The Executive Committee may wish to note document UNEP/OzL.Pro/ExCom/98/56 containing the updated report on the issue of alternatives in polyurethane foam manufacturing with a focus on small and medium-sized enterprises, in particular for spray and insulating foam applications (decision 96/53(c)).
