

2024 Progress Report of the Technology and Economic Assessment Panel

Chapter 8: Decision XXVIII/2, paragraph 5 - Technical Review of Alternatives Relevant to Group 2 Parties

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2016 Decision XXVIII/2: Decision related to Kigali Amendment

Paragraph 4: To request the TEAP to conduct periodic reviews of alternatives, using the criteria set out in paragraph 1 (a) of decision XXVI/9, in 2022 and every five years thereafter, and to provide technological and economic assessments of the latest available and emerging alternatives to HFCs

- [September 2022 Decision XXVIII/2 TEAP Working Group Report: Information on Alternatives to HFCs](#)
- [2022 TOCs Assessment Reports](#)

Paragraph 5: To request the TEAP to conduct a technology review four or five years before 2028 to consider a compliance deferral of two years from the freeze date of 2028 for Article 5, group 2, (G2) parties to address growth above a certain threshold in relevant sectors

- **Bahrain, India, the Islamic Republic of Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia and the United Arab Emirates**

Technology and
Economic Assessment
Panel

2022 Assessment Report

MONTREAL PROTOCOL
ON SUBSTANCES THAT DEplete
THE OZONE LAYER

REPORT OF THE
TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL

SEPTEMBER 2022

DECISION XXVIII/2 TEAP WORKING GROUP REPORT
INFORMATION ON ALTERNATIVES TO HFCs

TEAP Working Group on Decision XXVIII/2 paragraph 5

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2024 Technical Review

- As a one-time assessment to respond to 5, of Decision XXVIII/2, TEAP provides an updated technical review based on its September 2022 report
- While the 2022 review focused on alternatives for HFCs globally, this review focused on alternatives in sectors relevant to G2 parties
- The same sectors as in the 2022 report are covered in this review, focusing on the RACHP sector
- Sector information in the 2022 report remains relevant, so TEAP refers to that report for full details
- TEAP also considered other relevant changes that have occurred since adoption of Decision XXVIII/2 in 2016 that are relevant to G2 parties including:
 - Standards for refrigerants and RACHP equipment
 - Technology conversion investment and demonstration projects approved, implemented, or under implementation
 - Potential activities included in the 2024-2026 business plan under the MLF

Approach to Paragraph 5

- Based on the Terms of Reference (TOR) in 2016 Decision XXVIII/2, TEAP provides technical review of alternatives relative to G2 parties
- TEAP did not attempt to assess individual national market dynamics and possible implementation plans
- TEAP did not qualify whether alternatives will enable G2 parties to achieve certain reductions by a certain date, which requires consideration of factors beyond specified technical and economic criteria
- TEAP did not attempt to assess relative ability of G2 parties to comply with control measures, which depends on their Kigali Implementation Plans (KIPs) and implementation approach
- TEAP defers to parties to consider, or not, any changes to phasedown schedules

TEAP 2024 Progress Report Chapter 8 Outline

1. Introduction
2. Information on Alternatives in RACHP Relevant to G2 Parties
3. Information on Alternatives in Foams Sector
4. Information on Alternatives in Fire Suppression Sector
5. Information on Alternatives in Medical and Chemical Uses
6. Information on Standards, Technical Regulations, and Codes
7. Information on Relevant MLF Activities Related to the Kigali Amendment
8. HFC Consumption Data Reported by Some G2 Parties

Annexes:

1. Standards
2. Examples of Relevant MLF Demonstration and Investment Projects since 2016
3. Planned activities in the Adjusted Consolidated Business Plan of the MLF 2024-2026 for G2 Parties

**INFORMATION ON
ALTERNATIVES TO
HFCS IN THE
REFRIGERATION,
AIR CONDITIONING
AND HEAT PUMP
(RACHP) SECTORS**



HFC Consumption Dominated by RACHP

Global 2016 Data*	Article 5 Parties – 2022 Data
RACHP contributes to ~80% of the global GWP-weighted HFC consumption	RACHP is ~80% of HFC consumption as reported to MLFS by 117 out of 144 A5 parties (2022 Country Programme data)
Other sectors contribution is important to consider but together contribute one-fifth of global/A5 HFC consumption	

2022 Report Findings Remain Relevant for both G1 and G2 Parties

- Lower GWP alternatives to the popular high GWP HFCs are available for most RACHP applications
 - But there is limited accessibility to alternatives for some A5 parties
- There is still ongoing development of new lower GWP refrigerants
- There are a number of significant RACHP applications with widely available alternatives with GWP < 10
 - Hydrocarbons (HCs), CO₂ (R-744), ammonia (R-717) and hydrofluoro-olefins (HFOs)
- For some applications alternatives with GWP of up to 750 can quickly be adopted (e.g., HFC-32 and R-454B)

2022 Report Findings Remain Relevant, cont'd

- Lower GWP refrigerants are available and the technology is mature for many RACHP applications; however, there could still be minimal use of the popular high GWP HFCs in new equipment
- Lower GWP alternatives adoption can be increased by:
 - Measures to discourage import of equipment with high GWP HFCs
 - Awareness programs related to lower GWP alternatives
 - Training related to use of flammable refrigerants

Some applications still reliant on high-GWP refrigerants

- These are applications with small consumption of HFCs relative to other RACHP applications
- Transport refrigeration (vans, trucks, trailers, containers)
 - Was a major user of R-404A (GWP 3922, HFC blend)
 - R-452A (GWP 2140, HFO-HFC blend) now widely available
 - Lower GWP options under development
- Ultra-low temperature systems (e.g., freezers for vaccines at -70°C)
 - Rely on cascade refrigeration systems
 - Presently use high GWP gases, e.g., R-508B (GWP 13,396; HFC-PFC blend)
 - Lower GWP options mainly in development stage

Commonalities Among G2 Parties

- Most G2 parties have manufacturing enterprises producing RACHP units, with local or mixed ownership, and with varying capabilities for research and development
- At least one G2 party, India, also manufactures components that are used for building RACHP units like compressors or motors
- Manufactured units are mostly sold locally, but some parties have significant output made for export and needs to respond to the importing parties' requirements
- All the G2 parties are in a geographical region with similar climatic conditions although one party, India, is not defined as a high ambient temperature (HAT) country as per the definition set by Decision XXVIII/2, paragraph 29

Commonalities Among G2 Parties, cont'd

- All G2 parties have Minimum Energy Performance Standards (MEPS) in place; however, the MEPS are not harmonised and use different temperature settings for the efficiency ratings and use different minimum efficiency levels
- G2 parties are at varying stages of HCFC phaseout with some more advanced than the Montreal Protocol control targets
- Due to the HCFC phase-out, by 2024 the use of HCFC refrigerants in A5 parties has significantly decreased
- All G2 parties import HFC-based units across most RACHP applications

Decision XXVI/9, par. 1(a) Criteria Relative to G2 Parties

- **Commercial availability:** TEAP did not find a distinguishing factor for G2 parties in this criterion
- **Environmentally sound:** TEAP did not find a distinguishing factor for G2 parties in this criterion
- **Economically viable and cost effective:** TEAP did not find a distinguishing factor for G2 parties in this criterion
- **Safe to use in areas with high urban densities:** Some A5 parties have still not adopted international standards, while in others even if the standard is accepted, it is not mandatory
- **Ease to maintain or service:** All A5 parties may require training and mandatory certification procedures; G2 parties fall within three groups of higher consumption brackets and share common characteristics with the other parties in those brackets

Decision XXVI/9, par. 1(a) Criteria, cont'd

- **Technically proven:** TEAP considers that it is possible to produce a system using certain refrigerants that are accessible and technically proven in non-A5 parties whilst the local industries or consumers in G2 parties might have reservations in accepting the product
- **Having taken all the above criteria into consideration for G2 parties, the only distinguishing criterion for accessibility in G2 parties is whether refrigerants are technically proven**

Tables and lower GWP groupings

- TEAP categorised the lower GWP alternatives in groups as follows:
 - **Non-Montreal Protocol controlled substances (including multiple flammability and toxicity classes):** These substances have very low to zero GWP and zero ODP and include ammonia (R-717), hydrocarbons (HCs), CO₂ (R-744), HFOs & HCFOs
 - **A2L refrigerants:** these are Montreal-controlled substances that are mildly (or lower) flammable A2L (A2L refers to the safety class of refrigerants as ASHRAE-34 or ISO-817) and include HFC-32 and various HFC-HFO blends, with GWPs between 140 and 1,100
 - **A1 refrigerant blends:** these are Montreal-controlled non-flammable (A1 safety class) HFC or HFC-HFO blends with GWP that can exceed 1,100
 - **Refrigerants currently “under consideration”** TEAP uses this term to refer to refrigerants that are either under development, testing, or have not been commercialised yet globally; these refrigerants are consequently not accessible to G2 parties but are listed here
- Following are some example tables and remaining tables are in the chapter and in back-up slides to this presentation

Table 8.1 Factory sealed domestic and commercial refrigeration appliances

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Domestic refrigerators and freezers	Non-Montreal Protocol controlled substances, available HC-600a	Widespread use of HC-600a in most G2 parties
Commercial plug-in refrigeration	Non-Montreal Protocol controlled substances, available HC-290 , HC-600a A2L Refrigerant blends, some use, including. R-454C, R-455A	Growing use of HCs in some G2 parties
Heat pump tumble dryers	Non-Montreal Protocol controlled substances Recent introduction of hydrocarbon HC-290 A1 Refrigerant blends, available R-450A, R-513A	Little use of this application in G2 parties

Table 8.2 Food retail and food service refrigeration

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Condensing units	Non-Montreal Protocol controlled substances, available R-744, HC-290	Growing use of all these options in some G2 parties
	A2L Refrigerant blends – available, including: R-454C, R-455A	
	A1 Refrigerant blends - available, including: R-448A, R-449A, R-450A, R-513A	
Distributed systems	Non-Montreal Protocol controlled substances - available R-744	Growing use of all these options in some G2 parties
	A2L Refrigerant blends - available, including: R-454C, R-455A	
	A1 Refrigerant blends - available, including: R-448A, R-449A, R-450A, R-513A	
	Various refrigerants currently under consideration, including: R-457, R-454, R-449B, R-407H, HFO-1234yf, HFO-1234ze(E)	Not accessible in G2, or globally
Large central systems	Non-Montreal Protocol controlled substances available: R-744, R-717 is only available with secondary systems.	Growing use of all these options in some G2 parties
	A1 Refrigerant blends, available, including: R-448A, R-449A, R-450A, R-513A	

Table 8.4 Air-to-air conditioners and heat pumps

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Small self-contained AC window units <i>Charge limitations apply</i>	Non-Montreal Protocol controlled substances available: HC-290	Limited use in G2 parties
Small split AC (<12 kW) Non ducted split Ducted split Packaged ducted <i>Charge limitations apply</i>	Non-Montreal Protocol controlled substances available: HC-290, HC-1270 HFO-1234yf , HFO-1234ze(E)	Limited use in G2 parties
	A2L, Refrigerants available: HFC-32 R-454B	Growing use of all these options in some G2 parties
	Various refrigerants currently under consideration, including: HFC-161 , HFC-152a R-511A, R-457A, R-455A, R-459A , R-454A	Not accessible in G2, or globally

Table 8.4 Air-to-air conditioners and heat pumps, cont'd

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Larger split and packaged AC (>12 kW) Non ducted split Ducted split Multi split Variable refrigerant flow (VRF) Packaged ducted <i>Charge limitations apply</i>	Non-Montreal Protocol controlled substances available: HFO-1234yf, HFO-1234ze(E)	Accessible in most G2 parties, but extent of use is unknown
	A2L, Refrigerants available: HFC-32, R-454B	Growing use of all these options in some G2 parties
	Various refrigerants currently under consideration, including: HFC-161, HFC-152a R-511A, R-457A, R-455A R-459A , R-454A	Not accessible in G2, or globally




**INFORMATION ON ALTERNATIVES
TO HFCS IN THE FOAM, FIRE
SUPPRESSION, AND MEDICAL AND
CHEMICAL SECTORS**

Information on Alternatives

- For foam, fire suppression, and medical and chemical sectors, the 2022 Report findings remain relevant for both G1 and G2 parties
- **Foams update:**
 - HFC-365mfc has been reported as no longer commercially available as production ceased in September 2023, with no reports of any new manufacturing
- **Fire suppression updates:**
 - Both G1 and G2 parties face the same barriers to the use of lower GWP alternatives for fire suppression
 - The use of FK-5-1-12 may become affected by proposed PFAS regulations and definitions in the EU and other parties

Information on Alternatives, cont'd

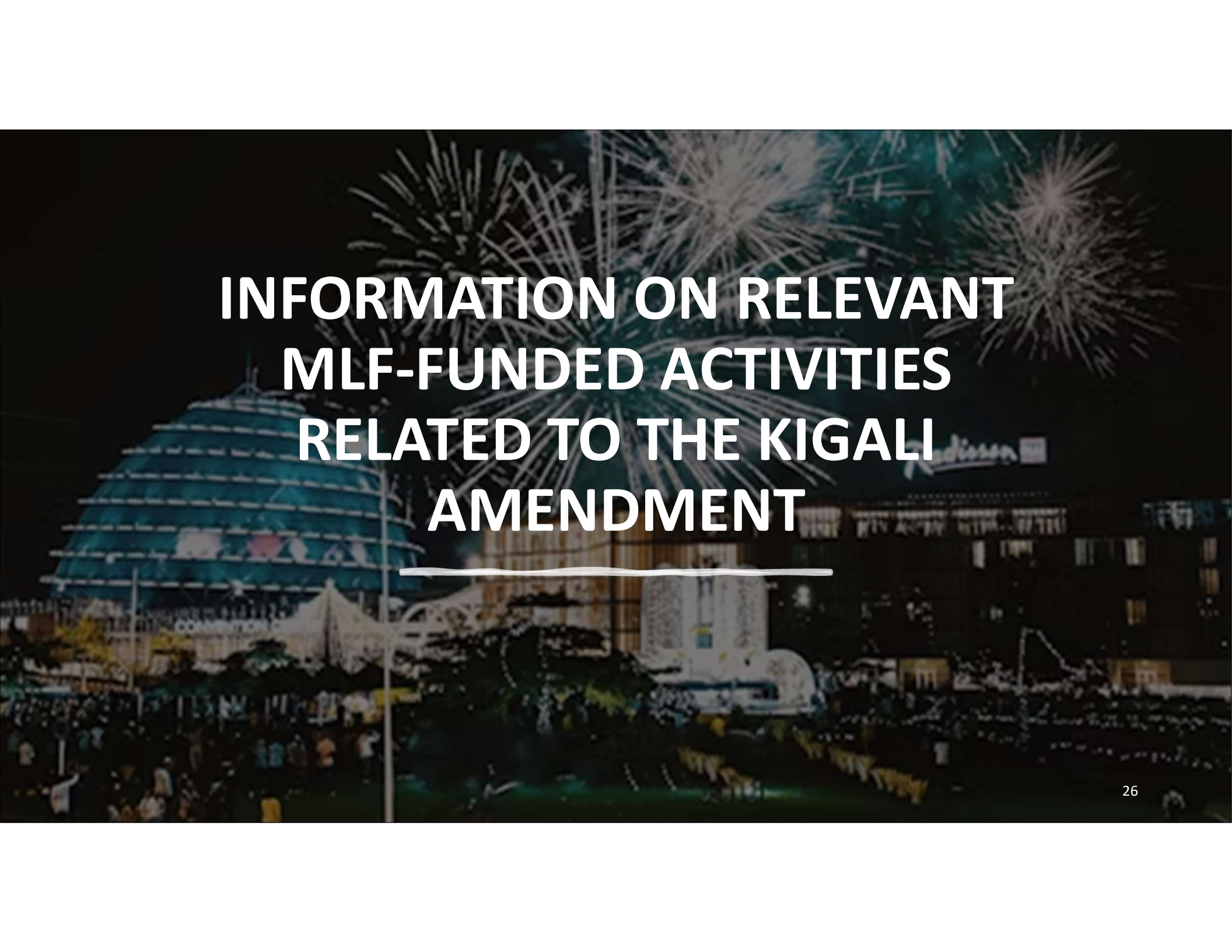
- **Medical and chemical uses updates:**
 - No significant updates for aerosols, solvents, semiconductor/electronics manufacturing and magnesium production
 - For MDIs, global legislation and corporate policies of major pharmaceutical companies may accelerate the introduction of lower GWP pMDIs in Article 5 parties
 - This could potentially mean lower GWP pMDIs are available in Article 5 parties from 2026 onwards
 - The reduction in use of HFCs in Europe/United States may lead to security of supply and commercial pricing concerns for Article 5 parties, including India

A woman wearing a white hard hat and a dark jacket is holding a clipboard and looking upwards in a server room. The room is filled with rows of server racks. The text "INFORMATION ON STANDARDS, TECHNICAL REGULATIONS, AND CODES" is overlaid in white on the image.

INFORMATION ON STANDARDS, TECHNICAL REGULATIONS, AND CODES

Information on Standards, Regulations, and Building Codes

- Standards, regulations and building codes have been regularly updated since 2016 incorporating learnings from company and industry sponsored research
- As the industry moves from conventional high GWP products toward lower GWP refrigerants, the safety classification of refrigerants are changing; therefore, equipment and installation standards need to be updated to incorporate these changes
- Some examples of equipment covered by standards include:
 - Compressors; commercial refrigerating appliances; heat pumps, air-conditioning units and dehumidifiers, including chillers; ice-cream appliances/ice makers; packaged AC systems; refrigerant recovery equipment
- Several G2 parties participate in the Gulf Cooperation Council (GCC) Standards Organization (GSO) (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and UAE)
- Examples of International and Regional RACHP standards can be found in Annex 2

A nighttime photograph of a cityscape with fireworks exploding in the dark sky. In the foreground, a large, illuminated dome structure, likely a government building, is visible. The scene is festive and celebratory.

INFORMATION ON RELEVANT MLF-FUNDED ACTIVITIES RELATED TO THE KIGALI AMENDMENT

Information on Relevant MLF-funded Activities Related to the Kigali Amendment

- Upon request by the WG co-chairs, the MLF Secretariat provided relevant information on projects completed, approved and/or under implementation on G2 parties
 - **In Annex 3:** Examples of Relevant Demonstration and Investment Projects for G2 parties, since 2016 (India, Bahrain, Iran, Kuwait, Pakistan and Saudi Arabia)
- Planned Activities included in the Adjusted Consolidated Business Plan 2024-2026
 - Only India and UAE have ratified Kigali Amendment (as of 19 April 2024)*; UAE does not receive MLF financial assistance
 - **In Annex 4:** Planned Activities in Adjusted Consolidated Business Plan of the MLF 2024-2026 for G2 Parties (India, Iran, Iraq, Oman, Pakistan and Qatar)

Information on HFC Consumption Reported by Some Group 2 Parties

Table 8.9 Reporting for HFC consumption by some G2 parties (MTCO_{2e}) (as of 4 March 2024)

Party	2019	2020	2021	2022	Ratification of Kigali Amendment
India			41,787,290	57,219,531	Yes
Oman	1,988,072	1,821,602	2,185,789	2,089,387	No
Pakistan	7,435,247	9,456,060			No

Decision XXVIII/2, paragraph 5: Technical Review of Alternatives Relevant to G2 Parties Conclusions

- In accordance with the TOR, TEAP provided technical review of alternatives relative to Group 2 parties based on the September 2022 report
- Did not attempt to qualify whether alternatives will enable Group 2 parties to achieve certain reductions by a certain date, which requires consideration of factors beyond specified technical and economic criteria
- Did not attempt to assess relative ability of Group 2 parties to comply with control measures, which depends on their implementation approach
- Defers to parties to consider, or not, any changes to phasedown schedules

Conclusions, cont'd

- Technical review reinforced key messages from 2022 report:
 - Development of lower GWP alternatives for most applications in all sectors since 2016 supports HFC phasedown globally
 - Alternatives in all sectors meeting technical criteria are in use by many parties, including G2 parties
 - Some technically proven alternatives accessible to all parties including in G2 parties have some challenges identified which need to be addressed
 - For most of the criteria investigated, TEAP working group did not find any distinguishing factor between G1 and G2 parties

Thank you!

BACK-UP SLIDES

Decision XXVI/9, par. 1(a) Criteria Relative to G2 Parties

- **Commercial availability:** Considers both availability and accessibility of refrigerants and RACHP products - some refrigerants that are commercially available globally are not necessarily accessible in all A5 parties; TEAP did not find a distinguishing factor for G2 parties in this criterion
- **Environmentally sound:** TEAP recognises that environmental soundness is a relative term and can depend on the geographical region
 - Variations are a factor of either policy and local legislation or of certain industry trends that are specific to some parties
 - TEAP did not find a distinguishing factor for G2 parties in this criterion

Decision XXVI/9, par. 1(a) Criteria, cont'd

- **Economically viable and cost effective:** Industrialised A5 parties might find some substances viable, or mandatory, for export but not for the local market; TEAP did not find a distinguishing factor for G2 parties in this criterion
- **Safe to use in areas with high urban densities:** Some A5 parties have still not adopted international standards, while in others even if the standard is accepted, it is not mandatory
 - The criterion also addresses the question of whether those parties have facilities for testing and the capabilities to test as per the standards
 - At higher ambient temperatures the capacity of air-conditioning equipment may need to be larger depending on the room size, which limits refrigerant charge with flammable refrigerants
- **Ease to maintain or service:** All A5 parties may require training and mandatory certification procedures (e.g., prescribing a minimum set of tools required for servicing flammable refrigerants)
 - G2 parties fall within three groups of higher consumption brackets and share common characteristics with the other parties in those brackets

Decision XXVI/9, par. 1(a) Criteria, cont'd

- **Technically proven:** TEAP considers that it is possible to produce a system using certain refrigerants that are accessible and technically proven in non-A5 parties whilst the local industries or consumers in G2 parties might have reservations in accepting the product
 - There can be many reasons including that the product is not tested for safety as per some international standards, lack of regulations, market push back, lack of spare parts, lack of adequate training, and flammability or toxicity issues
 - Applicability to HAT conditions: Even though India is not listed as a HAT party, it has local regions that experience HAT conditions and require HAT compatible products. HAT compatibility is related to EE and cooling capacity, both of which degrade with the increase in ambient temperature, especially for air-cooled products
- **Having taken all the above criteria into consideration for G2 parties, the only distinguishing criterion for accessibility in G2 parties is whether refrigerants are technically proven**

Table 8.3 Transport refrigeration

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Truck, trailers, light commercial vehicles (vans)	Non-Montreal Protocol controlled substances available: HFO-1234yf for light commercial vehicles only	Little or no current use in most G2 parties
	A1, HFC-HFC Blends available: R-452A	Little or no current use in most G2 parties
	Various refrigerants currently under consideration, including: R-744, HC-290	Not accessible in G2, or globally
Marine containers	Non-Montreal Protocol controlled substances, available: R-744	Containers are used for international trade; hence the available options are used in G2 parties
	A1 blends available, including: R-513A, R-452A	
	Various refrigerants currently under consideration, including: R-473A and HC-170 for ultra-low temperature applications	Not accessible in G2, or globally
Ships (refrigeration and comfort cooling)	Non-Montreal Protocol controlled substances, available: R-717, R-744	Many ships are used internationally; hence the available options are used in some G2 parties
	A1, Refrigerant blends, available R-513A	
	Various refrigerants currently under consideration, including: R-473A for ultra-low temperature applications	Not accessible in G2 parties, or globally
Rail air conditioning	A1, Refrigerant blends, available R-513A	Little or no current use in most G2 parties

Table 8.5 Applied building cooling systems

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Small chillers <i>Charge limitations apply</i>	A2L, Refrigerants HFC-32 R-454B R-452B	Growing use of all these options in some G2 parties
Large chillers	Non-Montreal Protocol controlled substances R-718 (water) very large chillers R-717 (ammonia) HCFO-1233zd(E) for large centrifugal chillers HFO-1234ze(E) for screw and centrifugal chillers R-514A for large centrifugal chillers HFO-1224yd(Z) for centrifugal chillers	Growing use of all these options in some G2 parties

Table 8.6 Mobile AC/HP

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
All applications; passenger cars, buses and trucks	Non-Montreal Protocol controlled substances HFO-1234yf R-744	Growing use of HFO-1234yf in imported cars in some G2 parties
	Various refrigerants currently under consideration, including: HC-290 R-513A	Not accessible in G2, or globally

Notes:

1. All the above refrigerants are applicable to passenger cars and buses. They require skilled personnel to service them.
2. The deployment of highly electrified vehicles (plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV) in Europe, China, India, and North America will lead to the implementation of heat pump systems and of a new generation of thermal systems. Manufacturers are working on the improvement of this feature by using cycle variations such as economiser coupled with vapour injected compressors.
3. R-744 is increasingly applied in fully electrified vehicles due to its good performance when operating as a reversible heat pump. However, R-744 is less suitable in hot and humid climates where EE is somewhat lower than that of HFC-134a and HFO-1234yf systems.
4. All refrigerants can be used at HAT conditions. R-744-based systems could show lower efficiency.

Table 8.7 Industrial refrigeration

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Small industrial chillers	Non-Montreal Protocol controlled substances HC-600a, HC-290	Growing use in G2 parties
	A2L, Refrigerants, available HFC-32 R-454C, R-455, R-454B, R-452B	Growing use in G2 parties
Small industrial distributed systems and heat pumps	Non-Montreal Protocol controlled substances HC-290	Growing use in G2 parties
	A2L, Refrigerants, available HFC-32 R-454C, R-455A	Growing use in G2 parties
	A1, Refrigerant blends - available R-448, R-449, R-450, R-513A	Limited use in some G2 parties

Notes:

1. R-717 and R-744 are the dominant options for large industrial systems (e.g., in food and drink manufacturing and bulk cold storage), with hydrocarbons used in some large specialised applications (e.g., in the petrochemical industry).
2. ISO 5149 and EN 378 require skilled workers with certain competence to service large industrial systems; their competence is defined by ISO 22712. Additionally, technician certification according to national norms and regulations is needed. There are no such requirements for systems containing less than 3 kg charge.
3. It is noteworthy that safety aspects are yet to be applied in most A5 parties including those of G2.

Table 8.7 Industrial refrigeration, cont'd

Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Medium & large industrial chillers	Non-Montreal Protocol controlled substances R-717, R-744 HFO-1234ze(E) R-718 (water) has temperature limitations HC-170 used in petroleum industries HC-1150 used for temperatures from -80 °C to -110 °C HC-1270	R-717 Accessible and used in most G2 parties R-744 Growing use in large and medium sized industrial applications. Special technology enables use in warm climates.
	A2L, Refrigerants, available HFC-32 R-454C, R-455A	Growing use in most G2 parties
Medium and large industrial distributed systems and heat pumps	Non-Montreal Protocol controlled substances R-717, R-744 HCFO-1233zd(E) – Has some ODP	Growing use in most G2 parties
	A2L, Refrigerants, available HFC-32 R-454C, R-455A	Growing use in most G2 parties
	Various refrigerants currently under consideration, including: HFO-1336mzz(Z)	Not accessible in G2, or globally

Table 8.8 Heating only heat pumps

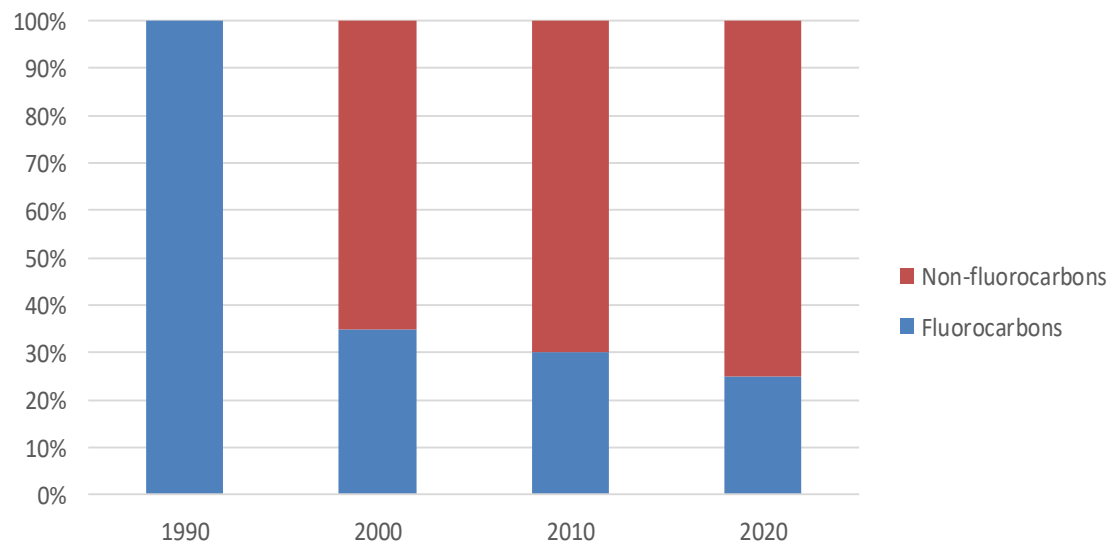
Application	Global alternatives to high GWP HFCs	Accessibility in G2 parties
Monobloc heat pump	Non-Montreal Protocol controlled substances HC-290	Limited use of the application in G2 parties
Domestic water heating	Non-Montreal Protocol controlled substances R-744	Limited use of the application in G2 parties
Monoblock and split heat pump	A2L, Refrigerants HFC-32 R-454B	Limited use of the application in G2 parties

Notes:

1. Heating only heat pumps are air-to-water systems used for space heating and for domestic hot water.
2. Safety constraints restrict the use of HC-290 to monobloc units located outdoors, if charge is higher than 150 grams, or indoor systems with ventilated cabinets (charge up to 500 grams).

2022 Report: Trend away from Fluorocarbons as a Foam Blowing Agent

Trend away from use of fluorocarbons in percent by decade

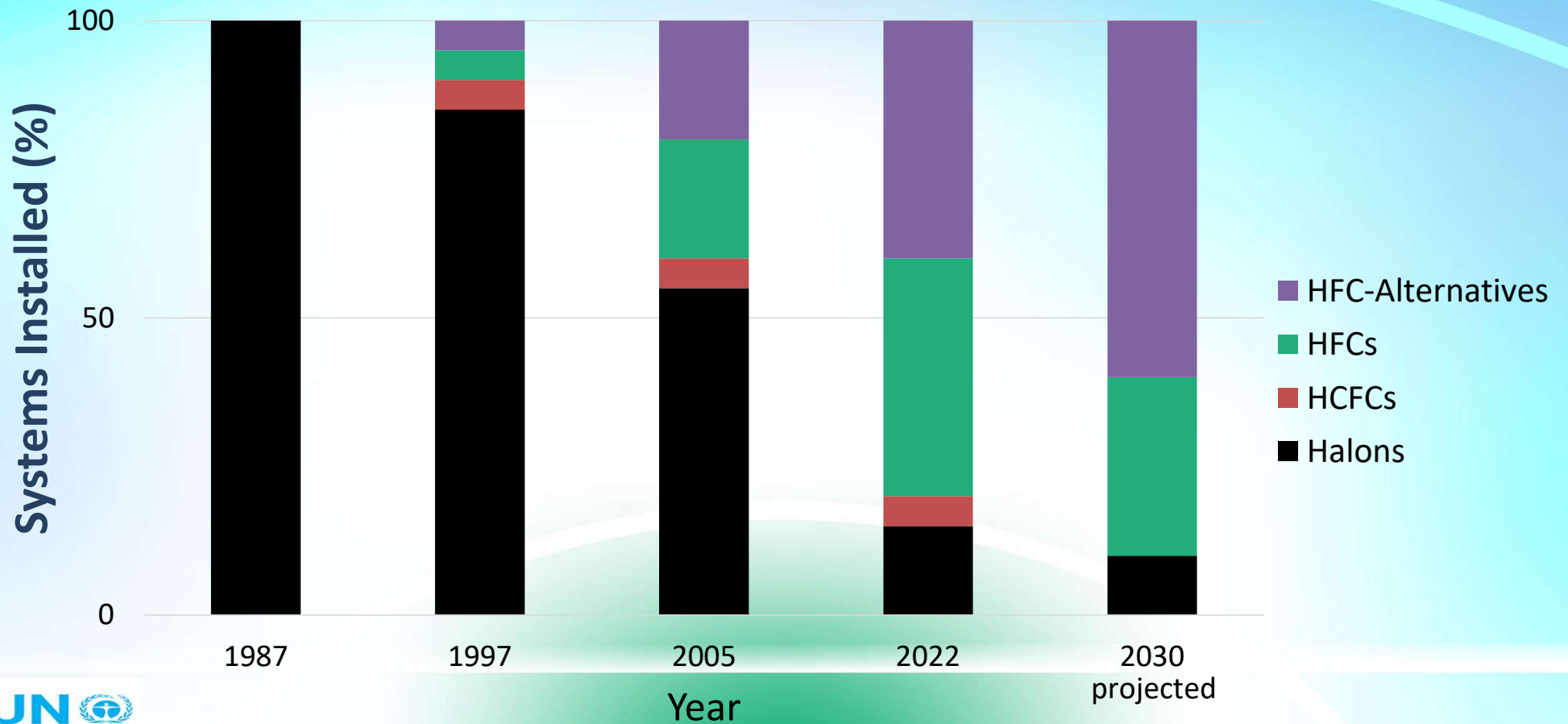


- No foam blowing agent (FBA) substitutes have the same technical properties and low cost of CFCs, which made them a universal solution for foams
- This has led to a fragmentation of foam production, with FBAs optimised to produce foams for specific uses
- Some markets, such as flexible foams, no longer use fluorocarbons (FCs) and are unlikely to be impacted by the HFC transition

Information on Alternatives for Foams

- 2022 Report findings:
 - There are alternatives to HFCs in commercial use in nearly every foam sector
 - Challenges remain for SMEs due to cost, supply and safety considerations
 - Safety considerations limit options for field-applied foams (e.g., spray foam)
 - Insufficient supply of HFO/HCFO FBAs has resulted in delayed conversions in some parties or reversion to HFCs for some companies
- Updates in 2024 Report with potential impact for all parties, **including those in G2:**
 - HFC-365mfc has been reported as no longer commercially available with production ceasing in September 2023
 - Although there may be some HFC-365mfc available in supply chains, no reports of new manufacture are known, and this alternative will not be commercially available once stocks are exhausted

2022 Report: Trends away from use of halons, HCFCs and HFCs



Information on Alternatives for Fire Suppression

- **2022 Report findings:**

- For some subsectors, HFCs have never been used to replace halons.
 - E.g., civil aviation cargo bays and airport crash fire rescue vehicles
- Many but not all subsectors that use HFCs have potential alternatives, but it is possible that not all applications can use them
 - E.g., very low temperature oil and gas production or specific cases for space or weight issues
- Some subsectors that use HFCs only have the original halon or HFCs as options.
 - E.g., military armoured vehicle crew compartment and civil aviation lavatory extinguishers

Information on Alternatives for Medical & Chemical Applications

- 2022 Report findings remain relevant for all all parties, including G2 parties:
 - Alternatives to HFCs in aerosols and solvents are widely available
 - HFC pMDIs are the dominant option for inhaled therapy in most markets
 - Dry powder inhalers (DPI) and aqueous soft mist inhalers (SMIs) are alternatives, although not all are universally available or suitable
 - New in-kind alternative propellants with lower GWPs, HFC-152a and HFO-1234ze(E), are in early stages of development
 - For semiconductor and other electronics manufacturing:
 - HFCs -23 (GWP 14,800), -32 (GWP 675), -41 (GWP 92) are used for etching and chamber cleaning
 - Alternatives include a range of fluorinated chemicals, many with higher GWPs, and one with a lower GWP <2
 - HFCs might be a preferred environmental choice in this application

Information on Alternatives for Medical & Chemical Uses, cont'd

– Magnesium production:

- SF₆ (GWP 22,800) is the most widely used cover gas
- Potential alternatives include HFC-134a (GWP 1430), a fluoroketone (GWP 0.1), sulfur dioxide (SO₂), and carbon dioxide, which are not always suitable
- HFCs could be a preferred environmental choice in this application

Information on Standards, Technical Regulations, and Codes



- Industry standards, technical regulations (e.g., Global Harmonized System) and building codes have been updated to reflect industry research and mitigation for new refrigerants since 2016

Table A2-1 International RACHP standards

Region	International Standards	Application Area	Title	Current Edition	Updates Since 2015
			Part 4: Operation, maintenance, repair and recovery	Edition 2: 2022	Covers equipment not under product standards such as IEC 60335-2-40, etc. Addition of guidelines for repair of equipment using flammable refrigerants (see Annex E)
International	IEC 60335-2-24	Ice-cream appliances/ice makers	Particular requirements for refrigerating appliances, ice-cream appliances and ice makers	Edition 8: 2020	Updates made regarding material encasing and in contact with thermal insulation; other updates made regarding motor-compressors, compatibility and testing.
International	IEC 60335-2-34	compressors	Particular requirements for motor-compressors	Edition 6: 2021	Updates made regarding application categories, motor compressor compatibility testing
International	IEC 60335-2-40	heat pumps, AC and dehumidifiers, includes chillers	Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers	Edition 7: 2022; Working on 8th edition. Expect to publish 2025	Updates since 2015: Overall larger charge for flammable refrigerants. Strategies used in standard: prevent refrigerant ignition by: limiting/removing ignition sources; refrigerant room/volume charge limitations, mitigation/ventilation strategies including safety shut-off valves and releasable charge.
International	IEC 60335-2-89	commercial refrigerating appliances	Particular requirements for commercial refrigerating appliances and ice-makers with an incorporated or remote refrigerant unit or motor-compressor	Edition 3: 2019; Working on 4th edition. Expect to publish Q4'2024	Since 2015: Overall larger charge sizes for flammable refrigerants using strategies such as air flow and specific design features (Annex C).

Annex 3: Examples of relevant demonstration and investment projects for G2 parties since 2016

COUNTRY	CODE	STATUS	TYPE	SUB-SECTOR	PROJECT TITLE	ODS REPLACEMENT	DATE APPROVAL
India	IND/EEF/93/DEM/507	NEW	DEM	Air conditioning	Design and development of a pilot scale energy-efficient rotary compressor along with microchannel heat exchanger compatible with R-290 technology at Godrej & Boyce Mfg. Ltd., for use in manufacturing of room air conditioners (decision 91/65)	R-290	Dec-23
India	IND/EEF/93/DEM/510	NEW	DEM	Commercial	Conversion of the manufacturing of commercial refrigeration appliances at Rockwell Industries Limited from HFC-134a to propane (R-290) (technical assistance to enhance the energy efficiency of the converted equipment) (decision 91/65)	R-290	Dec-23
Saudi Arabia	SAU/FOA/76/DEM/27	FIN	DEM	Rigid	Demonstration project for the phase-out of HCFCs by using HFO as foam blowing agent in the spray foam applications in high ambient temperatures	HFO	May-16
Saudi Arabia	SAU/REF/76/DEM/29	FIN	DEM	Air conditioning	Demonstration project at air-conditioning manufacturers to develop window and packaged air-conditioners using low-global warming potential refrigerants	HFC-32	May-16
Saudi Arabia	SAU/REF/76/DEM/28	ONG	DEM	Air conditioning	Demonstration project on promoting HFO-based low-global warming potential refrigerants for air-conditioning sector in high ambient temperatures	HFO	May-16

Annex 4: Planned activities in Adjusted Consolidated Business Plan of the MLF 2024-2026 for G2 parties

Country	Agency	Type ¹⁵⁵	Title	Required by Model	A-Appr. P-Plan'd	Remarks
India	UNDP	INV	Control and phase out HFC-23 by-product emissions	HFC-23	P	PRP requested in 2023.
India	UNDP	KIP	HFC phase-down plan	KIP Stage I	P	UNDP lead agency.
India	UNDP	INV	Demonstration Project for the conversion of HFC-134a in MAC for R-290 cascade system in SUBROS	KIP Stage I - Investment	P	PRP requested in 2023.
India	UNDP	PRP	PRP for HFC phase-down plan	KIP Stage I Preparation	P	Country ratified Kigali. UNDP is the lead agency.
India	UNEP	PRP	India HFC Phase down plan preparation	KIP Stage I Preparation	P	UNDP is a lead agency.
India	Germany	DEM	Design and development of a pilot scale energy-efficient rotary compressor along with microchannel heat exchanger compatible with R-290 technology at Godrej & Boyce Mfg. Ltd., for use in manufacturing of room air conditioners (decision 91/65)	Pilot Project for Energy Efficiency - Investment	P	
Iran (Islamic Republic of)	UNDP	PRP	PRP for HFC phase-down plan	KIP Stage I Preparation	P	Country has not ratified Kigali. UNDP is the lead agency.
Iran (Islamic Republic of)	UNIDO	PRP	HFC phase-down National Implementation plan (Preparation)	KIP Stage I Preparation	P	UNDP lead; UNIDO and UNEP cooperating implementing agencies
Iraq	UNEP	PRP	Iraq HFC Phase down plan preparation	KIP Stage I Preparation	P	UNEP is a sole agency. From BP 2023-2025. KA has not been ratified yet