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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Ninety-sixth Meeting
Montreal, 26–30 May 2025
Item 11 of the provisional agenda[1]

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 94/58(c))

Introduction

1. In response to a request made by the Executive Committee at its 93rd meeting, the Secretariat prepared for the 94th meeting a "Paper on the issue of alternatives in polyurethane foam manufacturing" (document UNEP/OzL.Pro/ExCom/94/58), providing an overview of HCFC phase-out projects approved in the polyurethane (PU) foam sector that had been assisted by the Multilateral Fund, experience gained in the implementation of those projects, best practices applied, information on each alternative with low global-warming potential (GWP) adopted in the PU foam sector through the funded projects and on the prices and availability of blowing agents, identified challenges, and feedback on the adoption of those technologies by region.

2. During the discussions at the 94th meeting, one member noted the persistently low availability and high prices of HFOs, questioned the sustainability of converting to other alternatives, some of which were deemed by enterprises to be unsuitable for certain applications, and emphasized the broader economic repercussions for Article 5 countries, the risk of non-compliance with their obligations under the funding Agreements with the Executive Committee, and subsequent penalty payments. Persisting difficulties faced by small- and medium-sized enterprises (SMEs) regarding HFO availability were acknowledged, with two members noting that some countries had achieved successful transitions, while implementation appeared to be more difficult for others, with progress levels varying across and within regions.

3. Following those discussions, the Executive Committee decided to request the Secretariat, inter alia:

(a) In conjunction with the implementing agencies, to prepare a paper, for consideration by the Committee at the 95th meeting, that updated information on the availability of technologies;

[1] UNEP/OzL.Pro/ExCom/96/1

prices of already selected alternatives in not-yet-completed PU foam sector projects in SMEs; programmes to facilitate access to low-GWP alternatives; and existing barriers to access those programmes by the local systems houses in Article 5 countries; and

(b) To update its report contained in document UNEP/OzL.Pro/ExCom/94/58 for consideration at the 96th meeting, with a focus on SMEs in the PU foam manufacturing sector, in particular for spray and insulating foam applications[2].

4. At the 95th meeting, in response to decision 94/58(b) and following consultations with implementing agencies and representatives of three HFO production enterprises, the Secretariat presented the "Update on the information on alternative technologies in the PU foam manufacturing sector for Article 5 countries" (document UNEP/OzL.Pro/ExCom/95/85), including on technology availability and prices, programmes to facilitate access to low-GWP alternatives, and barriers to accessing those programmes by local enterprises. In considering the document, one member noted that while some progress had been made in improving access to alternative technologies for Article 5 countries, the issue had not yet been fully resolved. Another member appreciated that some countries had opted for alternatives other than HFOs, while a third one clarified that the document aimed to help SMEs adopt non-flammable and non-corrosive alternatives. One member stressed the need for more detailed data to help Article 5 countries assess the sustainability of adopting HFO technology. Another acknowledged that here had been progress, although uneven among countries, and highlighted significant price differences in alternatives, supporting an update from the Secretariat at the 96th meeting to determine whether further action was required by the Executive Committee. Another member, acknowledging progress in ensuring better prices for HFOs, but noting that the issue had not been resolved, considered it important for the Committee to continue to follow up on the matter at the 96th meeting.

5. Following those discussions, the Executive Committee decided, inter alia:

(a) To consider the information contained in document UNEP/OzL.Pro/ExCom/95/85 while discussing the issue of alternatives in the PU foam sector; and

(b) To note that the Secretariat would update the report contained in document UNEP/OzL.Pro/ExCom/94/58 for consideration at the 96th meeting, in line with decision 94/58.

6. Accordingly, the present document was prepared in line with decisions 94/58(c) and 95/85(c), based on written input provided by UNDP, UNIDO and the World Bank outlining their experiences with implementing projects in the sector. It represents an update to documents UNEP/OzL.Pro/ExCom/94/58 and UNEP/OzL.Pro/ExCom/95/85 and should be read in conjunction with both those documents.[3]

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

7. Paragraphs 4 to 8 of document UNEP/OzL.Pro/ExCom/94/58 present detailed information on the number of projects approved in the PU foam sector under HCFC phase-out management plans (HPMPs) and KIPs and the associated consumption addressed. Since then, at the 95th meeting, the Executive Committee approved, as part of the KIP for Nigeria, a technical assistance project to phase out 472.50 mt or 375,165 CO_2-equivalent (CO_2-eq) tonnes of HFC-365mfc at two PU foam enterprises to adopt cyclopentane, HFO, and other low-GWP alternatives. At the 96th meeting, the Executive Committee is also considering projects in the PU foam sector submitted as part of the KIP for Egypt.

[2] Decision 94/58(b) and (c)
[3] Included as background documents under agenda item 11.

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

8. To update the reports contained in documents UNEP/OzL.Pro/ExCom/94/58 and UNEP/OzL.Pro/ExCom/95/85, the Secretariat requested information from the implementing agencies involved in PU foam projects. Specifically, agencies were asked to provide updates on the current availability and pricing of low-GWP technologies in Article 5 countries; key challenges faced by SMEs in adopting low-GWP technologies in the PU foam sector, particularly for spray and insulating foam applications; measures taken to address those challenges, including technical issues, safety and environmental concerns and other barriers; and the remaining unresolved challenges and potential strategies or ideas for overcoming them. The information provided by the implementing agencies is presented below.

9. UNDP provided updates on PU foam projects implemented in eight countries as follows:

(a) In Brazil, the PU foam sector plan was completed with the conversion of large enterprises to cyclopentane and assistance through systems houses to convert 200 downstream users, including SMEs, to methyl formate, water-based systems, methylal and HFOs. Challenges reported in previous meetings (e.g., availability of HFCs at competitive prices) persist, but low-GWP alternatives have been adopted by end users. HFOs are currently available, with prices in the range of US $14.00–18.00 per kilogram (kg);

(b) In Chile, the PU foam project, including SMEs, was completed. As previously reported, large users (i.e., continuous panel manufacturers) use cyclopentane, and medium and small users, including spray foam users, use HFOs, water, methyl formate and HFCs. All technologies are imported and there are no supply issues with fully formulated polyols containing HFOs, methyl formate or HFCs, but there have been some delays with HFO quoting and shipping. The prices of polyols fully formulated by the Chilean systems houses continue to be US $3.30/kg for water-based systems and US $5.50/kg for HFO-based blends. The differences between polyols formulated with HFCs and HFOs are 5 per cent or higher for spray applications, and 10 per cent for injected applications;

(c) In Colombia, the PU foam project, including SMEs, was completed. While there were no issues with HFO availability, pricing challenges persist, affecting the procurement of catalysts and other additives required for developing HFO-based polyol formulations. No variations have been reported on prices (US $17.00–19.00/kg for HFOs). One systems house reported supply delays due to logistical constraints of the main HFO producer;

(d) In Costa Rica, the PU foam project was completed (it did not include SMEs). The country imports small quantities of HFO-based systems which appear to be in stable supply; as previously reported, no issues were identified;

(e) In Egypt, the PU foam project including SMEs was completed. Large enterprises adopted cyclopentane, readily available in the market. SMEs use different technologies based on the systems house provider, including HFCs, methyl formate, and HFOs. The only challenge SMEs initially faced was in the higher prices of alternatives compared to HCFC-141b; however, this issue was resolved due to a greater availability of alternatives;

(f) In India, the PU foam sector plan, including SMEs, was completed with the conversion of 158 enterprises to cyclopentane, methyl formate, and in several cases to HFOs. The prices remain as reported at previous meetings: US $24.00/kg for HFOs; US $2.00/kg for cyclopentane pure or US $3.00/kg pre-blended; and US $2.00/kg for methyl formate and water-based systems;

(g) In Mexico, activities involving systems houses approved under the KIP for the PU foam sector plan have started. SMEs are included in the project, and alternatives to HFC-based systems will be analyzed; and

(h) In Uruguay, 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.

10. UNIDO provided updates on PU foam projects implemented in five countries as follows:

(a) In Argentina, while one supplier continued to report inability to supply HFO for the domestic market before 2026, two others reconfirmed their capacity for immediate supply, with the possibility of reducing delivery times for future purchases from the initially estimated 90 to 120 days. Local systems houses confirmed having found an affordable price for the transition; nearly all of them have placed first purchase orders for HFOs, with the first imports to be delivered in one-tonne containers that must be returned for reuse. One supplier reported that they could not guarantee quantities demanded by the systems houses due to a shortage of containers for shipping, which remains to be solved. While some enterprises still use HFCs as alternatives to HCFC-141b on a transitional basis, the Government reiterated that this was not a long-term solution, and noted that the country still needed the support of HFO-producing countries to ensure the local supply;[4]

(b) In Ecuador, cyclopentane-based systems were used mainly for commercial refrigeration and panel manufacturing (continuous and discontinuous). HFO-based systems have been tested by some enterprises with promising results, and others are planning to conduct trials in the short term. SMEs rely on distributors linked to foreign systems houses. Some distributors still hold inventories of HFC-based pre-blended polyols, expected to last until 2026. The price of HFC-based polyols is US $4.00/kg, and that of HFO-based polyols is US $7.00/kg. Prices have recently increased due to higher international freight costs and national tariff adjustments on imported chemical inputs. Some of the issues faced by SMEs include the availability and relatively lower costs of HFC-based systems that have delayed their transition to HFO-based technologies, safety concerns, and high capital investment required to adopt hydrocarbons (HCs);

(c) In Morocco, the conversion to cyclopentane had not yet been completed; consequently, no update was provided on substance availability and price. In general, systems based on cyclopentane (and methyl formate) have more stable procurement channels and offer the lowest cost (€2.63–2.66/kg of foam compared to €3.28/kg for HFO-1233zd(E) systems and €3.49/kg for HCFC-141b systems).[5] HFO-based systems also face supply-chain risks;

(d) In Pakistan, the price of bulk HFO-1233zd(E) is US $20.00/kg, bulk HFO-1336mzz(Z) is US $30.00/kg, and HFO-based polyols are estimated at US $4.75/kg. Some challenges faced with HFOs are that raw materials need to be maintained at 20–25°C before being transferred to the foaming or spray-foaming machine to avoid processing issues; and that formulations using HFO-1233zd(E) (or methyl formate) contain lower levels of blowing agent, which can cause surface bulging in thermoware products—a problem that remains unresolved; and

[4] Also discussed in document UNEP/OzL.Pro/ExCom/96/11 on projects with specific reporting requirements

[5] Based on the Euro to United States dollar exchange rate of 1:1.13 (on 5 May 2025), these prices correspond to US $2.98–3.01/kg for cyclopentane-based foam, compared to US $3.71/kg for HFO-1233zd(E) systems and US $3.95/kg for HCFC-141b systems.

(e) In Tunisia, a PU foam enterprise waited several months to receive a 28 kg sample of HFO-1233zd(E) for testing it in converted production lines. The sample, obtained through an intermediary, cost €67.44/kg—an unsustainable price, especially for SMEs. In contrast, purchasing directly from the producer in bulk (e.g., 9,000 litres) could reduce the cost to around €16.00/kg.[6] The enterprise is now in direct contact with the producer, who is expected to ensure regular supply at this more affordable rate.

11. The World Bank provided updates on PU foam projects implemented in four countries as follows:

(a) In China, the implementation of the PU foam sector plan, including SMEs, is ongoing. Prices of alternatives are US $12.00–16.00/kg for HFO-1233zd(E), US $30.00–35.00/kg for HFO-1336mzz(Z), and US $8.00–10.00/kg for HFC-245fa, given that China is the main supplier of HFOs and HFC-245fa to the region. One local systems house developed its own supercritical carbon dioxide (CO_2) spray-foam technology in cooperation with a local university and began manufacturing both the formulation and the equipment to apply it, reporting the following findings:

(i) Supercritical CO_2 can be used alone or with small amounts of HFCs or HFOs. While it may produce better quality foam than plain water-blown foam, it would still need additional HFO and HFC in the formulation to meet China's standard for insulation value; albeit at a lower fraction of HFO or HFC than normal formulations without liquid CO_2;

(ii) A spray-foam machine was developed for this technology with three raw material inputs (i.e., MDI,[7] formulated polyol based either on water, HFO, or HFC, and liquid CO_2). The machine would transform liquid CO_2 into supercritical CO_2 as one additional input into the spray gun;

(iii) Technicians would require additional training on machine use, as it requires continuous application to ensure a uniform mixture of the three inputs;

(iv) The systems house currently rents a unit to contractors using their formulated system. The units are not for sale due to concerns about reverse engineering, which would prevent the recovery of an estimated investment into research and development;

(b) In Indonesia and Viet Nam, the projects including SMEs were completed. No technology availability issues were reported; however, the cost of materials is still the main deciding factor in technology choice. HFOs and HFC-245fa prices in China can be used as reference, adding slight increases due to transportation, handling, and other factors; and

(c) In Thailand, the PU foam project including SMEs is ongoing. The cost of HFO-based formulations has been the main factor preventing their widespread adoption in the spray foam sector. The price of HFO-1233zd(E) is around US $18.00/kg, and HFO-1336mzz(Z) around US $35.00/kg. The estimated cost increments of the two HFO formulations, compared to HCFC-141b systems, are 70.6 and 127 per cent, respectively. One factor affecting the cost is the molecular weight of HFO-1336mzz(Z) (164g/mol), which is higher than that of HFO-1233zd(E) (130.5 g/mol) and thus requires more HFO-1336mzz(Z) in weight for the system with a similar mole fraction.

[6] Corresponding to of US $76.31/kg and US $18.11/kg, respectively.
[7] Methylene diphenyl diisocyanate

Observations

12. UNDP, UNIDO and the World Bank provided updates on PU foam projects that were either completed or being completed in 16 countries as part of HPMPs, and in one as part of a KIP. Of those projects, 16 included SMEs; 11 have been completed; one has been closed; and five are still ongoing.

13. Regarding the availability of low-GWP alternatives, the reported updates have not shown major variations from the information presented in previous reports: HCs, methyl formate, methylal and water-based technology continue to be available and used by many PU foam enterprises, depending on their size, characteristics, and application. HFOs have become available in an increasing number of countries (e.g., Brazil, Colombia, Costa Rica, Chile, Indonesia, Thailand, and Viet Nam). Other countries, however, have reported that despite substantive progress in discussions and logistical arrangements with suppliers, HFOs cannot be considered available at a commercial scale yet (e.g., in Argentina and Tunisia).

14. Regarding pricing, as previously reported, there are significant price variations among alternatives within the same country, as well as differences in the prices of identical alternatives across countries. Based on the updated information, several countries have seen a gradual decrease in HFO-1233zd(E) prices (e.g., Argentina, Thailand), with some reporting prices below US $20.00.kg (e.g., Brazil, China, Colombia, Indonesia, Thailand and Viet Nam).

15. Some of the main challenges to the adoption of low-GWP alternatives by SMEs continue to be associated with large investments and safety impediments associated with the use of HCs, especially in spray foam application, and the price and insufficient commercial availability of HFOs in several countries.

16. Regarding spray-foam technologies that could be suitable for SMEs, the World Bank reported that a systems house in China had developed a supercritical CO_2 technology, which addressed the safety concerns linked to flammable alternatives as well as performance limitations of water-based systems. The Secretariat notes that this technology had previously been successfully demonstrated under a Multilateral Fund project implemented by the Government of Japan in Colombia.[8] The demonstration confirmed that supercritical CO_2 was a technically viable replacement for HCFC-141b in spray foam applications, offering better performance than conventional CO_2 (water)-based foam. However, it was also noted that it had a higher thermal conductivity than HCFC-141b, which might require thicker foam and lead to increased operating costs. A key barrier was identified in the form of high capital costs of modifying the spray equipment and operating costs of proprietary polyols. It is noted that in the case of the Chinese systems house, the enterprise rents the foaming machines to be used with its formulations, potentially eliminating the capital cost burden for foam users.

RECOMMENDATION

17. The Executive Committee may wish:

(a) To note document UNEP/OzL.Pro/ExCom/96/60 including the updated report on the issue of alternatives in polyurethane (PU) foam manufacturing with a focus on small- and medium-sized enterprises, in particular for spray and insulating foam applications (decision 94/58(c)); and

(b) To consider the information contained in the document referred to in subparagraph (a) while discussing the issue of alternatives in the PU foam manufacturing sector.

[8] Final report available in document UNEP/OzL.Pro/ExCom/71/6/Add.1.