DEMONSTRATION OF LOW-COST OPTIONS FOR THE CONVERSION TO NON-ODS TECHNOLOGIES IN PU FOAMS AT VERY SMALL USERS (VSU)

OCTOBER 2019

FINAL REPORT

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Disclaimer

This demonstration project in Egypt was implemented by UNDP and the Government of Egypt.

VSUs are in this study defined as foam enterprises (end-users) that consumes less than 0.5 MT of HCFC 141b per year in the foam manufacturing process. Many VSUs practice hand-mix which is an operation deemed an industrial hygienic and health concern as no emission control or personal protection is used. Therefore, there is a need to improve current manufacturing practices for VSUs.

The finding of the project could be helpful for the implementation of programs designed for VSUs. The specific focus in this study is on VSUs and conclusions and recommendations cannot be extrapolated to non-VSUs and the applicability will also depend on local market conditions (availability of consumables and spare parts, after sale service, maintenance of the equipment, training, assistance from the local system houses, etc.).

UNDP does not in any way endorse the equipment (type, brand, manufacturers, etc.) that was tested in this study. The results cannot be used for any marketing purposes by public and private entities.

EXECUTIVE SUMMARY

This project for the Government of Egypt is based on ExCom Decision 72/40, offering a special window for demonstration projects and, at the same time, completing global efforts to make the ODS phaseout for SMEs (small and medium enterprises) and VSUs (very small users) in the foam industry more feasible and effective.

In Egypt, very small users usually account for less than a half ton of annual use of HCFCs on annual basis with infrequent services in foam blowing and application in the field. In this respect, it has been always difficult to achieve compliance for VSUs because of cost thresholds. Compounding the situation is that there are at least 8 viable options to replace HCFCs in PU foam, from which around five apply to Spray/PIP (Pour-In-Place). Some of these change equipment requirements—and prices. This report summarizes previous actions that can—and mostly have already—been taken to lower the cost threshold for this group of ODS users through following approaches:

- Management : Use local experts; work with group projects
- Technology : Evaluate and validate new technologies
- Equipment : Use more retrofit; develop affordable equipment
- Trials/Tests : Get suppliers (system houses) involved
- IOCs : Apply the lowest cost technology feasible in the national context

While all these approaches have led to significant cost savings, it was felt that more can be done to introduce very simple and affordable equipment for VSUs to replace current practice of hand mix for reasons of health and industrial hygiene for very low and infrequent ODS users. The purpose of this project therefore is to:

- Optimize and validate low cost chemical and equipment options for ODS phaseout at VSUs;
- Demonstrate these in downstream operations;
- Transfer the technology to interested system houses and other users around the world, and
- Use the outcome in existing projects thus improving the success of these projects.

The Project has attempted to economize costs for VSUs into three ways:

- For infrequent PU users, make available the option of prepackaged PU systems that are sealed, have a long lifetime and can be used upon demand. Alternatively design properly sized day tank options with moisture protection for PIP (pour-in-place) equipment (currently such equipment operates mostly from drums);
- Develop easy-to-use and maintain, low-cost foam dispensing units for low volume PIP/Spray Rigid Foam applications that demand low electrical power or no power at all for VSUs;
- Develop low-cost variable ratio foam dispensers for PIP rigid or integral skin applications for VSUs.

The equipment part of the project was be staged as follows:

1. The selection of (a) producer/installer/service provider(s) based on bidding through requests for proposals;
2. Review of substantially responsive offerings, followed by

- Negotiations with selected providers on modifications to reach potential cost savings (the goal is to reach a price level below US$ 10,000 for a PIP dispenser and US$ 30,000 for ISF equipment);
- Selection of equipment (one high-pressure, one low-pressure; one low-pressure variable ratio (ISF);

3. Procurement of the most promising equipment;
4. Validation of this equipment in the (Egyptian) market;
5. Formulation of a report to UNDP/EEAA/MFS on outcome, conclusions, limitations and recommendations, taking into account ExCom stipulations from a previous, interim report.

The implementation of the chemical part of the project was envisioned as follows:

1. Selection of a system house willing to cooperate on this approach;
2. Identification of existing prepackaged systems with stable storage life-time/easy component perforation when in need for field application. One company making these is in the USA but there might be more companies on the global market. Evaluate this technology at the selected system house;
3. If successful, install a local component facility and/or assembly facility;
4. Organization of trials/tests to assure that the equipment is suitable for the earmarked ODS phaseout technologies;
5. Incorporation of the outcome in the mentioned report in the equipment section;
6. While the project includes trials/tests, these will be conducted to the extent possible at system house development facilities and with one or two selected customers. Industrialization should take place through National Phaseout Plans.

The project was substantially implemented as designed through a Taskforce consisting of a dedicated project team, including an International Expert and a National Expert. The three system houses in Egypt, Baalbaki Egypt for Chemical Industries (BCI), Dow Middle-East (DME) and Technocom Commercial Agencies (TCA) cooperated closely with the Taskforce in evaluating the selected equipment. The prices of the selected equipment showed the following range of indicative prices compared to currently used equipment as follows, excluding delivery, warranty and other associated costs:

Equipment Category	Price	Notes
PIP Dispenser (Pumer, Tecmac)	From ca. US$ 5,500- 7,000	FOB[1]
SPF Dispenser (Pumer, Tecmac)	From ca. US$ 5,500- 7,000	FOB; no spray package included
ISF Dispenser (Transtecnica)	From ca. US$ 20,000	FOB

*Technically Pumer can be used also for PIP/SPF however, because it's low pressure it will be an air/PU mixture

From each category, one dispenser was purchased and placed for evaluation at the following Egyptian system houses.

Only a small number of VSUs (customers of the system houses) participated in field test due to limited number of dispensers available, and time available to complete the field tests.

An Agreement was signed to evaluate the dispenser in development departments of the system houses as well as with selected customers. The outcome of this evaluation can be summarized as follows:

[1] FOB = Price of equipment before shipment

Systems house	**Equipment tested**	**Blowing agent used**	**Results of testing**	**Tested with end-user? (Y/N)**
DOW (DME)	PUMER	ALL WATER BASED	NEGATIVE	Y*
BAALBAKI (BCI)	TECMAC	ALL WATER BASED METHYL FORMATE	NEGATIVE POSITIVE	Y*
TECHNOCOM (TCA)	TRANSTECNICA	HFO-1233	POSITIVE	Y*

*The end users (VSU) have no equipment and only a small number (one per each system house) of them participated due to time remaining in project's implementation. This can continue as part of the HPMP programme and its small users' component.

Analysis showed that the BCI and DME systems had both 1:1.5 ratio's (Taskforce had requested for 1:1) while the Pumer and Tecmac equipment operated on 1:1 (fixed) ratio. In other words, systems and dispensers were "incompatible". While the issue could have been resolved with a modification of the pump, the team asked the pertinent manufacturers if they could include "true" variable ratio so that they would be able to cope with all systems. This was the case with one supplier so that all available systems can be satisfactorily processed.

The difference in ratio was addressed with suppliers of equipment as well as the system houses. One supplier, Tecmac, can provide variable ratio dispensers immediately and such equipment has already been pursued in the mean time and can be supplied end of 2019 or beginning of 2020. Another supplier, Pumer, is prototyping a concept and expects to have a solution by December 2019, if successful. The team looked also into why there is need to deviate from the standard PIP ratio. From Dow and Baalbaki SHs, which offered water-based PIP systems based on 1:1.5 ratio, Baalbaki SH offered a methyl formate based 1:1 system, while Dow MidEast SH has been initiating development of such a system based on an HFO option.

It was therefore determined feels that the issue of diverging ratio's is addressed through:

- the availability of variable ratio dispenser from the same suppliers in the same price range, and
- using systems based on methyl formate/methylal (HCOs) and HFOs.

Further trials of all these systems could be conducted as part of the Egyptian HPMP programme and its VSU component.

As for the chemical packages, SHs showed no interest in pre-packaged chemicals. They see these:

- As a specialized application for back-fill around (electrical) posts and fences than as a way to extend the chemical life-time;
- While the life-time can be extended from 6 months to 2 years, they expect that this does not make up for larger chemical losses and of packaging materials;
- As an application that is not fit for a developing country. The main advantage of PU foam as back-fill material instead of concrete is time-saving through faster curing. This is interesting for developed countries with high wages but not for countries where labor is relatively cheap;
- Finally, the investment will be too high in view of the risk of non-acceptance by potential clients.

The option to offer different sizes of tanks and install silica gel breathers on the MDI tank (to avoid humidity in tanks) was, however seen as positive and was integrated in the dispenser specifications.

A number of conclusions of the entire project applicable for the VSU sector in Egypt is as follows:

Cost Evaluation (excluding delivery, certification, maintenance and servicing by warranty):

- **A basic, sole purpose, fixed ratio (**1:1/1:1.5/1.7**) PIP dispenser can now be purchased for starting US$ 5,500 rather than around US$ 10,000 or more.**
- **A basic, fixed ratio (**1:1/1:1.5/1.7) **Spray/PIP dispenser can be purchased for starting from US$ 7,000 rather than US$ 1510,000 or more.**
- **A basic, variable ratio Spray/PIP dispenser can be purchased starting from US$ 7,000 rather than US$ 15,000 or more.**
- **A basic ISF dispenser can be purchased for US$ 18,480 instead of US$ 25,000-30,000.**
- **Local or regional servicing/maintenance representation, spare parts availability, trouble-shooting speed and quality of support, training are important elements in the consideration**

Packaged Chemicals

Attempts to introduce smaller, packaged chemicals were not successful. It is better to install for PIP operations smaller sized tanks with silica gel breathers, to control humidity in the tank and to assure that the master drum is properly closed after filling.

1. INTRODUCTION

This project was submitted in response to the ExCom's Decision 72/40. The relevant part of this decision states as follows:

> *(i) The following criteria would be applied when selecting projects:*
>
> *a. The project offered a significant increase in current know-how in terms of a low-GWP alternative technology, concept or approach or its application and practice in an Article 5 country, representing a significant technological step forward;*
>
> *b. The technology, concept or approach had to be concretely described, linked to other activities in a country and have the potential to be replicated in the medium future in a significant amount of activities in the same sub-sector;*
>
> *c. For conversion projects, an eligible company willing to undertake conversion of the manufacturing process to the new technology had been identified and had indicated whether it was in a position to cease using HCFCs after the conversion;*
>
> *d. The project proposals should prioritize the refrigeration and air-conditioning sector, not excluding other sectors;*
>
> *e. They should aim for a relatively short implementation period in order to maximize opportunities for the results to be utilized for activities funded by the Multilateral Fund as part of their stage II HCFC phase-out UNEP/OzL.Pro/ExCom/72/47 36 management plans (HPMPs);*
>
> *f. The project proposals should promote energy efficiency improvements, where relevant, and address other environmental impacts;*

While the foam sector did not qualify for prioritization, the ExCom nevertheless approved the project, recognizing the need for effective implementation of technology transfer for very small users (VSUs), specifically in Egypt and where similar situations could occur.

This report first reviews **Past Efforts** made in this respect during the CFC phaseout period as well as during the HCFC phaseout over the last ten years. It is followed by chapters on **Project Design, Implementation/Outcomes, Conclusions** and **Limitations**.

2. HISTORY OF PAST EFFORTS TO LOWER COST THRESHOLDS

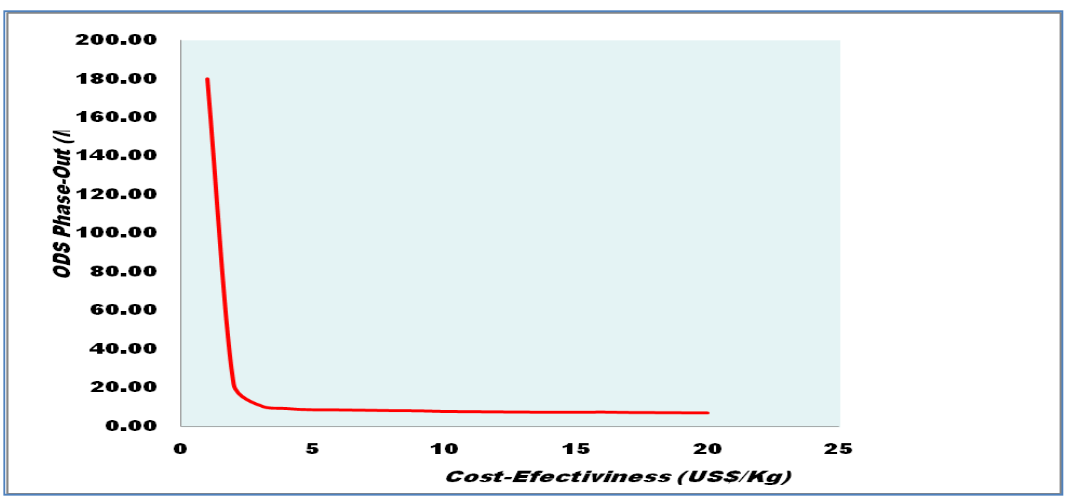
The stated objective of this projects is to:

- Optimize and validate low cost chemical and equipment options for ODS phaseout at VSUs;
- Demonstrate these in downstream operations;
- Transfer the technology to interested system houses and other users around the world, and
- Use the outcome in existing projects thus, at no additional costs, improving the success of these projects.

MLF projects are since 1993 subject to Cost-Effectiveness (C/E) Thresholds. In foam sector, these thresholds are based on the conversion cost for consumption volumes at large and medium size enterprises, and therefore are difficult to meet the funding demand by very small users (VSUs). Many VSUs practice hand-mix, an operation deemed an industrial hygienic concern as no emission control or personal protection is used. These companies need low cost/easy to use equipment that meets applicable limits on cost-effectiveness. Others use infrequently PU foams and have problems with inventories in view of the relatively short life-time of existing systems (3-6 months).

A first attempt to deal fairly and effectively with small users (SMEs) was a 1995 study by UNDP called ***"Determination of Cost-Effective Phaseout Approaches for Enterprises with relatively Small ODS Use"***.

The Multilateral Fund Secretariat (MFS) prepared, based on this study, Document 17/55 (June 30, 1995) called "Strategy Paper for Small Foam producing Enterprises". It recommended dividing projects by size and foam category; to assign to large and medium sized enterprises specific C/E thresholds and to make the approval of small projects subject to specific cost containment procedures. This would have addressed the issue. In developing the cost guidelines of the HCFC phase-out, the Executive Committee of the MLF decided to increase the cost-effectiveness threshold (CE) for foam SMEs up to 40% above the $7.83/kg CE when needed for the introduction of the low GWP alternatives (Desicion74/50). Although this policy helped to address the financial burden for SMEs to some extent, however, the cost challenge remains for very small users (VSU) since only a few thousand dollars are available for them and the conversion to the low GWP alternatives including the costs of complicated equipment and formula, safety measure, increased IOC for specific alternative and necessary training. Essential is to realize that the cost effectiveness increases exponentially when the consumption decreases, as following graph shows:



Following approaches have been attempted by to obtain cost containment when dealing with SMEs:

- Management : Use local experts; work with group projects
- Technology : Evaluate and validate new technologies
- Equipment : Use more retrofit; develop low-cost equipment
- Trials/Tests : Get suppliers involved, often combined with group projects
- IOCs : Apply the lowest cost technology

The following is a review of cost optimizing efforts in these categories:

Management - The largest success has been created by ODS phase-out projects using PU System Houses as project managers. This approach provided not only local project management but also larger economy of scale and supplier-arranged trials/tests.

Technology - The validation of new technologies was almost equally successful. In the foam sector, ten (10) demonstration projects to evaluate new—or to modify existing—technologies were conducted in the last several years. Through this program, methyl formate (MF) and methylal (ML)—both oxygenated hydrocarbons or HCOs— are now in application in a number of countries and in several of these countries by now conversions have been successfully completed. Some system houses are able to offer preblended hydrocarbons, including to smaller users in spray foam, with respective safety measures to be followed. While some of the demonstrated technologies suffer under economic constraints, such as license fees (supercritical CO_2) or high operating costs (HFOs), the program in general has contributed with new knowledge on low GWP HCFC replacement technologies.

Equipment - Attempts to optimize equipment costs had mixed results. The following summarized these attempts:

- Retrofit of equipment has optimized costs when using water, MF or ML technologies;
- Renting out equipment to very small users (VSUs) was not proved successful because of frequent mishandling of equipment as well as chemicals;
- An attempt to import low cost equipment was not fully successful because of lack of training and local equipment service (availability of consumables, spare parts and after sale service locally or regionally);
- An attempt to optimize costs of ISF equipment for VSUs required further fine-tuning;
- Infrequent use—in particular, when combined with bad maintenance—leads to aging issues with chemicals and maintenance issues.

Trials/Tests – through involvement of suppliers (system houses), trials could be lowered in price and amounts, while testing is generally provided through the supplier.

IOCs – While the freedom of choice between the available zero ODP/low GWP technology is maintained, the IOC is calculated on the lowest cost applicable technology.

Compounding the precarious position of the VSUs is the multitude of HCFC phaseout options:

- There were two (2) options to phase out CFCs in rigid PU foams—but there are eight (8) options to phase-out HCFCs in PU foams.
- Just one (1) of these CFC phase out options could be applied to Spray/PIP but all eight HCFC phase out options apply to Spray/PIP.

This leads to the offering of PU systems in the market that are more complicated in equipment requirements and therefore, more costly. Examples are different for different Polyol/MDI ratios—requiring variable output ratios—or the use of flammable substances, requiring emission exhaust or even explosion proof equipment. Equipment prices over-proportionally increase through these requirements for higher sophistication.

Clearly, and in spite of past successes, there was still a need to find solutions for very small users (VSUs)—in particular for PIP manufacturers who have the smallest volumes of consumption. The purpose of the project was to identify more simple, affordable equipment applicable for VSUs requirements and improved life-time for chemicals in case of low/sporadic use.

3. PROJECT DESIGN

The Project was generally designed into three stages:

- For infrequent PU users, make available the option of pre-packaging PU systems that are sealed, have a long life-time and can be used upon demand. Alternatively, develop properly sized day tank options with humidity control for PIP equipment;
- Develop specifications for a basic, easy-to-use and maintain lower cost foam dispensing unit for PIP/Spray rigid foam applications;
- Develop specification for a low-cost, variable ratio foam dispenser for rigid foam PIP/Spray foam and integral skin foam applications.

The equipment part of the project was be staged as follows:

- Develop specifications for the mentioned dispensers to be used for bidding by existing suppliers;
- Select equipment through open bidding;
- Purchase and validate the most promising equipment;
- Report to UNDP/EEAA/MFS on the outcome, conclusions and recommendations.

Interested equipment suppliers that could potentially meet requirements from the project are listed below as prospective bidders to provide such services. It was emphasized that selection was subject to applicable procurement procedures which included their display on the UNDP web-site and allowed therefore other, not yet identified bidders as well to apply.

- Pumer	Belo Horizonte	Brazil	RPF only
-Transtecnica	Porto Alegro	Brazil	ISF and RPF
- Cannon	Milano	Italy	ISF and RPF
- Zadro	Guadalajara	Mexico	ISF only
- Tec Mac	Milano	Italy	ISF and RPF
- BMK	St. Louis	USA	RPF only

Further, the implementation of the chemical part of the project was envisioned as follows:

1. Selection of a system house willing to cooperate on this approach;
2. Identification of existing pre-packaged systems with stable storage life-time/easy component perforation when in need for field application. One company making these in the USA but there could be more companies on the global market. Evaluate this technology at the selected system house;
3. If successful, install a local component facility and/or assembly facility;
4. Conduct trials/tests to assure that the equipment is suitable for the proposed technologies;
5. Include the outcome in the mentioned report in the equipment section.

While the project includes trials/tests, these will be conducted to the extent possible at system house development facilities and with one or two selected customers. Industrialization should take place through National Phaseout Plans.

3.1. EQUIPMENT

VSUs overwhelmingly produce products consisting of rigid PU foam. There is, however, also some production of integral skin foam (ISF). Past experience has shown that combining these two applications in one dosing machine will not lead to lower costs. The machine requirements are too different to be combined. In addition, many VSUs do—or would like to—combine PIP with Spray and are willing, in case they are eligible for PIP only, to pay the cost difference. Therefore, low cost options were pursued in the following categories:

- PIP only for rigid PU foam
- Spray/PIP for rigid PU foam
- Pouring for ISF foams

Technical specifications will be developed for each of these machine groups. For each of these categories, potential suppliers will be identified world wide and, if interested asked for quotations.

3.2. CHEMICALS

Some VSUs produce infrequently for products such as molds, setting electrical or fence poles and other construction applications, etc. Some require small, pre-determined amounts of chemical to set a pole—much like cement but much faster in solidifying, some others require larger amounts but irregularly. Because of irregular, in field use, there are problems with chemical life-time—now typically 3-6 months when stored properly but much shorter in field use. A life-time of at least one year is desired. The Taskforce located a company that manufactures pre-packaged chemicals for pole setting applications with a life-time of up to 2 years and intended to bring this technology to the attention of existing system houses that were interested.

But there are other options as well. The prevailing current equipment at this time is the Spray equipment used for in-place pouring (PIP). They are fed from 200 l barrels—two barrels at a time, Polyol blend and MDI—through drum pumps. Because 400 l is a large amount, these drums are exposed to the atmosphere for a long time allowing oxidation, hydrolysis and MDI to react. This shortens the life-time of material considerably. Introducing day-tanks, sized for the type or application and fitted with silicone dryers would go a long way in protecting these chemicals better and prolonging the useful life-time. Introducing smaller drums might work also in some applications, as will better procedures (protected vents on drums, etc.).

In this respect, it was proposed to discuss these options with System Houses and their end-users before developing equipment specifications or specific chemical packaging systems.

3.3. ESTIMATED POTENTIAL PROJECT IMPACT

Depending of the stage of industrial development and the population size of a country, VSUs' market share in foam applications can range from 5% to more than 30%.

It was proposed to implement this programme in Egypt, since system houses are highly developed there, and a large number of VSUs are present on the market.

The Egyptian HPMP Stage I made a reference that "from available information it has been determined that "Micro Users" (=*VSUs*) account for 22.3 t HCFC-141b and, <u>assuming an average use of 250 kg/y per company, include up to 100 companies</u>", so there was sufficient market for trials, tests and equipment validation.

The current demonstration project contributes to a complementary phase-out of 4.4 ODP tons at VSUs unaccounted in HPMP-I and further researched as potential additional VSUs under HPMP-II preparation process.

3.4. CHOICE OF HCFC REPLACEMENT TECHNOLOGY

Foam dispensers are based on blending of two reactive components: isocyanate, and polyol blend. The polyol blend includes polyol as the main component but also other, minor, components such as blowing agent(s), stabilizer, catalysts etc. When blended, this leads to a controlled blowing and polymerization reaction, resulting in polyurethane foam.

The foam dispenser poses in principle no restriction on the type of blowing agent. This implies that any HCFC replacement can be used. However, there are safety considerations to be taken into account. Based on such considerations, flammable systems have in general been avoided unless special safety features have been incorporated. However, one cannot take the flammability of a pure component to predict the flammability of a blend or mixture. If the blowing agents are water, methyl formate (up to 5.5%), methylal (up to 5%), HFCs or HFOs—or combinations of these—then the blend is non-flammable. If the blend contains hydrocarbons (HCs), then the result is, as a rule, flammable with resulting safety pre-cautions required to be in place. Methyl formate and methylal blends, if properly prepared, can thus be treated the same way as water, HFCs and HFOs. As blends are prepared by System Houses, these have to take safety precautions when blending the original components.

A new development changed this situation: pre-blending of HCs at system house level. Up to recent years, the normal procedure would be that the end processor had to blend hydrocarbons in-house. Some exceptions were discovered in the market where the end processor, to save the costly pre-blending installation, received pre-blended HC systems (Bayer) or injected HCs directly in the mixing head (Elastogran/BASF). These approaches were analyzed in a previous pilot project in Egypt and concluded that both approaches are feasible and can save costs.

4. PROJECT IMPLEMENTATION AND OUTCOME

4.1. EQUIPMENT

A taskforce consisting of one person delegated by EEAA, and two experts – national and international from the project team, was handed the task of implementing this project.

The taskforce first contacted all the known equipment suppliers that had shown interest in cooperating on this project. With their input, technical specifications were prepared based on which the procurement process on a basis of a bidding was conducted. **Attachment-2** shows these specifications.

The invitation to bid was sent to all these suppliers, and, in addition, published on a procurement web-site. After a technical and a price evaluation, the following equipment was selected (prices determined for this regional location exclude delivery, warranty, servicing support etc):

- PIP dispenser for rigid PU foam from US$ 5,500
- Spray/PIP dispenser for rigid PU foam from US$ 7,000
- Pouring dispenser for ISF foams from US$ 20,000

From each category, one dispenser was purchased and placed for evaluation at the following Egyptian system houses:

- Baalbaki Chemical Industries (BCI) Tecmac Dispenser (Spray/PIP)
- Dow-Middle East (DME) Pumer Dispenser (PIP)
- Technocom Commercial Agencies (TCA) Transtecnica Dispenser (ISF)

An Evaluation Agreement was signed in which the system houses agree to evaluate the dispenser in their development department as well as with selected customers in the field.

Regretfully, there were some transportation and connection damages that delayed installation and start-up of the equipment. Ultimately, all equipment was functioning, and the evaluation process could be conducted. The outcome of this evaluation can be summarized as follows:

Systems house	Equipment tested	Blowing agent used	Results of testing	Tested with end-user? (Y/N)
DOW (DME)	PUMER	ALL WATER BASED	NEGATIVE	Y*
BAALBAKI (BCI)	TECMAC	ALL WATER BASED METHYL FORMATE	NEGATIVE POSITIVE	Y*
TECHNOCOM (TCA)	TRANSTECNICA	HFO-1233	POSITIVE	Y*

*The end users (VSU) have no equipment and only a small number (one per each system house) of them participated due to time remaining in project's implementation. This can continue as part of the HPMP programme and its small users' component.

Subsequent analysis determined the BCI and DME systems had a 1:1.5 ratio by volume (despite the project asked for 1:1—but it was their standard Non-HCFC PIP system). The Pumer and Tecmac equipment operated on 1:1 (fixed) ratio by volume. In other words, systems and dispensers were "incompatible". While the issue could have been resolved with a modification, the project asked the pertinent manufacturers if they could include variable ratio so that they would be able to cope with all systems. This was the case for Tecmac, and such a machine was purchased to verify the statement. However, as the variable system is known and proven, it is expected that this equipment can process satisfactory with all locally available systems. Pumer is developing such a modification.

This incident brought to light an important fact: the need for variable ratio under the HCFC phase-out program. While under the CFC phaseout program there was no change in ratio needed for PIP applications, under the HCFC program this appears to be advisable or even essential. In particular, for all-water-based formulations the need for more MDI leads to ratios of between 1:1.5 and 1:1.7. This is not the case for HCO and HFO formulations so, if a processor wants to keep his supply options open, having variable ratio on his/her foam equipment is essential. The Transtecnica dispenser has this feature, but the Pumer and Tecmac dispensers - not.

Following other comments do apply, too:

- The simplified equipment from **Pumer** is, despite being the lowest price, is amazingly sturdy. Set-up instructions were provided by video—which was easy but did not work well with trouble shooting. The dispenser works pneumatically. The foam at BCI and DME (water-based) was too soft and shrunk. However, at TCA the foam was perfect: fine, closed cells, firm to the touch and no shrinkage. The implementation team concluded to system issues at BCI and DME. It turned out that the system required a 1:1.5 ratio while the dispenser provides 1:1 (all by volume). This is fine for hand mixed foam, where the ratio can adapt (manually) easily—but not for a dispenser. Pumer can provide a different pump, suited for 1:1.5 ratio but that defeats the purpose (complicated, not suited for 1:1 systems, more expensive). It was already concluded that, where the market offers different ratios for the same application—based on different phaseout technologies—variable ratio is needed. The Pumer's option is not considered as suited for such markets. Instead, it is suited for "homogenous" VSU markets.

- The **Tecmac**'s equipment was developed from a more expensive dispenser with more complex technical features available earlier. The machine worked mechanically well in trials. Exactly the same experience as with Pumer equipment was faced—and the same conclusion was drawn—with the Tecmac dispenser. However, in this case, the solution was easy. The producer can offer—and offered—the same dispenser with variable ratio at virtually the same price. Therefore, such equipment is universally suited for the VSU market.

- The **Transtecnica's** reduced specification dispenser is earmarked for ISF as well as RPF applications. It is well designed and sturdy. It performed well with all systems. When using high viscous (ISF) systems, prior calibration is required (pump slip). It is the most expensive dispenser of the three and probable only affordable under MLF funding for companies that produce ISF or with a large counterpart funding. But, the Transtecnica dispenser is suited for all applications. If used for spray, the user should realize that it generates PU/air laydown which is more irregular than airless laydown.

4.2. CHEMICALS

From the beginning, system houses showed scant interest in pre-packaged chemicals. They see this:

- Rather as a specialized application for back-fill around (electrical) posts and fences than as a way to extend the chemical life time;

- While the life time can be extended from 6 months to 2 years, they expect that this does not make up for larger chemical losses and of packaging materials;
- They also view this as an application that is not fit for a developing country. The main advantage of PU as back-fill material, instead of concrete, is time saving through faster curing. This is interesting for developed countries with high wages but not for countries where labor is relatively cheap;
- The related investment as too high in view of the risk of non-acceptance of these systems by end-users.

A visit at a company in North America, where such product is made, confirmed the high related investment and the specialized application for back-filling (where the packaging is integrated in the back-fill and no waste is created). It was decided not to spend remaining funding in further pursuing this part of the project.

The option to offer different sizes of tanks and install silica gel breathers on the MDI tank was integrated in the dispenser specification. The silica gel keeps the humidity out and the tanks allow to keep the drums closed.

5. CONCLUSIONS and LIMITATIONS

From the results received for the VSU trials compared to current pricing, it was determined that:

- In Egypt, very small users usually account for less than a half ton or lower of HCFCs on annual basis with infrequent services in foam blowing and application in the field. Other interested countries should determine applicability of the findings of the report to their conditions, and VSU markets, if they exist.

- Minimum-level technical specifications for dispensers were developed and only basic features required for a PIP, PIP/Spray and ISF works were left as compared to regular models of same equipment (with no delivery, warranty and other costs included):

    - A basic, sole purpose, fixed rate PIP dispenser can now be purchased from US$ 5,500 (before shipment). The average current market price is around US$ 10,000 or more.
    - A basic Spray/PIP dispenser with variable ratio can now be purchased from US$ 7,000 and higher (before shipment). The average current market price is US$ 15,000 or more.
    - A basic ISF dispenser can now be purchased from US$ 20,000 (before shipment). The average current market price is US$ 25,000-35,000.

- The field tests for VSUs in the Egypt's market were performed with help of participating system houses manufacturing polyols and a small of number of end-users due to time limitations in the programme. Despite being simple equipment, a training was required for technicians.

- Project implementation should strictly follow established processing and occupational health requirements when equipment is planned and/or in use and should respect restrictions applicable to specific polyols.

- The study did not evaluate the long-term sustainability (availability of consumables, spare parts, after-sale service, maintenance, durability of equipment, etc.)

- Attempts to introduce smaller, packaged chemicals were not successful. It is better to install, for PIP operations, small sized tanks with silica gel breathers and to assure that the master drum is properly closed after filling.

ATTACHMENT I:

Incorporation of Stipulations from the ExCom

The ExCom, upon receiving a preliminary report on the VSU project, stipulated, under others, that the final report on this project should include:

- Details of the comparison of the specifications of the original equipment with those of the optimized low-cost units;
- The performance of the equipment during testing, including the foam systems used during the testing;
- The results of using the new equipment and
- Recommendations regarding its utility for very small users.

These stipulations were incorporated in the current document as follows:

SPECIFICATIONS

It is not possible to reduce the development of the specifications for the VSU equipment to just one original template. The Taskforce looked into a multitude of existing equipment in the market—at least 20 different suppliers in different parts of the world. They even reviewed hardware from some end-users that made their own equipment.

The project team prepared out of these offerings three simplified, “barefoot”, specifications for what is at the minimum needed to conduct a PIP, PIP/Spray and ISF task. That excludes, under others, timers, heated hoses, sophisticated (self-) cleaning features—in—short, everything that facilitates the operator’s task but is not absolutely needed, while still offering a machine that provides a suitable product and a safe operation. The “barefoot” specification was then “upgraded” depending on its use with tanks, a PIP injector, limited (5-6 m) hose, static mixer and low-pressure rotating pumps (ISF)and variable ratio (ISF).

Based on these specifications, an open (internet) bidding was conducted and selected three (3) candidates that offered equipment that appeared to meet the specifications. From these three, prototype equipment was purchased and tested it in the laboratory and at the end user level.

From the feedback received, some changes were made in the specification:

- Variable ratio is desired for all applications. The simplest dispenser may achieve that with cylinder exchange (“limited”) variability; the others - with (“true”) variability.[2]
- Installation by a trained (local) mechanic is required; training by video is not sufficient.

PERFORMANCE TESTING

The Taskforce placed each prototype at a selected System House, and found out that, despite the equipment is simple, a technician is needed to provide training and supervise the start-up. The Taskforce collected feedback from SHs and end users. In particular, the feedback from end-users—the actual target of the whole exercise—was obtained in terms of direct interviews (verbally) and

[2] “Limited Variable” ratio (German: Sprung-fix) is meant variable ratio through the replacement of one pump cylinder by one of a different volume (1:1; 1:1.5; 1:1.7, etc). “True Variable” ratio means seamless variability (1:1 thru 1:1.7).

not in the form of physical data. The system houses prepared a written report but asked for confidentiality.

During the change from CFCs to HCFCs — practically the only phaseout option for PIP and spray — the system ratio remained 1:1. It was surprising that the project team was now confronted with different ratios (1:1 and 1:1.5), based on the use of different phase-out technologies (water or HFOs). Even equipment with fixed ratio can be adapted but this is a cumbersome operation. Variable ratio is recommended.

OUTCOME

The achieved result in terms of simplification of equipment in the selected application areas will make more small users being able to use very basic dispenser equipment, therefore reducing the co-financing burden of VSUs. This is especially important when the previous rent-out dispenser models of operation with VSUs have not performed well, or costs of equipment available of the global market was high.

Safety measures should also be in place when processing polyols, and training is required for technicians despite equipment being of simple design.

RECOMMENDATIONS

Chapter 5 of the report lists conclusions.

ATTACHMENT II:

DISPENSER SPECIFICATIONS and TECHNICAL EVALUATION of BIDS

Project:	**Low Cost Options for the Conversion to non-ODS Technologies in PU Foams at Very Small Users (VSUs)**
Reference :	**RFQ / UNDP / 003 / 2018**
Funds Provided by:	**The Multilateral Fund for the Implementation of the Montreal Protocol (MLF)**

1. INTRODUCTION

The objective of this project is to support very small users (VSU) of PU systems in a cost-effective way by optimizing, validating and disseminating easy to use low cost PU metering equipment. A request for quotation for mobile foam dispensers for rigid or integral skin PU foam and mobile foam dispensers for pour-in-place rigid PU foam has been issued and 3 potential suppliers have responded to this RFQ.

This technical analysis report (TAR) reviews the technical parameters that were received on their compliance. A selection recommendation finalizes the TAR.

2. BIDDERS

Following is an overview of the companies that responded to the RFQ:

COMPANY	ABBR.	COUNTRY of MANUFACTURE
Polyurethane Ind. COM. Ltda	Pumer	Brazil
Tecmac	Tec	Italy
Transtecnica Ind.Con.Ldta	Trans	Brazil

3. TECHNICAL EVALUATION

Item 1 SPECIFICATIONS FOR A SMALL POUR-IN-PLACE DISPENSER FOR RIGID PU FOAM

Description of basic unit	Mobile two component dispenser to produce rigid PU foam for pour-in-place applications		Vendor's Confirmation			
			Pumer	Tec	Trans/ option 1	Trans/ option 2
	Capacity	Approximately 4-7kg/min	Y	Y	Y	Y
General features	Equipped with:	A pumping system capable to handle viscosities up to 1,000 cPs.	Y	Y	Y	Y
		Isocyanate pump lubrication or scrape ring	Y	Not needed	Y	Y
		Safety valves or rupture disks to safeguard against over-pressure	Y	Y	Y	Y
		Working pressure appr.y 25 bar at gun exit	Y	Y	No	Y
Applicator(s)	Pouring gun attached to 5-10 m hoses		Y	Y	Y	Y
Tanks	Two chemical tanks, one for polyol blend and one for MDI		Y	Y	Y	Y

Size	**25-50 l with a filter against humidity on MDI**	**Y**	**Y**	**Y**	**Y**
Barrel pumps	**For the polyol blend**	**Y**	**Y**	**Optional**	**Optional**
	For the isocyanate	**Y**	**Y**	**Optional**	**Optional**
Compressor	**Sized for the function of the equipment**	**Y**	**Y**	**Y**	**Y**
Location	**Integrated or separately delivered**	**Y**	**Y**	**Y**	**Y**
Power	**220V, 50Hz, 1 Phase**	**Y**	**Y**	**Y**	**Y**
Spare Parts	**Consumable and wear parts, suitable for one year of normal operation of the equipment, from the date of commissioning. The spare parts shall accompany the equipment**	**Y**	**Y**	**Y**	**Y**
Installation, Commissioning	**Instruction of a local representative to provide installation, connection to utilities, start-up, trial runs, operation and basic maintenance**	**Y**	**Y**	**Y**	**Y**
Manuals	**One set of instruction manuals for operation, service and maintenance and spare parts catalog (in English; can be instead or in addition be provided electronically)**	**Y**	**Y**	**Y**	**Y**
General Requirements	**1. The equipment offered shall be covered under a defect liability (parts and labor) for a minimum period of 12 months from the date of commissioning** **2. The equipment offered should conform to approved international quality certification, such as ISO, CE, etc.** **3. The prices to be quoted inclusive of sea-worthy packing, if applicable.** **4. Freight (DAT recipient) to be quoted separately** **5.The consumable and spare parts shall be shipped together with the equipment**	**Y**	**Y**	**Y**	**Y**

Item 2 SPECIFICATIONS FOR A SMALL SPRAY/POUR-IN-PLACE DISPENSER FOR RIGID PU FOAM APPLICATIONS

Description of basic unit	**Mobile two component dispenser to produce rigid PU foam for spray and pour-in-place applications**		**Vendor's Confirmation**			
			Pumer	**Tec**	**Trans/ option 1**	**Trans/ option 2**
	Capacity	**Approximately 4-7kg/min**	**Y**	**Y**	**Y**	**Y**
General features	**Equipped with:**	**A pumping system capable to handle viscosities up to 1,000 cPs.**	**Y**	**Y**	**Y**	**Y**
		Isocyanate pump lubrication or scrape ring	**Y**	**NOT NEEDED**	**Y**	**Y**
		Safety valves or rupture disks to safeguard against over-pressure	**Y**	**Y**	**Y**	**Y**
		Working pressure 25-70 bar at gun exit	**Y**	**Y**	**NO**	**Y**
Applicator(s)	**Pouring gun attached to 5-10 m hoses**		**Y**	**Y**	**Y**	**Y**
	Sprayfoam package (gun and extra hose) must be available		**Y***	**Y**	**NO**	**NO**
Tanks	**Two chemical tanks, one for polyol blend and one for MDI**		**Y**	**Y**	**Y**	**Y**
Size	**25-50 l with a filter against humidity on MDI**		**Y**	**Y**	**Y**	**Y**
Barrel pumps	**For the polyol blend**		**Y**	**Y**	**Optional**	**Optional**

	For the isocyanate	**Y**	**Y**	**Optional**	**Optional**
Compressor	**Sized for the function of the equipment**	**Y**	**Y**	**Y**	**Y**
Location	**Integrated or separately delivered**	**Y**	**Y**	**Y**	**Y**
Power	**220V, 50Hz, 1 Phase**	**Y**	**Y**	**Y**	**Y**
Spare Parts	**Consumable and wear parts, suitable for one year of normal operation of the equipment, from the date of commissioning. The spare parts shall accompany the equipment**	**Y**	**Y**	**Y**	**Y**
Installation, Commissioning	**Instruction of a local representative to provide installation, connection to utilities, start-up, trial runs, operation and basic maintenance**	**Y**	**Y**	**Y**	**Y**
Manuals	**One set of instruction manuals for operation, service and maintenance and spare parts catalog (in English; can be instead or in addition be provided electronically)**	**Y**	**Y**	**Y**	**Y**
General Requirements	**1. The equipment offered shall be covered under a defect liability (parts and labor) for a minimum period of 12 months from the date of commissioning** **2. The equipment offered should conform to approved international quality certification, such as ISO, CE, etc.** **3. The prices to be quoted inclusive of sea-worthy packing, if applicable.** **4. Freight (DAT recipient) to be quoted separately** **5.The consumable and spare parts shall be shipped together with the equipment**	**Y**	**Y**	**Y**	**Y**

Item 3 SPECIFICATIONS FOR A MOBILE FOAM DISPENSER FOR RIGID OR INTEGRAL SKIN PU FOAM

Mobile foam dispenser with variable output between 2 and 7 l/min to produce rigid and integral skin PU foam for small Applications		**Vendor's Confirmation**		
		Pumer	**Tec**	**Trans**
Output at mixing ratio 1:1	**7 l/min (approximately)**		**Y**	**Y**
	120 g/sec (approximately)		**Y**	**Y**
As a minimum, the unit must be equipped with:	**Filters before the component pumps**		**Y**	**Y**
	Safety valves or rupture disks for over-pressure		**Y**	**Y**
Two (2) variable output metering pumps			**Y**	**Y**
Capacity suitable of the entire machine rating			**Y**	**Y**
Hydraulically or pneumatically operated static or impingent mixing head/pistol, self-flushing or with manual flushing system			**Y**	**Y**
Size	**Suitable for entire output range**		**Y**	**Y**
Support	**Connected through a 5-10 m hose system**		**Y**	**Y**
Two (2) working tanks (polyol, isocyanate) to serve the dispensing unit			**Y**	**Y**
Isocyanate tank protected against humidity the infiltration of humid air			**Y**	**Y**
Working volume of 25-50 l per tank			**Y**	**Y**
Functions	**Buttons for start/stop, pour and emergency stop**		**Y**	**Y**
	Shot timer with digital readout		**Y**	**Y**
Power	**220 V; 50 Hz; 2 phases**		**Y**	**Y**

Spare Parts	**Consumable and wear parts, suitable for one year of normal operation of the equipment, from the date of commissioning. The spare parts shall accompany the equipment**		**Y**	**Y**
Installation, Commissioning	**Instruction of a local representative to provide installation, connection to utilities, start-up, trial runs, operation and basic maintenance**		**Y**	**Y**
Manuals	**One set of instruction manuals for operation, service and maintenance and spare parts catalog (in English). Instead or in addition, an electronic copy can be provided**		**Y**	**Y**
General Requirements	**1. The equipment offered shall be covered under a defect liability (parts and labor) for a minimum period of 12 months from the date of commissioning** **2. The equipment offered should conform to approved international quality certification, such as ISO, CE** **3. The prices to be quoted inclusive of sea-worthy packing, if applicable.** **4. Freight (DAT recipient) to be quoted separately** **5. The consumable and spare parts shall be shipped together with the equipment**		**Y**	**Y**

4. OBSERVATIONS

For Item 1:

- Tec's explanation that its isocyanate pump does not need lubrication or a scrape ring is accepted
- Trans/option 1 did not meet the required working pressure and therefore does not qualify
- Pumer and TecMac should provide clarification on why they did not offer Power 220V, 50Hz, 1 Phase with the equipment (has been confirmed in the meantime)
- Pumer offers training, installation assistance trouble-shooting and maintenance assistance by digital media—which can be accepted

For Item 2: same comments as under 2 and, in addition:

- Pumer offers a spray option at low pressure with an air spray gun

For Item 3:

- Tec explains that safety valves for over-pressure are not needed. However, as rupture discs are included, the relevant specification is met
- Upon review of the metering pump details from Tec it is determined that a fixed ratio offer is made which does not qualify.

5. CONCLUSION

For Item 1: Pumer and Tecmac are substantively responsive

For Item 2: TecMac is substantively responsive subject to clarification as mentioned on electrical power (has been confirmed)

For Item 3: Transtecnica is substantially responsive. **Tecmac** is not responsive. **Pumer** did not bid

ATTACHMENT III:
EVALUATION COMMITMENT LETTERS

Egyptian Environmental Affairs Agency
National Ozone Unit

United Nations
Development Programme

Dear ....,

You, as manager of a system house know too well that producing PU foam products by hand will expose the operator to hazardous emissions and will, on longer term, impact the health of the worker. Therefore do the MLF sponsored projects not allow hand mix operations -which hampers in financially and technically assisting those, mostly very small units (VSUs).

EEAA, in cooperation with UNDP has been granted by the MLF a project to search the international market on "Entry Level" type of PU foam production equipment, which would lower the cost threshold of providing a foam dispenser to a level that would allow to address even very small users in a safe way within the policies of the Fund.

We have selected models from three machine manufacturers which will be arriving within the next month or so in Egypt for evaluation. We are offering each of the three local PU system houses one of these dispensers for evaluation. The dispenser is, after completing - and reporting to us on - the evaluation for you to keep and to be used in your development and customer service program.

Attached to this letter you will find the specifications of the dispenser as well as the type of product the machine is designed for. We request you to first - within a month after receipt - make sure that the machine conforms to these specifications and can indeed produce the product it claims. We then ask you to place the machine with one of your customers who can assure an intensive use for about one year and is willing to report on a monthly base how the machine is performing.

Your cooperation will be highly appreciated
Sincerely

Amany Nakhla	Ezzat Lewis
Program Officer UNDP	Head of Ozone Unit EEAA

I, ...Yehia Lotfy..........duly representing ....TECHNO COM...........declare herewith on behalf of my company that we are willing to receive the dispenser T=15/2 PMH under the conditions as outlined above.

23.12.2018

تكنو كوم للتوكيلات التجارية
ش.ذ.م.م.

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Your cooperation will be highly appreciated
Sincerely

Amany Nakhla	Ezzat Lewis
Program Officer UNDP	Head of Ozone Unit EEAA

I, ...Mona Adel... duly representing ...Dow Mideast... declare herewith on behalf of my company that we are willing to receive the dispenser .... under the conditions as outlined above.

DOW MIDEAST SYSTEM S.A.E
DOW
داو ميدايست سيستمز ش.م.م

ATTACHMENT IV:
PICTURES OF THE OFFERED EQUIPMENT

Pumer

Transtecnica

TecMac Fixed ratio

TecMac variable ratio