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Addendum

PROJECT PROPOSALS: BRAZIL

Please insert the attached Annexes to document UNEP/OzL.Pro/ExCom/28/25 as follows:

Sector: Foam

Annex I: Justification for the Use of HCFC-141b

Please insert after page 14.

Sector: Fumigant

Phasing out methyl bromide in the entire Tobacco Sector

Please insert paragraphs 1 to 13 at the end of page 20 in Secretariat's Comments section.

Sector: Refrigeration

Annex I: Justification for the Use of HCFC-141b

Please insert after page 25.

Sector: Foam

Annex I

JUSTIFICATION FOR THE USE OF HCFC-141B
(Extract from the Project Document)

NOTE FROM THE SECRETARIAT:

Six projects – Espuma Oeste and JNP Group Project (Multiple Sub-sectors) and Ananda, Isotherm, Polsul Group Project and SIFC (Rigid Foam Sub-sector) – include conversion to HCFC-141b. The analyses and justification provided for the use of HCFC-141b in all the projects were similar. Therefore the description in Espuma Oeste which includes the justification applicable to all the sectors in the other projects has been reproduced below as a sample. The others, if required, will be provided on request.

Phaseout of CFC-11 by conversion to water-blown technology in flexible molded foam, to water and methylene chloride blown technology in semi-rigid packaging foam, and to HCFC-141b in the manufacture of flexible integral skin foams at Espuma Oeste.

Flexible integral Skin Foam

Accepted ODS phase-out technologies for *integral skin molded foam* are:

CLASSIFICATION	LIQUID TECHNOLOGY	GAS TECHNOLOGY
LOW ODP TECHNOLOGIES (“INTERIM”)	HCFC-141b	HCFC-22,
NON-ODS TECHNOLOGIES (“PERMANENT”)	PENTANE ALL WATER BLOWN	HFC-134a

The selection of the alternative technology would be governed by the following considerations:

a) Proven and reasonably mature technology
b) Cost effective conversion
c) Local availability of substitute, at acceptable pricing
d) Support from the local systems suppliers
e) Critical properties to be maintained in the end product
f) Meeting established standards on environment and safety

HCFC-141b has an ODP of 0.11. Its application is proven, mature, relatively cost-effective and systems that fit Espumas’ applications are locally available. HCFC-141b can, however, be destabilizing in higher concentrations, being a strong solvent, which may lead to the need to increase the foam density. Being an interim option, its application would only be recommended if permanent options do not provide acceptable solutions.

HCFC-22 has an ODP of 0.05 and is under ambient conditions a gas. It is not offered in the applicable regional area as a premixed system and would require an on-site premixer.

In the permanent solutions, pentane is a technologically feasible alternative. However, the use of hydrocarbons is a preferred solution when feasible from a safety and cost effectiveness standpoint. The relatively high investments for safety costs tend to limit pentane use to relatively large CFC users. In addition, the use of pentane is limited to those enterprises whose facilities can be adapted to meet safety requirements, and can be relied on to maintain safe operations.

Water-blown foams are an attractive option, as the technology is a permanent solution and is technically available. In addition, carbon dioxide, the resulting blowing agent from the water-blown technology, has no ODP, making water blown a favourable final solution. However, the systems costs are higher with water blown foams than for CFC foams and higher densities are required, resulting in higher incremental costs. The capital investments are not nearly as high as for pentane.

HFC-134a is under ambient conditions a gas. It is not offered in the applicable regional area as a premixed system and would require an on-site premixer.

It should be noted that in some individual cases, methylene chloride has been utilised as an effective solution, but due to processing concerns, it cannot be seen as an overall permanent solution.

<u>Rigid/Semi-rigid foams</u>

ODS phase-out technologies for *rigid polyurethane (PU) foam* are:

CLASSIFICATION	LIQUID TECHNOLOGY	GAS TECHNOLOGY
LOW ODP TECHNOLOGIES (“INTERIM”)	HCFC-141b HCFC-141b/HCFC-22	HCFC-22
NON-ODS TECHNOLOGIES (“PERMANENT”)	(CYCLO)PENTANE, WATER, LIQUID HFCs (-365,-245fa)	HFC-134a

The selection of the alternative technology is governed by the following considerations:

a) Proven application and reasonable maturity of the technology
b) Cost effective conversion, in view of one-time as well as recurrent costs
c) Local availability of substitute, at acceptable pricing
d) Support from the local systems suppliers
e) Critical properties to be maintained in the end product
f) Meeting established standards on environment and safety

HCFC-141b has an ODP of 0.11. Its application is proven, mature, relatively cost-effective and systems that fit Espumas’ applications are locally available. HCFC-141b can, however, be destabilizing in higher concentrations, being a strong solvent, which would lead to the need to increase the foam density. As an interim option, its application would only be recommended if permanent options do not provide acceptable solutions.

HCFC-22 has an ODP of 0.05 and is under ambient conditions a gas. It is not offered in the applicable regional area as a premixed system and would require an on-site premixer.

HCFC-141b/HCFC-22 blends can reduce the solvent effect of HCFC-141b alone and therefore allow lower densities while maintaining acceptable insulation values. The blends are, however, not available in Brazil or neighbouring countries. On-site multi-component blending would significantly increase the one-time project costs. In addition, the technology is not proven for pour-in-place (PIP) applications. Being an interim option, the same restrictions as for HCFC-141b would apply.

(CYCLO-)PENTANE is not an acceptable alternative. The use of hydrocarbons is a preferred solution only when feasible from a safety and cost effectiveness standpoint. The relatively high investments for safety costs tend to limit pentane use to relatively large CFC users. In addition, the use of pentane is limited to those enterprises whose facilities can be adapted to meet safety requirements, and can be relied on to maintain safe operations.

WATER-BASED systems are more expensive (up to 50%) than other CFC-free technologies due to reductions in insulation value (requiring larger thickness) and lower cell stability (requiring higher densities). They are also currently not available in the Brazil, although this may change in the next two years based on MLF-sponsored activities. Water-based formulations tend to be most applicable in relatively less critical applications, such as in situ foams and thermoware. In PIP for insulation applications, while in principle feasible, it would require an increase in panel thickness, which is not practical or cost effective.

LIQUID HFCs do not currently meet requirements on maturity and availability. Trials show that systems based on these permanent options would be feasible in PIP applications.

HFC-134a is under ambient conditions a gas. It is not offered in the applicable regional area as a premixed system and would require an on-site premixer. It is also less energy efficient, and expensive compared to most other technologies.

Flexible Molded Foams

The presently preferred ODS phase-out technologies for cold cure molding polyurethane foams are:

CLASSIFICATION	**TECHNOLOGY**
LOW ODP TECHNOLOGIES (“INTERIM”)	HCFC-141b
ODS-FREE TECHNOLOGIES (“PERMANENT”)	WATER LCD (Liquid Carbon Dioxide) GCD (Gaseous Carbon Dioxide)

The selection of the alternative technology would be governed by the following considerations:

a) Proven and reasonably mature technology
b) Cost effective conversion
c) Local availability of substitute, at acceptable pricing
d) Support from the local systems suppliers
e) Critical properties to be maintained in the end product
f) Meeting established standards on environment and safety

HCFC-141b has an ODP of 0.11. Its application is proven, mature, relatively cost-effective and systems that fit Espumas' applications are locally available. As an interim option, its application would only be recommended if permanent options do not provide acceptable solutions.

WATER BASED SYSTEMS are the preferred conversion option. Water blown systems are commercially available and provide superior environmental performance (no ODP or GWP), no health and safety hazard, and allow economical conversion. Water based systems include several variations, including water + additives (mostly used in hot cure foams), TDI technology (using 2 polyols and a TDI blend - systems from ARCO including "Hyperlite" and "Celestia", also systems from Bayer and Dow), and MDI technology (including "lite MDI", a new technology from ICI). These systems require the purchase of additional storage and metering systems to avoid cross contamination between chemical systems.

The technology based on the inclusion of CO_2 - liquefied (LCD) or gaseous (GCD) - as an auxiliary blowing agent is the most interesting replacement option that recently emerged. The technology provides significant economic and environmental benefits. It has no ODP, GWP or health hazards. The technology allows lower foam densities while essentially retaining quality.

Disadvantages are relatively high initial investment and more complicated process/process control. The technology can be applied in two ways:

- **Direct** through injection in, or just prior to, the mixing head. This allows instantaneous formulation change and in this way, very flexible manufacturing. The maximum amount of CO_2 that can be injected is 3% of the foam mixture. This is equivalent to almost 10% CFC-11 replacement, and is sufficient to cover any replacement scenario. The technology is only offered as LCD.

- **Indirect** through premixing in one of the foam components. This is realized preferably in the isocyanate to avoid potential hydrolysis that would occur in the polyol component. As this is in principle a "batch" system - even when effected in the day-tank on a continuous basis, no instantaneous formulation change is possible. The tank has to be emptied and refilled with another CO_2 concentration. Also the control on the CO_2 concentration is more critical, as this concentration has to be maintained over a longer period against a tank atmosphere. An advance is that LCD as well as GCD can be applied, reducing the investment considerably. The maximum amount of CO_2 that can be added to the foam formulation is restricted - less than 1% - and the technology may be reduced to a co-replacement option.

After considering the above factors, Espumas has the following options available:

Flexible Molded:	HCFC-141b, Water based, LCD
Rigid/Semi-rigid:	HCFC-141b, water based
Flexible Integral Skin:	HCFC-141b, water based, pentane

For the flexible molded foam and the rigid/semi-rigid foam, Espumas has decided to opt for a permanent solution. For flexible molded operations, conversion will be directly to water based formulations of their own development. For the rigid/semi-rigid applications, Espumas will develop their own water based and/or methylene chloride blown formulations.

For the flexible integral skin application, Espumas has considered the permanent solutions of water based formulations and pentane. The enterprise is not willing to assume the safety risks associated with the use of pentane. Experience with water based formulations is that these formulations currently result in a product that is too dense and expensive for their application. (See Annex 8 for the details of Viable Alternative Costing.) The costs to convert to water based systems are $605,990, or $110.18/kg ODP eliminated. As a result, the enterprise has chosen to implement HCFC-141b as an interim option until a permanent solution of acceptable quality is available.

The enterprise has accepted this recommendation. It has also been informed that HCFC's are transitional substances, and that under present Multilateral Fund rules, they will not be able to seek additional funding from the MPMF at a later date to convert to zero-ODP technologies.

Phasing out methyl bromide in the entire Tobacco Sector

Incremental cost of the project

1. The floating tray system in micro-tunnels has been selected since it is: (i) a cost-effective technology (increases number of seedlings produced per square meter, thus requiring less surface area); (ii) commercially available and in use by the majority of tobacco growers in developed countries; (iii) reliable (low incidence of weeds and nematodes and replants needed, seedlings produced have good diameter, and high weight of roots); and (iv) sustainable. This technology will require less labour resulting in lower operating costs. However, up front costs are needed for purchasing materials for the construction of the micro-tunnels (tunnel frame, plastic covers and plastic trays).

2. The cost of installation of the 240,218 micro-tunnels in Brazil has been estimated at US $34.99 million (Section 8, page 22 of the proposal). UNIDO has indicated that costs for other materials (e.g., plywood, clipping device and seed feeders) will be paid by the farmers. If these costs were to be included in the project, the total cost of the micro-tunnels would amount to US $45.47 million (a difference of US $10.48 million).

3. The two components that have a significant impact on the overall cost of the project are: (i) the size of micro-tunnels, and (ii) labour. As in any other large-scale projects, small changes in any of these components will result in major changes in project costs.

Size of micro-tunnels

4. With the floating tray system technology, trays with 200, 242 and 288 cells are commonly used worldwide (each cell holds one seed). The selection of the capacity of the cell depends, *inter alia*, on the local climatic conditions, the substrate used and the type of seeds. The size of a micro-tunnel is thus related to the number of cells in each tray: the larger the number of cells in a tray, the smaller the size of the micro-tunnel.

5. The size of the micro-tunnels in the Brazil project is based on trays with 200 cells. The number of cells have been selected taking into account that tobacco fields are not irrigated and thus, more substrate is needed to keep seedlings in good conditions. These trays were used in the demonstration project implemented by UNIDO. Trays with 242 cells, however, have been used by farmers in the United States in relatively dry climatic conditions without an irrigation system. It has been demonstrated that, under these conditions, there are no detrimental effects on the quantity of seedlings or the quality of the tobacco produced; nor is there a biological difference in the survival of 200 cell plants versus 242 cell plants (i.e., the same amount of rainfall would be required for both to survive).

6. If the design of the micro-tunnel is based on trays with 242 cells, about 17.3 per cent less area would be needed and therefore, less materials (plastic, trays, aluminum rods) and chemicals (fertilizers, substrate) resulting in less labour. Accordingly, the cost of the micro-tunnels (including trays) will be reduced from US $34.99 million to US $28.94 million (if other materials are included as indicated in paragraph 2 above, the costs of the micro-tunnels would be

reduced from US $45.47 million to US $37.60 million). Additional operating savings could also be realized due to lower amounts of fertilizer, pesticides and substrate.

Operating costs

7. The total operating costs of the project is based on two main categories: farm materials (seeds, fertilizers, substrate, pesticides) and labour (Section 8.2, page 23 in the project proposal).

(a) In the traditional system (e.g., using methyl bromide), the cost for farm materials is estimated at US $59.665 per hectare and labour costs at US $85.000 per hectare. Thus, the total operating cost for four years, covering the total production area of 240,28 hectares, is US $45.44 million for farm materials and US $64.72 million for labour (or US $110.16 million in total).

(b) In the floating tray system, the cost for farm materials is estimated at US $59.512 per hectare and labour costs at US $57.404 per hectare. Thus, the total operating costs for four years are US $45.32 million for farm materials and US $43.71 million for labour (or US $89.03 million in total).

(c) Therefore, the net operating savings is estimated at US $21.13 million (US $110.16 million less US $89.03 million).

Labour in the traditional system

8. The traditional seedbed technology requires clipping the beds and pulling and transplanting seedlings into the soil. Labour costs associated with these operations were not included in the project proposal (Section 5, page 35 of the project). Based on evaluations in the field conducted in the United States, the time required for these operations varies from 19 to 26 hours per hectare. Thus, labour costs would increase by US $18.60 per hectare (assuming 19 hours of additional labour). Accordingly, the total labour costs for four years would be US $78.89 million, instead of US $64.72 million as calculated in the project.

Labour in the floating tray system

9. Based on the demonstration project, the pricking-out operations are estimated at 25 hours per hectare (as shown in Section 5, Labour, page 35 in the project proposal). This takes into account the time required to remove the plants from those cells where more than one seed is sometimes sown per cell, and to replant those that have not germinated. UNIDO indicated that this small cost (equivalent to 49.1 per cent of total labour cost) is a guarantee that the floating system works properly. However, field surveys in the United States have shown that the time required for pricking out operations in floating tray systems is between two and three hours per hectare. Considering a pricking-out time of 12.5 hours per hectare (four times higher than in the United States) instead of the 25 hours considered in the project, the labour costs would be US $42.733 per hectare (instead of US $57.403 per hectare calculated in the proposal). Accordingly, total labour costs would be US $32.54 million for four years (instead of

US $43.71 million). Accordingly, operating cost for four years would be US $32.54 million instead of the US $43.71 million estimated in the project.

<u>Summary</u>

10. Taking into account the above observations, the operating costs for four years (NPV) are summarized as follows (in million US $):

	Traditional system	Floating tray system
Farm material	45.44	45.32
Labour	78.89	32.54
Total cost	124.33	77.86

11. Thus, the net operating savings would be US $46.47 million (US $124.33 million less US $77.86 million) instead of US $21.13 million calculated in the project.

12. When calculated as the net present value for four years, operating savings are greater than the cost of the project (US $28.94 million as indicated in paragraph 6 above) using micro-tunnels with trays of 242 cells. The net present value savings for four years are also greater than the cost of the project (US $37.60 million) calculated using micro-tunnels with trays of 242 cells after adding costs for the additional materials not originally included in the project (e.g., plywood, clipping devices and seeders as specified in paragraph 2 above).

13. The following observations are important:

(a) In the traditional production systems, labour wages vary depending on the type of tobacco produced: US $8.76/day for Virginia tobacco (with 7.763 effective working hours per day) and US $7.07 for Burley tobacco (with 8.05 working-hours per day) (Section 5 page 35). In the floating tray system, labour wages are the same irrespective of the type of tobacco produced. The labour costs for the floating tray system has been based on Virginia tobacco (the most expensive); if these costs are based on labour wages for Burley tobacco (at US $7.07/day), higher operating savings would be realized.

(b) The size of the project takes into account 12 per cent loss in seedlings production. However, losses using float bed systems are in the order of 8 to 10 per cent. A two per cent reduction in the size of the micro-tunnels could further reduce the costs of the micro-tunnels by two per cent accordingly.

Sector: Refrigeration:

Annex 1

Justification for the Use of HCFC-141b
(Extract from the Project Document)

Sub-Sector: Commercial Refrigeration

(a) Conversion from CFC-11 to HCFC-141b, and from CFC-12 to HFC-134a and from R-502 to R-402a in the manufacture of commercial refrigeration products at General Icy

Foam:

ODS phaseout technologies for *rigid PU foams in thermal insulation applications* are:

CLASSIFICATION	LIQUID TECHNOLOGY	GAS TECHNOLOGY
LOW ODP TECHNOLOGIES (“INTERIM”)	HCFC-141b HCFC-141b/HCFC-22	HCFC-22
NON-ODS TECHNOLOGIES (“PERMANENT”)	(CYCLO)PENTANE, WATER, LIQUID HFCs (-365,-245fa)	HFC-134a

The selection of the alternative technology is governed by the following considerations:

a) Proven application and reasonable maturity of the technology
b) Cost effective conversion, in view of one-time as well as recurrent costs
c) Local availability of substitute, at acceptable pricing
d) Support from the local systems suppliers
e) Critical properties to be maintained in the end product
f) Meeting established standards on environment and safety

Following is a discussion of the mentioned technologies in view of these criteria specifically applied for the operations of GENERAL ICY:

HCFC-141b has an ODP of 0.11. Its application is proven, mature, relatively cost-effective and systems that fit GENERAL ICY’s applications are locally available. HCFC-141b can, however, be destabilizing in higher concentrations, being a strong solvent, which would lead to the need to increase the foam density. As an interim option, its application would only be recommended if permanent options do not provide acceptable solutions.

HCFC-22 has an ODP of 0.05. It is not suitable for PIP applications because of frothing.

HCFC-141b/HCFC-22 blends can reduce the solvent effect of HCFC-141b alone and therefore allow lower densities while maintaining acceptable insulation values. The blends are, however, not available in Brasil or neighboring countries. On-site multi-component blending would significantly increase the one-time project costs. In addition, the technology is not proven for PIP applications. Being an interim option, the same restrictions as for HCFC-141b would apply.

(CYCLO-)PENTANE cannot be used - and never has been used - for PIP applications, where ever-changing ambient conditions do not provide the required safety.

WATER-BASED systems are more expensive (up to 50%) than other CFC-free technologies due to reductions in insulation value (requiring larger thickness) and lower cell stability (requiring higher densities). They are also currently not available in the Brasil, although this may change in the next two years based on MLF-sponsored activities. Water-based formulations tend to be most applicable in relatively less critical applications, such as in situ foams and thermoware. In PIP for insulation applications, while in principle feasible, it would require an increase in panel thickness, which is not practical or cost effective.

LIQUID HFCs do not currently meet requirements on maturity and availability. Trials show that systems based on these permanent options would be feasible in PIP.

HFC-134a is not suitable for the subject PIP application.

<u>Foam:</u>

Based on the before mentioned, the use of HCFC-141b is the only currently feasible option and is recommended to be employed as an interim solution. Water based technology or liquid CFCs can follow this in the future. The equipment installed under this project allows these technologies without further adaptations. The enterprise would incur, however, higher production costs that cannot be quantified at this time.

The enterprise has accepted this recommendation. It has also been informed that HCFC's are transitional substances, and that under present Multilateral Fund rules they will not be able to seek additional funding from the MPMF at a later date to convert to zero-ODP technologies.

(b) Phase out of CFC-11, CFC-12 and R-502 by conversion to HCFC-141b technology (foam) and HFC-134a and R-404a technology (refrigerant) in the manufacture of milk coolers and display cabinets at Incomar

<u>Foam Operation</u>

The presently available ODS phaseout technologies for *rigid polyurethane insulating foams* are:

CLASSIFICATION	LIQUID TECHNOLOGY	GAS TECHNOLOGY
LOW ODP TECHNOLOGIES (“INTERIM”)	HCFC-141b HCFC-141b/22	HCFC-22
NON-ODS TECHNOLOGIES (“PERMANENT”)	(CYCLO)PENTANE, WATER, LIQUID HFC’s (-365, -245fa)	HFC-134a

The selection of the alternative technology is governed by the following considerations:

a) Proven and reasonably mature technology
b) Cost effective conversion
c) Local availability of substitute, at acceptable pricing
d) Support from the local systems suppliers
e) Critical properties to be maintained in the end product
f) Meeting established standards on environment and safety

HCFC-141b has an ODP of 0.11. Its application is proven, mature, relatively cost-effective and systems that fit Incomar's applications are locally available. HCFC-141b can, however, be destabilizing in higher concentrations, being a strong solvent, which would lead to the need to increase the foam density. Being an interim option, its application would only be recommended if permanent options do not provide acceptable solutions.

HCFC-22 has an ODP of 0.05 and is under ambient conditions a gas. It is not offered in the applicable regional area as a premixed system and would require an on-site premixer. Its insulation value is somewhat less than with HCFC-141b.

HCFC-141b/HCFC-22 blends can reduce the solvent effect of HCFC-141b alone and therefore allow lower densities while maintaining acceptable insulation values. The blends are, however, not available in Brasil or neighboring countries. On-site blending would significantly increase the one-time project costs. Being an interim option, the same restrictions as for HCFC-141b would apply.

(CYCLO-)PENTANE meets all selection criteria except availability. It is not available from the current supplier. Usage would exclude any indigenous systems house. There are expected investment costs of US$485,000, and the incremental operating costs, because systems will have to be specially designed and possibly imported, may also increase. The enterprise is not in a position to pay the additional US$266,000 for incremental capital costs and is not willing to enter into the risk of committing to systems that are, at best, restricted in availability.

WATER-BASED systems are not acceptable in performance for this application, which is considered a critical application. In addition, water based systems are not locally available.

LIQUID HFCs do not currently meet requirements on maturity and availability.

HFC-134a is under ambient conditions a gas. It is not offered in the applicable regional area as a premixed system and would require an on-site premixer. It is also less energy efficient, and expensive compared to most other technologies.

Foam Operation

The presently available ODS phaseout technologies for *rigid polyurethane insulating foams* are:

CLASSIFICATION	LIQUID TECHNOLOGY	GAS TECHNOLOGY
LOW ODP TECHNOLOGIES (“INTERIM”)	HCFC-141b HCFC-141b/22	HCFC-22
NON-ODS TECHNOLOGIES (“PERMANENT”)	(CYCLO)PENTANE, WATER, LIQUID HFC’s (-365, -245fa)	HFC-134a

The selection of the alternative technology is governed by the following considerations:

g) Proven and reasonably mature technology
h) Cost effective conversion
i) Local availability of substitute, at acceptable pricing
j) Support from the local systems suppliers
k) Critical properties to be maintained in the end product
l) Meeting established standards on environment and safety

HCFC-141b has an ODP of 0.11. Its application is proven, mature, relatively cost-effective and systems that fit Incomar’s applications are locally available. HCFC-141b can, however, be destabilizing in higher concentrations, being a strong solvent, which would lead to the need to increase the foam density. Being an interim option, its application would only be recommended if permanent options do not provide acceptable solutions.

HCFC-22 has an ODP of 0.05 and is under ambient conditions a gas. It is not offered in the applicable regional area as a premixed system and would require an on-site premixer. Its insulation value is somewhat less than with HCFC-141b.

HCFC-141b/HCFC-22 blends can reduce the solvent effect of HCFC-141b alone and therefore allow lower densities while maintaining acceptable insulation values. The blends are, however, not available in Brasil or neighboring countries. On-site blending would significantly increase the one-time project costs. Being an interim option, the same restrictions as for HCFC-141b would apply.

(CYCLO-)PENTANE meets all selection criteria except availability. It is not available from the current supplier. Usage would exclude any indigenous systems house. There are expected investment costs of US$485,000, and the incremental operating costs, because systems will have to be specially designed and possibly imported, may also increase. The enterprise is not in a position to pay the additional US$266,000 for incremental capital costs and is not willing to enter into the risk of committing to systems that are, at best, restricted in availability.

WATER-BASED systems are not acceptable in performance for this application, which is considered a critical application. In addition, water based systems are not locally available.

LIQUID HFCs do not currently meet requirements on maturity and availability.

HFC-134a is under ambient conditions a gas. It is not offered in the applicable regional area as a premixed system and would require an on-site premixer. It is also less energy efficient, and expensive compared to most other technologies.

(c) Phasing out CFC-12 with HFC-134a and CFC-11 with HFC-141b at five commercial refrigeration companies (umbrella project)

Substitute of CFC-11 as a blowing

1) Drinking fountains: The PU thermal insulation of the drinking fountains will be substituted by EPS mouldings (without ODS), although this will demand more labour attention to seal off the mouldings so that no infiltration of humidity will occur. Of the present total CFC-11 consumption, about 50% will be eliminated through the EPS mouldings. So for this case a permanent solution for the elimination of CFC-11 was found.

2) Commercial freezers and display cabinets:

Table 2 shows the CFC-11 alternatives for foam blowing and their ozone depleting potentials.

Table 2. Alternative blowing agents to replace CFC-11

Foaming Agent	*Ozone Depleting Potential (ODP)*
HCFC 141b	0.11
HCFC 142b	0.065
HCFC 142b + HCFC 22	0.06
HFC 134a	0
Cyclopentane	0

It can be seen that HCFC-141b, HCFC-142b and the blend of HCFC-142b/HCFC-22 all have some ODP and are therefore accepted only as transitional substances.

When considering long-term replacements the field is narrowed to HFC-134a and cyclopentane. In Europe, HFC-134a was used as a blowing agent for a short time, but it was abandoned because it is very expensive compared to CFC-11 and cyclopentane. It is very unlikely that HFC-134a will become a widely used ultimate blowing agent for polyurethane foam in the refrigeration sector.

Lately, all major European manufacturers have already started using cyclopentane to produce polyurethane foam and similar trend is seen in many other parts of the world except North America.

However, cyclopentane is an explosive chemical. Since cyclopentane and polyol cannot be delivered premixed in drums or tanks as is the case with CFC-11 and polyol it is necessary to provide an expensive explosion proof mixing station. The same applies for the foaming machine.

In order to ensure operational safety when using the highly flammable and explosive cyclopentane and to meet the relevant requirements of the local authorities, it is necessary to install a gas detector system in the foaming department around the foaming machine.

Due to the current layout of the plants where several machines are installed next to each other installation of comprehensive automatic sprinkler fire protection systems is inevitable.

In order to prevent hazards and achieve compliance with established safety rules for the machinery and the plant, a safety exhaust system is also necessary in the foaming department in all areas where cyclopentane is in use and could escape.

All machinery and equipment which may come into contact with pure cyclopentane or cyclopentane/polyol must be explosion-proof and/or encapsulated.

To make the foaming jigs explosion-proof, it is necessary to replace electrical contacts, switches, motors etc. with specially designed explosion-proof ones. All foaming jigs and plugs must be fitted with a good earth connection to avoid sparks generated by static electricity. The workers' clothes and shoes must be made of antistatic material and the floor must be covered with antistatic paint.

As a precaution against static induced explosions, it is also necessary to inject nitrogen into the foaming cavity, immediately prior to the injection of the polyurethane material into the cabinet. This requires installation of N_2 tank, ring line and injection nozzles.

An emergency motor-generator must be provided to supply electric energy for the safety system even in case of black-outs.

Following completion of the installation an international institution in cooperation with local authorities must certify the safe operation of the foaming installation.

These measures would increase the cost of the project by at least US$ 300,000 by company which would make the cost effectiveness of the project unacceptable. The enterprise has no financial means to complement the grant with the additional funds required for the implementation of the project with cyclopentane technology.

Moreover, the recipient companies are very small enterprises with weak technical support staff especially in the field of maintenance and the present staff would be not able to run the plant and carry out the required maintenance procedures.

On the basis of these considerations the recipient companies decided to adopt HCFC-141b as a long term replacement for CFC-11 for foam blowing.

Formulations with this substance are already in use in Brazil, so various system houses can supply the necessary compounds. So for products which are not drinking fountains, the companies opted for this solution.