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LIQUID CARBON DIOXIDE (LCD) TECHNOLOGY AND GUIDELINES FOR LCD PROJECTS

Report on Liquid Carbon Dioxide (LCD) Technology and Guidelines for the LCD Projects

SECRETARIAT'S COMMENTS AND RECOMMENDATIONS

COMMENTS

1. At its 35th Meeting the Executive Committee decided to request the Secretariat, in consultation with the implementing agencies, to re-examine LCD technology and the guidelines for projects converting to the technology and to report on its findings to the 37th Meeting of the Executive Committee (Decision 35/16 (a)). The Secretariat submitted to the 37th Meeting a status report (UNEP/OzL.Pro/ExCom/37/57) in which it described actions that had been taken in response to the decision.

2. The following procedures were undertaken to conduct a study to re-examine the technology and guidelines:

- Review and collation by the Secretariat of all relevant information on approved LCD projects, except those in the China Foam Sector Plan for background information for use by the consultant to carry out the study;
- Presentation of information by implementing agencies on issues of project implementation based on a uniform format prepared by the Secretariat. The information was also used as background information by the consultant;
- Preparation of terms of reference by the Secretariat and their review by the implementing agencies;
- Selection of a consultant by the Secretariat to undertake the study;
- Preparation of a questionnaire by the consultant for information collection from Article 5 enterprises and its administration by the Secretariat in collaboration with implementing agencies and NOUs;
- Visits by the consultant and discussions with the following:
  - All suppliers of LCD technology;
  - Foam manufacturers using LCD technology in Europe;
  - Foam manufacturers in Article 5 countries for which LCD projects have been approved.
- Preparation and presentation of a report by the consultant;
- Circulation of the consultant's report for comments by the implementing agencies.

3. In view of the fact that almost all the experts familiar with the LCD technology are either associated with the technology providers or with the implementing agencies, the identification of a suitable expert to undertake the study became difficult and was delayed. Furthermore, due to travel and scheduling difficulties, the visits to selected enterprises in Article 5 countries could only be completed by mid-September 2002. Hence, the complete report could only be available for presentation to the 39th Meeting.

4. The consultant visited the facilities and had discussions at all three suppliers of LCD technology and equipment, namely Beamech and Cannon Viking both in the United Kingdom and Hennecke in Germany. The consultant also visited five major foam manufacturers in Germany, Italy and the United Kingdom and 21 foam manufacturers with approved LCD projects at different stages of implementation in Iran, Morocco, Tunisia and Turkey.

5. Based on the information collected from the sources mentioned above, the consultant prepared a report which is available on request. The report indicated that as at 31 December 2002, 21 projects to phase out 2,295 ODP tonnes CFC out of 59 projects had been reported by the implementing agencies as completed. However, in general the completed projects had succeeded only in converting the enterprises foam production from the use of CFC to methylene chloride and not to LCD as intended in the projects. The summary of the findings is attached.

6. The report was circulated to the implementing agencies on 2 and 3 March 2003 with a request for comments by 7 March 2003. As of that date only UNIDO had responded with comments.

7. In its comments, UNIDO fully agreed wit the general conclusion about the maturity of the technology for use in Article 5 countries, especially countries of the Middle East and its concomitant technical and financial implications to the foam manufacturer. UNIDO also agreed to the need for a proposed penalty clause in equipment purchasing contracts concerning commissioning protocols stating that currently the general format of UNIDO's contracts provide for a chapter on penalties, but in the UN practice the implementation of the penalty clauses could be time consuming.

RECOMMENDATIONS

8. The Executive Committee may wish to consider the findings of the study as contained in Annex I and request the implementing agencies to use them as guidance in the implementation of on-going approved LCD projects as well as the development and implementation of future LCD projects.

Annex I

FINDINGS OF THE STUDY ON LCD TECHNOLOGY

1. As of the end of 2002, fifty-nine projects (excluding four cancelled projects) had been approved at the cost of US $30.2 million to phase out 6,105 ODP tonnes of CFC. Twenty-one projects had been completed to phase out 2,295 ODP tonnes CFC. UNDP had completed six of fourteen projects, UNIDO twelve of nineteen projects, the World Bank three of twenty projects and GTZ had not completed any of its six projects. It had taken between 1 year 9 months and 5 years 7 months to complete the projects with average duration of 3 years 7 months. There is therefore the need to expedite implementation of the remaining approved projects.

2. The implementation of the LCD technology in Article 5 countries has achieved very limited success. Although 21 projects have been reported as completed the goal of replacing CFC with CO_2 as blowing agent has not been achieved as enterprises continue to use methylene chloride either exclusively or as the major auxiliary blowing agent, rather than CO_2 following conversion to LCD. The study revealed that only about 50 tonnes of LCD equivalent to 230 ODP tonnes of CFC-11 was used in 2002 on a sustainable basis by three enterprises in Argentina and one in China. This implies that investment of US $11.0 million in the LCD technology resulted in replacement by LCD of only 10% of the CFC-11 used by the enterprises. The remaining 90% was replaced primarily by methylene chloride. Thus the cost-efficiency of the replacement of CFC by liquid CO_2 is US $48.8/kg.

3. The biggest challenge facing the Multilateral Fund and its agents the implementing agencies as well as the stake holders - the technology suppliers, and recipient governments and enterprises involved with the transfer of the LCD technology to Article 5 countries is how to attain sustainable conversion to the technology, especially in the long term, after the implementing agencies have signed off the project as “completed” within the Multilateral Fund definition of project completion. For instance, UNDP stated that it had adopted a two step approach to implement the projects in Argentina (where the enterprises were already using significant amounts of methylene chloride) by first converting to methylene chloride followed by LCD. UNDP claimed that this allowed "project completion on time" since CFCs were phased out adding that "the longer phase-in period did not affect project completion since the CFCs were phased out in the first step of the process". UNDP's definition of LCD project completion misplaces the objective of the project for which substantial investment was allocated, namely to assist the enterprise to convert to an environmentally sound and economically advantageous technology.

4. The study showed that in the case of Argentina, considered to be a success by both the technology supplier and the implementing agency, in 2002, four years after the officially reported completion date of 1998, one of the companies, Limansky, for instance could only use 1.3 tonnes of LCD as against 79.6 tonnes of methylene chloride, while the other larger companies could use only a small fraction of their potential for LCD application. There is no indication when the reported elimination of methylene chloride would occur, because the “phase-in” period has not been defined. A provision in the contract between the implementing

agencies and technology suppliers as well as in project commissioning protocols that specifies the length of the phase-in period, where applicable could address what appears to be a serious omission, and in a way, provide a benchmark for determining whether the transfer of the technology has occurred successfully or not.

5. The lack of definition of phase-in period, as well as what constitutes a successful project completion in project commissioning protocols tends to put recipient enterprises at a disadvantage and encourages unlimited use of other blowing agents. In order to avoid this situation contracts between the implementing agencies and technology suppliers should include a provision that defines the phase-in period where appropriate or the period within which complete change-over to LCD from all other previously used blowing agents would occur, with appropriate penalties if goals are not met. This would provide assurance to recipient governments and enterprises that the technology would work to their advantage. The open-ended phase-in period, in reality, does not make any of the players involved in the technology transfer accountable for failure to reach the goal of substituting CFC with LCD, or for when the project should be deemed to have been completed.

6. At the time most of the projects were approved, the LCD technology was not a fully matured technology suitable for the production of the type of low density foams produced in many Article 5 countries. This created considerable difficulties for the enterprises, as they had to endure extensive periods of trials and “experimentation” resulting in loss of confidence in or abandonment of the technology.

7. Latest developments in the technology since the year 2000 have centred on modifications to the equipment which facilitate the use of organic and inorganic fillers, (polymer polyols, melamine, calcium carbonate etc) added to the basic polyol stream. These activities are considered essential to achieve the required hardness values of the very low density foam currently produced in Article 5 countries. The modified laydown devices and equipment to regulate filler particle size are still not fully proven and there are good reasons to be doubtful of the ability of LCD technology, in its present form, to handle on a continuous basis the very high level of fillers that certain markets (particularly Chinese) require. The rigorous standards of cleanliness required, "where even the tiniest of impurities stemming either from existing foaming plants or the raw materials used may cause considerable production malfunctions" would be met by only a few Article 5 country enterprises. For many enterprises, it could be practically impossible to meet such standards. Furthermore, the use of polymer polyols raises a concern among the Article 5 enterprises since it adds to their production costs. Implementing agencies will need to keep the situation constantly in review and advise their clients on the necessary measures required to ensure sustainable conversion to LCD.

8. Technology suppliers lacked adequate number of experienced technicians to meet the challenge of delivering the technology at the same time to a large number of enterprises in diverse geographical areas. Hence the multiple simultaneous project start-ups, particularly in countries with multiple projects militated against achievement of successful LCD conversions. For countries with multiple LCD projects conversion such as China and Iran, implementation strategies are needed. It would be useful for the implementing agencies and the technology suppliers in collaboration with NOUs to draw up schedules (monitored by the NOU) for completing the projects. These schedules should be made available to the Secretariat and a

mechanism put in place for follow-up and periodic monitoring. Priority in project implementation should be given to companies whose baseline equipment lend themselves to retrofits rather than replacement of whole lines or individual production parts.

9. In spite of the complexity of the technology, the selection of recipient enterprises by implementing agencies sometimes neglected to take account of the technical capacity or experience of the enterprise to absorb the technology or the ability of baseline equipment to adapt to the technology, some baseline equipment being obsolete or rudimentary home-made plants. In future projects these factors should be seriously taken into consideration in selecting enterprises for LCD projects.

10. The incremental capital cost range approved under the guidelines of US $501,000-US $721,000 (including 10% contingency) was found to be excessive, resulting, in several instances, in project funding that should be considered as being in excess of actual funding requirements. Thus the average approved cost of the projects was US $563,100. Thirty-seven projects (66 per cent) had approved funds exceeding US $500,000, with seven of them exceeding US $600,000. The highest funded projects for single LCD units were projects for Piero SAIC in Argentina (UNDP) at US $654,500, Beijing Foam in China (World Bank) at US $720,000, Urosan Kimiya in Turkey (UNIDO) at US $643,500 and US $643,500. Piero SAIC was originally approved to use acetone while Beijing Foam was approved to use methylene chloride with forced cooling.

11. The LCD system can be retrofitted to the existing foam equipment either as a direct system or indirect system, the indirect system being the cheaper of the two options. There is no evidence that the direct system offers any concrete advantages over the indirect system. Therefore, unless otherwise justified by the technology supplier, the indirect system should be the preferred retrofit option. Depending on whether direct or indirect system is retrofitted to the existing foam machine the total project cost of the retrofit would range between US $420,000 and US $460,000. Thus it appeared from the analysis of project funding requirements that unutilized funds would normally be expected following completion of projects with single LCD units approved in excess of US $500,000.

12. Installation of a new foam line is not a requirement for converting to LCD technology. However, several projects have resulted in the replacement of the baseline foam production line invariably causing delay in their implementation. Where it has been agreed by the implementing agency that the existing production lines be replaced, the enterprises, if necessary, could be made to phase out their CFCs in two steps – first by converting to methylene chloride as soon as possible and then to LCD within a clearly defined time-frame, in order to avoid delay in the elimination of CFC by the country concerned. Old machines in these situations would be destroyed only when the company has achieved a steady state in foam production with LCD. Companies involved should be made to sign an agreement to this effect with the Government (NOU) ensuring its enforcement.

13. No determination of incremental operating costs or savings could effectively be made due to the lack of LCD operating experience of the Article 5 enterprises examined in the study. However, in Europe, formulation cost savings with LCD compared to CFC's are approx. 3% for foam densities of 17/18 kg/m^3 based on current European price levels and which tend to confirm

the existing guideline value of 5% or US $0.10/kg for Article 5 countries as being of the right order of magnitude for foam densities down to 10 kg/m^3.

14. Whilst in Europe no significant difference in yield is perceived when operating with LCD this, based on experience to date, is not likely to be the case in Article 5 countries. The present guideline values of 4% and 2% yield loss for the first two years are likely to suffice only if the existing trials and commissioning procedures are revised to achieve a more effective transfer of the technology involved. Should this be achieved by dedicating more resources to commissioning trials, etc the existing guidelines for yield losses could also be maintained.

15. The remaining incremental operating costs, including maintenance, power were also difficult to ascertain in the circumstances. Levels of US $12,000 for maintenance and US $4,000 each for power and LCD tank hire could be considered adequate.

Special Case of China

16. The situation of China is unique in the sense that by all accounts new or future flexible foam projects for conversion to LCD technology will come from China under the special agreement under which foam programme operates. While developing LCD projects under the China foam sector plan it would be advisable for the Government and the World Bank to take account of the issues addressed in the study.

17. The slow pace of project implementation of the 14 World Bank projects as well as the apparent lack of sustainability of the new technology should be a cause for concern, particularly when taken against the background of future expansion in the programme in China. These issues need to be expeditiously addressed by the World Bank.

LCD Guidelines

18. The guidelines for approval of projects for conversion to LCD by themselves appear to be well founded, considering the state of the art of the LCD technology at the time that the guidelines were formulated and adopted. Hence the guidelines could be maintained with the following proposed changes.

Criteria of Selection

- The criteria for selection of an enterprise to receive the technology in the current guidelines appear to be inadequate. It would be rather doubtful to expect the level of the required technical expertise and financial capacity for a successful LCD conversion from a company using 50 ODP tonnes CFC per annum. Ideally an enterprise requiring to convert to LCD technology would be an enterprise with a minimum annual foam output of 2,500 ODP tonnes with a minimum of 50% below the density of 20 kg/m^3. In addition, the baseline foam equipment should be demonstrably capable of retrofit to LCD production;

- There should be demonstrated economic conditions or regulatory measures in place in the country that would enhance the economic advantage of the use of LCD and thereby facilitate its sustainability. (These would include government policy, trade and economic measures

that discourage the use of CFC-11 and, in particular, methylene chloride and promote the use of LCD as a foam blowing agent for large scale foam production).

Costs

19. Incremental capital costs based on indirect or direct retrofit would comprise the following:

Item	**Cost (US $)**
LCD unit	335,000 - 375,000
Civil works, trial and training	55,000
Phase-in trial costs	20,000 (as needed)
Technical support	10,000
Total	**420,000 - 460,000**

Contingency: 5 - 10% of the total incremental capital cost

No technology license fee is included.

20. Incremental operating costs/savings: The basis for calculation of incremental operating costs and savings currently based on theoretical formulations is substantially correct and could be maintained in the absence of adequate practical experience in Article 5 countries.

21. In addition to the above criteria and costs, relevant contracts and equipment commissioning protocols agreed between implementing agencies/recipient companies and technology providers should include an obligation (possibly, with appropriate penalties) on the part of the technology provider to ensure that the commissioning of the equipment results in the production of at least one grade of the company's foam to the standard full-scale production run of the company.

Trials

22. In view of the state of the technology and the identified technical issues, the traditional short trial runs (five minute duration) are clearly unsuitable with LCD and are insufficient to demonstrate the functionality of the plant/equipment, to verify the suitability of the formulation or to select the correct operating parameters. Foam production trials with LCD using fillers (organic and inorganic) have been frequently interrupted prematurely (after ten minutes) due to the pressure build up in the froth lay down device with a consequent and significant increase in foam scrap rates. Therefore, as a practical demonstration of the technology, and for the purposes of satisfying a commissioning protocol, trials should include at least one run of not less than 30 minutes duration. Such a trial, brought to a successful conclusion would enable the enterprise to acquire operating experience and they could then, with the assistance of the technology/raw materials supplier proceed to diversify their LCD density range. In future projects, additional funding for phase-in trials of up to two foam grades could be included in the incremental capital costs of the project.

Training

23. The foam manufacturing companies which were visited in Europe generally showed willingness to share their experience with their Article 5 counterparts. The technology suppliers in collaboration with implementing agencies may wish to tap into the pool of experience in the developed countries and consider through, for example, organization of seminars and workshops which bring together LCD-based foam producers in developed and developing countries or some bilateral mechanism for sharing experiences as a means of assisting and motivating Article 5 companies towards successful conversions.

Reporting on Completed Projects

24. Reporting on completed projects in the limited number of project completion reports currently available on completed LCD projects generally fail to provide a clear picture of funds expended. A more transparent accounting for the funds expended could be requested from the implementing agencies in their project completion reports, in particular where the project's cost exceeded US $450,000 or where a new foam line has been installed. The information to be provided should include, among others, the type of technology used and the associated costs (Cardio, CO-2 or Novaflex), the cost of new foam line and/or the cost of optional extra equipment, counterpart contribution of the recipient enterprise. The Secretariat and the implementing agencies may also have to review the reporting format to ensure that project completion reports reflect the achievement of the objectives in the LCD projects rather than transitional objectives which have not been approved.
