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THE MULTILATERAL FUND FOR THE
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**PAPER ON THE CHALLENGES IN IMPLEMENTING CONVERSION PROJECTS IN THE
REFRIGERATION, AIR-CONDITIONING AND HEAT PUMP SECTOR DUE TO
SUPPLY-CHAIN ISSUES AND POSSIBLE WAYS TO ADDRESS THE CHALLENGES
(DECISION 96/59)**

Background

1. The transition to low global-warming potential (low-GWP) refrigerants in the refrigeration, air-conditioning and heat pump (RACHP) sector is a central pillar of countries' efforts to phase down hydrofluorocarbons (HFCs) under the Kigali Amendment to the Montreal Protocol. Issues related to supply chains are linked with the implementation of manufacturing conversion projects supported by the Multilateral Fund.
2. At its 96th meeting, the Executive Committee discussed the challenges faced by countries in the implementation of Kigali HFC implementation plans (KIPs) particularly those related to the supply chain for alternatives and the equipment components of the RACHP sector. Those challenges were summarized in document UNEP/OzL.Pro/ExCom/96/2² of Secretariat's activities. During the same meeting, members emphasised the need to look at supply chain issues in a holistic manner, exploring supply chain issues further and that efforts should focus on identifying both challenges and solutions.
3. Following the discussions, the Executive Committee requested the Secretariat to prepare for its consideration at the 98th meeting, in consultation with bilateral and implementing agencies, a paper on the challenges on availability, price, technical specifications and other barriers, as relevant, experienced by Article 5 countries in implementing conversion projects in the RACHP sector due to supply-chain issues

¹ UNEP/OzL.Pro/ExCom/98/1

² Paragraphs 8 through 10 of document UNEP/OzL.Pro/ExCom/96/2 summarize feedback collected by the Secretariat at the inter-agency coordination meetings (IACM) and as requested by the 95th meeting under the agenda item "Other matters."

related to alternative refrigerants, parts and components, and equipment, as well as possible ways to address those challenges.

4. This paper was prepared through consultations with bilateral and implementing agencies, drawing on the discussions at two inter-agency coordination meetings (IACM). The Secretariat additionally conducted several rounds of in-person and online discussions with industry representatives from both Article 5 and non-Article 5 countries, including technology providers, component manufacturers and industry associations.

Scope of the paper

5. The paper's scope is limited to supply chain challenges on ongoing conversion projects in the refrigeration and air-conditioning (RAC) manufacturing sectors that have been implemented over the past three years as part of the KIPs. Feedback was collected through the relevant implementing agencies, covering 22 projects, including three projects targeting small- and medium-sized enterprises (SMEs), across 13 countries: Argentina, Colombia, Costa Rica, Egypt, India, Indonesia, Jordan, Lebanon, Malaysia, Morocco, Nigeria, Sri Lanka, and Tunisia. Table 1 below presents the distribution of these projects by sub-sector and region from which information and feedback were sought.

Table 1. Distribution of conversion projects by region and sub-sector

Region	Residential air-conditioning	Commercial air-conditioning	Commercial refrigeration	Domestic refrigeration	SMEs manufacturing	Total
Africa	2	—	1	2	1	6
Asia and the Pacific	—	1	3	1	—	5
Latin America and Caribbean	1	1	2	—	1	5
West Asia	2	—	2	1	1	6
Total	5	2	8	4	3	22

6. It was noted through discussions with bilateral and implementing agencies that supply chain challenges also extend to final RACHP equipment and services. However, in keeping with the specific mandate established under decision 96/59, the Secretariat has focused this paper exclusively on ongoing conversion projects, with the broader product and services dimension highlighted, under the Secretariat's observations section of the document, for possible future work.

7. To facilitate a structured analysis, the Secretariat designed a questionnaire to solicit feedback from bilateral and implementing agencies on three main elements examined: availability, price, technical and other issues. The questionnaire was structured to collect information across each RACHP sub-sector, with dedicated section for SMEs and feedback from national ozone units (NOUs), collected through the agencies. The questionnaire used is provided in annex I to the present document.

Key findings from conversion projects

A. Availability of refrigerants and components

8. Across all RACHP sub-sectors, difficulties in securing reliable and timely access to alternative refrigerants and their compatible components constitute one of the most significant barriers to conversion project implementation.

Domestic refrigeration

9. Conversion projects in the domestic refrigeration manufacturing sub-sector have not yet reached the implementation stage in most cases, which limits a full practical assessment of availability constraints under real project conditions. However, the likelihood of facing availability issues is considered very limited, given the maturity of the technology over many years across numerous countries, including Article 5 countries. As projects progress toward implementation, any availability challenges that may emerge are expected to relate to securing a sustained supply of hydrocarbon (HC) refrigerants and compatible compressors, which might be relevant to some and not all Article 5 countries. Monitoring of availability issues will therefore be essential as these projects advance.

Commercial refrigeration

10. Commercial refrigeration conversion projects face considerable availability constraints, particularly given the diversity of system types and charge sizes involved. A central challenge is the high dependence on imports for alternative refrigerants and key components such as compressors and controllers, compounded by the limited local availability of certified components for large-scale systems requiring carbon-dioxide (CO₂) or HC-based solutions. Supply gaps are further aggravated by import delays, shipping constraints, and customs clearance issues that directly affect project timelines and delivery schedules.

11. Beyond the immediate supply chain constraints, the sector also faces structural weaknesses that undermine long-term conversion efforts. Limited local refrigerant reclamation infrastructure restricts the ability to recover and reuse refrigerants during conversion activities, adding both cost and logistical burden to projects. Equally concerning are the weak regulatory mechanisms to prevent the circulation of spurious or non-conformant refrigerants, including significant gaps in supplier registration, tracking systems, and enforcement capacity.

Residential air-conditioning

12. The residential air-conditioning sub-sector has experienced moderate improvement in the availability of HFC-32, the primary alternative refrigerant being adopted in this category, though constraints persist. While HFC-32 availability is generally adequate, it remains largely dependent on imports and a limited supplier base, leaving the sector vulnerable to supply disruptions. This dependence has been further compounded by a historical lack of HFC-32 compressors in the larger capacity ranges required by some local manufacturers, which has constrained conversion timelines and slowed the pace of transition.

13. A notable structural challenge has been the insufficient scale of individual manufacturer demand to trigger local or regional production runs, a gap that was only bridged once demand aggregation at the sector level reached a critical mass. Beyond HFC-32, availability constraints persist for HC refrigerants such as R-290 used in lower-capacity residential equipment, indicating that supply chain gaps remain across the refrigerant spectrum and will require continued attention as conversion projects advance. This is particularly relevant for the majority of Article 5 countries that lack the capacity to produce refrigerant-grade HCs.

Commercial air-conditioning

14. Commercial air-conditioning manufacturing conversion projects continue to encounter availability constraints related to key components and refrigerants. A persistent challenge is the continued reliance on imported compressors, copper components, inverter electronics, and refrigerant, with limited local manufacturing capacity for these items. While the availability of HFC-32 has improved, it remains unstable

due to shipping delays and limited storage infrastructure suited for A2L refrigerants,³ and distribution and packaging challenges continue to affect the reliability of component supply chains and overall market stability.

15. A broader structural concern is the uneven access to alternative technologies across the sector. Manufacturers operating outside the Multilateral Fund conversion programmes face considerably greater difficulty sourcing the components and refrigerants needed for the transition, creating a two-tier dynamic that risks an uneven sector-wide shift. If left unaddressed, this disparity could undermine the long-term market transformation, or its desirable speed, needed to achieve sustained, sector-wide adoption of low-GWP technologies.

16. As a cross-cutting concern across several sectors, the low availability of HFOs was widely noted. Global HFO supply continues to improve and diversify, particularly in non-Article 5 markets where incremental capacity expansions, regional manufacturing arrangements, and greater regulatory clarity have provided some support, but progress remains slow, especially in Article 5 countries. Production of HFOs remains highly concentrated in only two countries.

17. HFOs demand in Article 5 countries is expected to materialise progressively as the implementation of KIPs advances. A critical distinction must nonetheless be drawn between global production availability and effective market access at the country level, as the two do not necessarily move in tandem. Translating global supply growth into reliable country-level access will require sustained investment in local distribution networks, service providers, and re-packaging capacities. The latter issue has emerged as a principal barrier to securing a steady supply of HFOs. Larger Article 5 economies can play an important role as regional supply and knowledge hubs, while targeted support for smaller markets will be essential to ensure an equitable transition. These barriers and challenges have an impact to the price of the HFOs which is already high compared to other alternatives.⁴

B. Price of refrigerants and components

18. The cost of transitioning to low-GWP technologies represents a significant financial barrier for manufacturers across all RACHP sub-sectors. Price pressures affect both the upfront capital investment required to adapt manufacturing facilities and the ongoing costs of procuring alternative refrigerants and compatible components.

Domestic refrigeration

19. Given that most domestic refrigeration conversion projects have not yet commenced implementation, detailed information on price impacts under real project conditions is not yet available. Drawing on experience in other sub-sectors with HC refrigerants such as R-600a, anticipated price challenges may include higher component costs for HC-compatible compressors and the need for safety-related equipment upgrades. However, information gathered from the funding of numerous projects indicates that the cost differential between HC-based and HFC-based compressors has been largely eliminated worldwide, though the volume of business may still affect the cost structure, particularly at the early stages of a market transformation. Cost data will need to be collected systematically as projects advance.

³ According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 34, refrigerants are classified using a combination of a letter designating toxicity and a number designating flammability. A2L indicates mildly flammable and A3 indicates highly flammable refrigerants.

⁴ Reference to table 11 “Average price of HCFCs, HFCs and alternatives” of document UNEP/OzL.Pro/ExCom/98/5

Commercial refrigeration

20. Commercial refrigeration conversion projects entail some of the highest cost burdens across the RACHP sector, driven by the complexity of systems and the safety requirements associated with flammable and high-pressure refrigerants. Substantial capital investment is required to adapt manufacturing plants to meet applicable safety standards, encompassing storage systems, refrigerant charging machines, ventilation systems, leak detection equipment, and emergency response infrastructure. These upfront costs are compounded by significantly higher component prices, particularly for compressors designed for R-290 and CO₂ systems, where cost increases of 30–35 per cent⁵ compared to conventional alternatives have been reported, as well as additional expenditure on ATEX-certified⁶, or similar, equipment and backup power systems required for CO₂ applications.

21. Beyond capital costs, manufacturers face ongoing financial pressures that affect their competitiveness and long-term viability. Exposure to raw material price volatility and exchange-rate fluctuations places particular strain on import-dependent producers, while compliance with quality control regulations further increases production costs and risks reducing price competitiveness against larger multinational manufacturers. At the same time, the need to adopt advanced and often costlier technology to meet stringent energy performance benchmarks, such as those set by minimum energy performance standards (MEPS) and quality control orders, renders the overall cost of conversion particularly challenging for local manufacturers operating in price-sensitive markets.

Residential air-conditioning

22. Price pressures in the residential air-conditioning sub-sector are primarily linked to international market dynamics, reflecting the sector's scale worldwide and the rapidly increasing demand in Article 5 countries, as well as the higher cost base of alternative technologies. Refrigerant and component prices are closely tied to international commodity markets and subject to volatility driven by global supply and demand dynamics, while HFC-32 systems and their compatible components carry a price premium compared to conventional HCFC-22 and R-410A options. These challenges are further compounded by rising equipment and delivery costs stemming from global logistics constraints and economies of scale, creating additional budgetary pressures for manufacturers operating under fixed project budget envelopes.

Commercial air-conditioning

23. The commercial air-conditioning sub-sector faces cost pressures from both input materials and the capital intensity of conversion. Rising prices of key raw materials, particularly for heat exchanger and refrigerant circuit components, combine with high capital investment requirements for producing advanced, energy-efficient equipment compatible with low-GWP refrigerants. These pressures are particularly acute for small and medium size manufacturers, which represent most manufacturers in Article 5 countries, and who face the additional constraint of limited access to external finance, credit facilities, or risk-sharing mechanisms, leaving them disproportionately exposed to the financial demands of technology transition.

C. Technical specifications and other issues

24. Beyond availability and price, RACHP conversion projects face a range of technical, regulatory, and capacity-related challenges. These encompass gaps in standards, workforce skills, market acceptance, and safety compliance, all of which affect the pace and quality of technology transitions.

⁵ Indicative figure provided by implementing agencies based on experience from ongoing conversion projects.

⁶ ATEX: refers to the European Union (EU) directives that regulate equipment and work environments with explosive atmosphere.

Domestic refrigeration

25. As domestic refrigeration conversion projects have not yet entered the implementation phase, technical challenges are anticipated but not yet confirmed through practical experience. Based on the characteristics of HC refrigerants typically used in this sub-sector, key technical concerns are likely to include the safety management of flammable refrigerants, the adaptation of production lines and safety testing protocols, and the certification of converted manufacturing equipment. Detailed technical information will become available as projects advance.

Commercial refrigeration

26. Commercial refrigeration systems present among the most complex technical challenges in the RACHP sector, given the range of refrigerants involved, including HCs, CO₂, and ammonia. A fundamental constraint is the limited design and engineering capability among local manufacturers for developing low-GWP refrigeration systems, particularly multi-stage CO₂ cascade configurations and large-charge HC applications. Compounding this, the handling of flammable refrigerants requires skilled labour and upgraded safety infrastructure, both of which remain insufficient in many Article 5 countries, while outdated or missing national standards and test methods, including those for MEPS testing of commercial refrigeration systems when available, create further regulatory uncertainty that could slow conversion progress or introduction of products into local market.

27. Market adoption challenges add another layer of complexity to the transition. Hesitancy around HC systems persists, particularly for larger refrigerant charge sizes, while CO₂ systems, though more widely accepted in certain commercial applications, demand a higher level of technical expertise that many local manufacturers have yet to develop. Reliability concerns also remain significant, with frequent compressor failures under high-temperature operating conditions, especially in hot climates, posing ongoing challenges to the consistent performance of low-GWP systems in the field or lack of capacity to properly design CO₂-based systems in such operating conditions.

Residential air-conditioning

28. Technical and regulatory barriers in residential air-conditioning conversion relate primarily to safety standards, certification processes, and market confidence. Flammability concerns associated with A2L and A3 refrigerants continue to weigh on market acceptance, particularly among installers, retailers, and consumers who remain cautious. These confidence gaps are further compounded by the high costs of certifying and verifying converted manufacturing lines, driven by the limited number of accredited service providers available in many Article 5 countries, while compliance with safety requirements for A2L and A3 refrigerants, encompassing charge size limits, component ratings, and installer training; presents an additional and often demanding technical barrier for manufacturers undertaking conversion.

Commercial air-conditioning

29. Commercial air-conditioning conversion faces multifaceted technical challenges spanning workforce capacity, regulatory readiness, and market awareness. A primary concern is the limited local capability to design and manufacture equipment configured for low-GWP refrigerants, particularly for larger-capacity commercial systems where technical complexity is greatest. This is compounded by a significant shortage of trained and certified technicians for the installation, servicing, and maintenance of A2L and A3 refrigerant-based systems, undermining the sector's ability to support and sustain converted equipment in the field.

30. Regulatory and market confidence challenges further complicate the transition. National safety regulations and technical standards for A2L refrigerants such as HFC-32 remain incomplete or still evolving in a number of countries, creating uncertainty for both manufacturers and installers navigating compliance

requirements. Safety considerations during the transportation, installation, and servicing of mildly flammable refrigerants continue to affect market confidence and procurement decisions, while limited awareness among technicians, retailers, and consumers regarding new refrigerant technologies and their safe handling practices remains a persistent barrier to broader market uptake.

Issues related to small- and medium-sized enterprises

31. SME manufacturers face disproportionately severe availability challenges due to their limited trading power, small order volumes, and weaker integration into international supply chains. Access to alternative refrigerant components is constrained by highly concentrated importer markets, with few distributors dominating local supply, making it particularly difficult for SMEs with limited procurement capacity to identify reliable sources. These difficulties are further compounded by minimum order requirements, high import costs, and decreasing component availability for larger systems requiring specific technology e.g., CO₂- or ammonia-based solutions, while the limited availability of specialised tools and equipment for HC-based manufacturing processes adds another layer of constraint to their operational capacity.

32. SMEs also face compounded price challenges that reflect both their structural disadvantages and the specific demands of transitioning to low-GWP technology. High costs for key components, particularly compressors designed for A3, A2L, and CO₂ refrigerants, are exacerbated by the significant investment required for safety infrastructure upgrades, specialised manufacturing equipment, and ATEX-certified components. These burdens are intensified by small market size, currency risks, and domestic tax structures that reduce the competitiveness of locally manufactured equipment, while limited economies of scale and intense competition from multinational manufacturers erode profit margins and leave SMEs with insufficient resources for research, development, and skills investment.

33. Regarding the technical and capacity deficits that SMEs face, given their limited access to training, technical assistance, and regulatory support, they face major gaps exist in technical capacity for system redesign, component selection, safety procedures, and refrigerant charging management, compounded by limited access to expert support and skilled human resources, especially in countries without well-established vocational training programmes in RACHP technology. These challenges are further heightened by any compliance burden associated with transitions to MEPS, the safety and logistics complexities of handling flammable refrigerants, and a widespread lack of awareness among SME operators regarding applicable regulations, technical standards, and available support mechanisms for technology conversion.

34. A summary of key findings across the different sub-sectors is presented in a master sheet included as annex II to the present document.

Possible ways to address the identified challenges

35. The challenges identified in this paper span multiple dimensions, including supply security, cost competitiveness, technical capacity, and regulatory readiness, and require coordinated responses at national, regional, and international levels. The following measures were suggested as part of the questionnaires received and the discussions held.

36. To address availability issues, implementing agencies and NOUs could facilitate demand aggregation mechanisms to consolidate purchasing volumes across manufacturers, reducing dependence on individual import channels and enabling access to more favourable supply terms. This should be complemented by support for the development of regional distribution hubs for alternative refrigerants and compatible components to reduce lead times and improve supply reliability, alongside efforts to strengthen local and regional refrigerant reclamation and recovery infrastructure to support the circular use of refrigerants during conversion and servicing activities. Supply chain resilience should further be enhanced by encouraging diversification through proactive engagement with multiple qualified suppliers and

supporting supplier registration and tracking mechanisms to address the risk of spurious refrigerants, as well as by promoting information-sharing platforms among Article 5 countries and implementing agencies to improve forecasting and early identification of availability constraints. This would ensure synchronised efforts and aligned phase-down activities, particularly for SMEs, thereby reducing the burden on industry.

37. On price issues, co-financing opportunities with multilateral and bilateral financing instruments should be explored to support the high capital investment required for safety infrastructure upgrades and manufacturing conversions, with funding arrangements that recognise and compensate for incremental costs associated with ATEX certification, CO₂ system backup power, and advanced safety equipment. Access to affordable financing for SMEs should be supported through technical assistance components or cooperation with development finance institutions, while economies of scale should be promoted by supporting sector-wide or multi-country conversion projects that enable aggregated procurement of components and reduce per-unit costs. Raw material price trends and exchange-rate risks should also be monitored as part of project risk management frameworks, with provisions for budget adjustments where necessary.

38. To address technical specifications and other challenges, efforts should focus on supporting the development, harmonisation, and enforcement of national and, where applicable, regional safety standards for A2L, A3, and CO₂ refrigerant applications, drawing on related international standards, alongside investment in dedicated market-driven training programmes for technicians, engineers, and safety officers on the safe handling, installation, and servicing of low-GWP equipment. The establishment or strengthening of accredited testing and certification facilities for converted manufacturing lines should be supported to enable cost-effective and timely compliance verification, while market acceptance assessments and awareness campaigns targeting installers, retailers, and consumers should be conducted to build confidence in alternative low-GWP technologies. Manufacturers should be encouraged to engage early with energy efficiency requirements, including transitions to MEPS requirements, and regulatory capacity in Article 5 countries should be strengthened to systematically develop, enforce, and update technical standards and environmental regulations relevant to low-GWP refrigerant management.

Secretariat's observations

39. The Secretariat also noted that time is a critical factor in overcoming supply chain challenges, as market maturity and economies of scale can only be achieved through the development of a wider, equitable, and non-monopolised supply infrastructure. This must be accompanied by the establishment of market acceptance, product competitiveness, and consumer confidence in RACHP equipment. The time required to reach these conditions varies across Article 5 countries and may be considerably longer in countries with limited market size, unless a regional acceleration in the uptake of low-GWP technologies can be achieved.

40. The supply-chain challenges documented in this paper are not isolated to individual projects or countries; they reflect systemic barriers to the large-scale adoption of low-GWP refrigerant technologies across the RACHP sector in Article 5 countries. Availability constraints, elevated costs, and technical capacity gaps are interrelated and mutually reinforcing. Addressing them effectively will require coordinated action across implementing agencies, governments, industry stakeholders, and the Multilateral Fund.

41. The severity of challenges varies significantly by sub-sector. Commercial refrigeration and manufacturing at SMEs, face the most complex combination of barriers, given the range of refrigerants involved, the technical demands of system design, and the limited financial and human resources available. Residential and commercial air-conditioning sub-sectors benefit from greater market familiarity with HFC-32 but continue to face regulatory, certification, and awareness-related obstacles. Domestic refrigeration projects, while at an early stage of conversion and for original equipment manufacturer (OEM)

with low production capacity, are likely to encounter availability and cost challenges as implementation progresses.

42. The Secretariat notes that a proactive, enabling environment, including robust standards frameworks, trained workforces, and diversified supply chains is foundational to the success of conversion projects. Support by the Multilateral Fund that addresses not only incremental capital costs but also the upstream supply-chain and capacity enablers of conversion will be critical to achieving durable technology transitions at scale.

43. The analysis conducted in this paper does not include specific pricing data for refrigerants or system components, for either conventional or alternative options, nor does it address regional market share distributions, owing to limited data availability and the rapid market shifts surrounding alternative refrigerants in recent years. Economic constraints arising from global or regional instability and trade-related restrictions were likewise outside the scope of this analysis. Regular monitoring of supply chain challenges, as investment preparation and conversion projects advance, would enable the Executive Committee to better distinguish between challenges that are likely to resolve through market dynamics and those that persist as structural barriers requiring further support.

Recommendation

44. The Executive Committee may wish:

- (a) To note the paper on challenges in implementing conversion projects in the refrigeration, air-conditioning and heat pump sector due to supply-chain issues and possible ways to address the challenges, contained in document UNEP/OzL.Pro/ExCom/98/57;
- (b) To request bilateral and implementing agencies to take into account supply-chain challenges along with possible ways to address them, when designing and implementing conversion projects, including in reporting on project progress and upon project completion; and
- (c) To request the Secretariat to include, as applicable, in meeting documents on project proposals submitted for consideration by the Executive Committee, a section on supply chain challenges.

Annex I

OUTLINE OF THE QUESTIONNAIRE TO COLLECT FEEDBACK ON RACHP SUPPLY CHAIN ISSUES FROM ONGOING CONVERSION PROJECTS UNDER THE KIPS

Table 1: Outline of the questionnaire designed to solicit experiences of implementing agencies in implementing conversion regarding availability, price, and technical issues of alternative refrigerants and equipment/components

Area covered	Examples of issues		
Supply chain of alternatives refrigerants, parts and components and equipment/component (Manufacturing lines and final product)	Availability issues	Price issues	Technical specifications and other barriers
	Availability in local market	Price to OEM compared to international market price	Suitability for local operating conditions
	Ability to order from abroad	Over-pricing due to mark-ups local/regional suppliers	Suitability to local MEPS and energy labeling requirements
	Lead time for delivery (delivery time)	Additional costs due to volume of business or shipping costs	Issues related to local standards or codes

Table 2: Outline of the questionnaire designed to solicit feedback from NOUs through implementing agencies in relation to local supply chain barriers

Area covered	Examples of issues
Local manufacturers included in the conversion projects	Issues related to identifying supply sources
	Cost related issues
	Shipping and customs clearance issues
	Issues related to cost of final product compared to old technology
Other local manufacturers not included in the conversion projects	Issues related to identifying supply sources
	Cost related issues
	Shipping and customs clearance issues
	Issues related to cost of final product compared to old technology
Refrigerants and components' suppliers	Demand size issues
	Shipping and packing issues
	Distribution network issues
SMEs	Availability in local market
	Cost of refrigerants or component
	Technical capacity in re-designing and selecting right components
	Safety and logistics related issues
Regulatory and/or standards related issues	Lack or outdated local standards of refrigerants or RACHP final products
	Local MEPS level is not met by new components
	Conflict with building's codes
	Safety issues during transportation, operation, and servicing

Annex II

SUMMARY OF FINDINGS ON CHALLENGES EXPERIENCED BY ARTICLE 5 COUNTRIES IN IMPLEMENTING CONVERSION PROJECTS DUE TO SUPPLY CHAIN ISSUES

■ Availability ■ Price ■ Technical and other

	Availability	Price	Technical and other issues
Commercial Refrigeration	- High import dependence on refrigerants, compressors and other components - Limited certified components for large-scale CO₂ and HC systems - Import delays, shipping and customs clearance issues - Weak regulatory controls against spurious refrigerants	- High capex for safety upgrades (ventilation, leak detection) 30–35 percent higher compressor costs for HC and CO₂ systems - Extra costs for ATEX-certified equipment and CO₂ backup power - Raw material price volatility and exchange-rate exposure	- Limited design capability for CO₂ cascade and HC systems - Insufficient skilled labor for flammable refrigerant handling - Outdated national standards and test methods - Compressor failures under high tropical temperatures
Domestic Refrigeration	Projects have not yet commenced. Anticipated challenges include HC-compatible compressor shortages, higher safety capex, and production line adaptation for flammable refrigerants.		
Residential Air-Conditioning	- HFC-32 adequate but import-dependent; limited supplier base - Historical shortage of HFC-32 compressors in larger capacities - Demand aggregation needed to trigger production runs	- Prices tied to volatile international commodity markets - HFC-32 systems carry a premium over HFC-22 / R-410A - Rising logistics costs exceed fixed project budgets	- Flammability concerns limit market acceptance - High certification costs; few accredited providers - Safety compliance: charge limits, component ratings, training
Commercial Air-Conditioning	- Heavy reliance on imported compressors, copper and inverter electronics - HFC-32 supply improved but unstable; limited storage infrastructure - Non-Multilateral Fund manufacturers face greater technology access barriers	- Rising copper and aluminum prices (heat exchangers) - High capex for advanced energy-efficient components - Cost pressures acute for SMEs with limited finance access	- Limited local capability for low-GWP large-capacity systems - Shortage of certified technicians for A2L/A3 systems - A2L safety regulations are still evolving in some countries
SME Manufacturing	- Highly concentrated importer markets limit access - Minimum order requirements & high import costs - Component availability drops for larger charge sizes - Limited specialised tools for HC manufacturing	- High compressor costs for HC, A2L and CO₂ systems - Investment needed for safety upgrades and ATEX components - Small market size, currency risks & taxes cut competitiveness - Intense multinational competition erodes margins	- Major gaps in system redesign & safety procedure capacity - Limited access to technical assistance and skilled staff - MEPS transition adds compliance burden - Low awareness of regulations & support mechanisms