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Executive Committee of the
Multilateral Fund for the
Implementation of the Montreal Protocol

Tenth Meeting
Montreal, 28-30 June 1993

REQUESTS FOR BILATERAL CONTRIBUTIONS

1. Pursuant to Article 10 of the Protocol as amended and Decision IV/18 of the Fourth Meeting of the Parties, the Executive Committee is charged with assessing bilateral requests.

2. A request was received from the Government of the United States of America (as annexed) to credit US $396,110 in bilateral assistance against its 1993 contribution to the Fund. The assistance will be provided for "Staged Project to Produce CFC-Free Refrigerators in China: Stage 1a - Model Prototype Development and Testing".

General Comments

3. The production of refrigerators approached seven million units in 1992 which was an 18 per cent increase over 1991 production. This project involves three stages leading to the conversion of the second largest refrigerator plant in China for the production of CFC-free refrigerators. The purpose of stage 1 is to complete pilot production and testing. This request covers stage 1a which involves the development and testing of model prototypes. Following the successful completion of stage 1a, stage 1 will be completed with the field testing of over 100 units.

4. The project document provides an excellent discussion of the pertinent project-related information required by the Committee for project submissions. Although this request will not result in immediate ODS phase-out, it is an important preliminary step toward the eventual elimination of a significant amount of CFC-11 and CFC-12 consumption in China's growing domestic refrigeration sector.

5. Implementing agencies should take into account these activities and co-ordinate their work programmes where appropriate.

Recommendation

6. This request complies with the bilateral contribution guidelines (UNEP/OzL.Pro/ExCom/5/16, paragraph 55) and the criteria for assessing costs as bilateral contributions (UNEP/OzL.Pro/ExCom/7/22/Rev.1, page 4). The requested amount does not exceed 20 per cent of the United States' contribution to the Fund for the year 1993.

7. It is, therefore, recommended that the United States of America Government's request should be approved and the Treasurer should credit the requested amount, US $396,110, accordingly.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
AIR AND RADIATION

26 May, 1993

Dr. Omar El-Arini
Chief Officer
Multilateral Fund

Dear Dr. El-Arini

On May 17, 1993, I submitted a status report on bilateral activities being undertaken by the USEPA, and a description of a refrigeration project which EPA and China have agreed to undertake. Due to the number of pressing matters that need to be considered at the 10th meeting of the Executive Committee, we agreed to postpone consideration of our status until the next meeting. However, as discussed, we would still like the China project to be considered at this meeting.

The China project documentation was submitted in accordance with Article 10 of the Montreal Protocol as amended, and para 9 of the Terms of Reference for the Multilateral Fund as agreed to in Copenhagen. We are seeking approval of this project, and a corresponding offset against our assessed 1993 contribution. The bilateral cooperation being proposed represents well below the 20 percent ceiling established by the Fund's Terms of Reference. Additionally, the proposed use of bilateral funds strictly relates to compliance with the provisions of the Protocol, provides additional resources, and meets agreed incremental cost. Finally, we have received approval from the Government of China to use bilateral assistance to provide support to produce CFC free refrigerators; the project submitted on May 17 would initiate work on the first stage in this project.

Please feel free to call me if you have any questions regarding this proposal.

Sincerely,

Paul S. Horwitz
International Advisor
Stratospheric Protection Division

PROJECT COVER SHEET
5/16/93

Country:	China
Project Title:	Staged Project to Produce CFC-Free Refrigerators in China (Stage 1a - Model Prototype Development and Testing)
Sector Covered:	Domestic Refrigeration
ODS Consumption in Sector:	4.2 million kg CFC-11 in 1992 1.15 million kg CFC-12 in 1992
Project Impact (Objective - one plant):	Phase out 310,000 kg/yr CFC 11 and 85,000 kg/yr CFC 12 by 1995. (one line at plant) Phase out 620,000 kg/yr CFC 11 and 170,000 kg/yr CFC 12 by 1996. (second line at plant)
Project Duration:	6 months total for Stage 1a
Incremental Cost:	US $396,110 -- Stage 1a
Proposed ODS Grant/ Bilateral Funding	US $396,110 -- Stage 1a
Cost Effectiveness:	Not applicable to prototype testing stage
National Coordinating Agency	Ministry of Light Industry
Coordination with Other Implementing Agency	UNEP___ UNDP___ UNIDO___ WB_x_

PROJECT SUMMARY

BACKGROUND

China is a Party to the Protocol operating under Article 5 paragraph 1, and is eligible for funding from the Multilateral Fund.

In 1992, it is estimated that China produced 6.8 million refrigerators for domestic use, 18% more units than during the previous year. These refrigerators consumed 1.15 million kg of CFC-12 and 4.2 million kg CFC-11.

The U.S. Environmental Protection Agency has been working with the Chinese government, national laboratories, universities, and refrigerator factories to develop and manufacture CFC-free refrigerators in China. The overall goal is the accelerated phase-out of CFCs used for domestic refrigeration in China. The project is based on ongoing cooperative work between the U.S. and China to identify and develop successful options for the phase-out of CFCs from Chinese domestic refrigerators. The potential CFC reductions resulting from the success of this project are very large.

The project will proceed in 3 stages leading to the conversion of a refrigerator plant to facilitate the production of CFC free refrigerators. This staged approach is consistent with the recommendations of the OORG. Preliminary work (which has already been completed) and the first stage are described below. The purpose of stage 1 is to complete pilot production and testing, with an emphasis on reliability. The purpose of this proposal is to seek pre-approval for funding stage 1a of the project. Stage 1a involves the development and testing of model prototypes. Successful completion of Stage 1a will lead to Stage 1b, in which one or two refrigerator models will be selected for field testing, 100 to 200 units of the selected model(s) will be manufactured and will undergo extensive field testing.

DESCRIPTION OF WORK TO DATE

Preliminary Work

Preliminary work, which was recently completed through the use of non-compensated bilateral assistance, involved the identification of potential non-CFC refrigerants and blowing agents for insulation. This preliminary work took place from March 1991 through April 1993. Accomplishments to date of this joint effort include:

- Identification of key personnel and organizations. Selection of key refrigerator and compressor factories for further work; (see attached list)

- o Completion of preliminary assessment of equipment, testing capability (including equipment test cells and compressor testing equipment), and ability to alter factories;

- o Initiation of work to adapt refrigerators to CFC-free materials; Exchange of information between China and the U.S. to facilitate technology transfer activities. Initiation of laboratory and factory testing and evaluation of alternative refrigerants, including performance, cost of changeover, safety, materials availability, materials compatibility, and compressor performance;

- o Successful design, construction, operation and testing of an initial prototype refrigerator without CFC-12 based on conventional and Lorenz cycles. Testing checked for quality of operation and cooling characteristics.

- o Planning for the next stages of the project to phase out CFCs from refrigerators, including stage 1a (for which funding is being sought) and 1b was completed.

- -- To assist in this work, EPA provided China with approximately 230 kg of refrigerants and lubricating oils. The materials included 141b, 134a, 123, 143a, R32, R270, 142b, ester oil, mineral oil, alkylbenzene, DuPont MP 33, and DuPont MP 39.

- -- In cooperation with Americold/Electrolux, EPA has provided China with 12 compressors compatible with 152a. The compressors have been calorimeter tested and further compressors will be made available as the project progresses.

<u>Stage 1a Project Description (This proposal)</u>

In stage 1a, model CFC-free prototypes will be built and tested. The goal of stage 1a is to identify and optimize 1 or 2 designs which will successfully and effectively use CFC substitutes. BHEARI, the Qindao Refrigerator Factory, and the Ministry of Light Industry will be involved during this stage. Qindao Refrigerator Factory is the second largest refrigerator factory in China, with an estimated 6% of the market in 1991. Work at Qindao would serve as a template for the other factories in China.

Stage 1a Activities:

CFC-free Foam

1. Determine the amount, location and type of non-CFC foam insulation necessary to optimize refrigerator performance through testing in the laboratory and at the factory. Based on research conducted during preliminary work, the primary CFC-free foam

blowing agent under consideration is HCFC-141b. EPA is working with ICI to help establish a long term, stable link for technology transfer. As technology advances, the project will move out of this temporary material and into a material with lower or no ozone depleting properties. (One possible long term alternative may be cyclopentane.)

2. Determine the compatibility of non-CFC foam with other materials in the unit, as well as the durability and structural suitability of the foam through testing in the laboratory and at the factory.

3. Determine other changes necessary to optimize the performance of the CFC-free insulation. Model current and improved performance. Redesign and construct prototypes with the improvements necessary to maintain refrigerator performance with the CFC-free foam. Test the performance of the redesigned units and make further suggestions to improve the insulation performance.

CFC-free Refrigerants, Compressors, and Lubricating Oils

4. Determine compressor size and type, and identify compatible lubricating oils for a compressor which will reliably run on non-CFC refrigerants. Based on the most recent findings, refrigerants under consideration are likely to include 134a, 152a, and a 152a/22 mix.

5. Choose condensers, evaporators, anti-sweat devices based on test results from current Chinese technology adapted to work with the chosen CFC-free refrigerant. Among the CFC-free refrigerants under consideration by China include HFC-152a (a domestically available, easily produced substitute), or refrigerant blends.

Compressors suitable for each major CFC-free refrigerant will be purchased in China and abroad. Compressors will be supplied by Electrolux/Americold. Americold has tested compressors designed for 134a in calorimeters and in lifecycle tests. Americold has calorimeter tested compressors designed for 152a, and will proceed with lifecycle testing during the coming months. We anticipate that in the long term, Electrolux will work with the appropriate Chinese firms (operated as a joint ventures) to supply reliable compressors for production of CFC-free refrigerators. 134a compressors will be obtained from the Heihe/Electrolux joint venture. Compressors specifically designed to use 152a and the appropriate alkylbenzene lubricants have been obtained from Americold/Electrolux. Compressor suppliers will provide adequate technical support to assure that the appropriate designs, lubricants, and testing are available to support the chosen refrigerant(s).

Results:

The overall results for Stage 1a will be one or two overall refrigerator designs that include choice of one blowing agent (probably 141b) and amount of insulation, and one refrigerant or blend with an appropriately designed compressor. The chosen designs will be for 2 compartment, 220 liter units which have been tested in a minimum of 3 climates appropriate for China.

SCHEDULE

Date	Tasks
<u>Preparation</u>	
January 1993	EPA and MLI discuss project plan and schedule for work from now through field testing of new refrigerators.
	EPA and China exchange information to support preliminary prototype design. China and EPA discuss prototype test methods and evaluation criteria.
	EPA receives gasket, door corners, drawings of gaskets and doors and blueprints of Qindao 220 liter refrigerator from China.
February 1993	Meetings in China between Chinese and U.S. experts to obtain information discuss choice of prototype designs and testing protocols for prototypes.
	EPA provides Qindao with preliminary suggestions for gasket and door improvements.
	NEPA delegation meets in U.S. with U.S. counterparts to negotiate agreements.
	University of Maryland receives one Qindao 220 liter refrigerator for testing.
March 1993	EPA identifies source of appropriate compressors for use in project.
April 1993	152a compressors shipped to BHEARI for use by BHEARI and Qindaoheier Factory.
May - June 1993	China and the U.S. formalize project agreements.

Stage 1a

May - August 1993	China builds prototype units using several designs. China ships examples of each type to U.S. China and U.S. begin testing of prototypes.
November 1994	3rd Annual Sino - U.S. Refrigeration Workshop
December 1993	Complete testing of prototypes.

Future Activities

Following successful completion of these Stage 1a activities, the US and China expect to seek funds for Stage 1b of the process. In Stage 1b, the prototype test results will be used to build an example model for field testing. This example model will combine all the improvements indicated to assure reliable functioning of the CFC free unit. A refrigerator line will be modified to allow manufacture of approximately 100 - 200 of the improved design for in use field testing. Field testing will include life cycle testing and more extensive testing to assure reliable performance in all major Chinese climates (temperature and humidity). Safety testing and performance testing will be reviewed by experts in the field at universities, and in government and industry. During Stage 1b, a feasibility study will be conducted to identify steps and costs for factory changeover to production of all CFC-free refrigerators.

Preliminary Schedule for Stage 1b

January 1994	Build and test in laboratory 2 examples of field test refrigerators using most successful prototype design.
February 1994	Review of test results by experts in the field.
April 1994	Re-tool as necessary to build 100-200 field test units.
	Begin feasibility study
June 1994	Begin production of 100-200 refrigerators using the most successful prototype design.
July 1994	Begin field testing of the performance of the refrigerators.
June 1995	End field testing of the performance of the refrigerators.

The final results of stages 1a and 1b will be the identification of a reliable CFC free refrigerator design that has been thoroughly tested for reliability, performance and safety in three major Chinese climates. Stage 1 will also provide a completed feasibility study that outlines the steps and costs for factory changeover and other plans necessary for successful completion of Stage 2.

Upon successful completion of Stage 1b, Stage 2 would be started. Stage 2 involves the efficient conversion of the entire factory to the manufacture reliable CFC-free refrigerators.

PROJECT FINANCING/PROPOSED BUDGET

This project will be financed through US bilateral assistance. All stage 1 costs are considered incremental costs.

Overall Budget
Stage 1

Stage	TOTAL (US $)
1a	$ 396,110
Estimate for 1b	$ 932,640

Response to Questions Raised by OORG Reviewer

The project document submitted was significantly adjusted to take into account issues raised during an initial review of the project. The following paragraphs respond to new matters discussed in the attached OORG review.

1. While the OORG recommendations did not explicitly include testing of alternative refrigerants prior to plant conversions for prototyping, when different refrigerants are proposed for use, we believe that such a prudent step could save millions of dollars. 152a is less costly and China has their own source of this chemical. Additionally, recent tests have documented that the efficiency of U.S. refrigerators using 152a was 2% better than that for similar units employing 134a. The design of Chinese refrigerators is significantly different and similar data must be developed. Use of 134a is still possible.

2. Technology transfer is being supplied by both the compressor manufacturer, Americold, and the foam chemical supplier, ICI Polyurethanes. An expert team of consultants is also being assembled to assure that the required manufacturing expertise is available. EPA will work with the Chinese team to provide additional consulting services as needed.

3. The initial six month testing period will be for both efficiency, and testing of reliability and initial material interactions. Based on the results of this initial testing, a refrigerator will be manufactured and undergo a much longer period of reliability testing. The initial test will allow us to fine tune prototype production, and make it all the more likely that no problems will occur in that more expensive stage.

4. While accelerated life cycle testing equipment and limited energy efficiency testing facilities are available at BHEARI, and Quindao, some questions have been raised by some international experts about efficiency related results of previous Chinese refrigerator testing. It was agreed that some of the units would be shipped to the US for energy testing at the University of Maryland, and some would be tested in China. This will help validate results. Life cycle testing will be done only at BHEARI.

5. While the compressor manufacturer may have some preliminary information on efficiency and reliability of both refrigerants being considered, and will thus, reduce the time necessary for testing, initial testing is being done for multiple reasons, and, efficiency and reliability must be assessed within the context of full product operation and materials interaction. Compressor efficiency and reliability, while important, does not answer all questions which should be addressed before significant funds are expended.

6. Cyclopentane blown foams are being extensively tested in Europe, and conversion of several factories is underway.

Information available to us suggests that capital costs would be in the range of $200,000 to $250,000 for premixing equipment and $100,000 to $250,000 for ventilation and explosion proofing per line to modify a facility to use cyclopentane. Equipment is not available in China to make cabinets with cyclopentane. Cabinets would have to be shipped to Europe for foaming and then back to China for buildup.

7. We do not believe that there will be unsolvable questions, or that the probability of significant questions is higher with 152a than with 134a. In any event, the initial testing is designed to ensure a reliable and efficient product, and to examine production issues before significant funds are expended. EPA, together with help from compressor manufacturers will provide project support as necessary to ensure project success.

8. The goal would be to have one refrigerator design which could work effectively in the 3 major climate zones existing in China.

9. It is currently estimated that costs incurred in China for Stage 1a testing will be around $100,000; additional costs are related to technology transfer and US testing.

China

REVIEW OF A STAGED REFRIGERATOR PROJECT

Manufacture of Refrigerators with HFC-134a, 152a or Blends in the Refrigeration Circuit

Project Proposal by the US EPA, May 1993

Manufacturing of Refrigerators with Compressors Provided from Americold or from an Electrolux joint venture

Kuijpers, LJM (OORG)
Eindhoven,
1993 05 14
RTU-UEPA-LK-93161 -lk

REVIEW OF THE PROPOSAL

Recommendation

The project description proposes financing for a phased research /development stage and production of non CFC- refrigerators. The phased approach is in agreement with the OORG recommendations, although it should be stated that the OORG recommendations did not take into account a stage for R&D, i.e. a stage where different refrigerants would be investigated.

There is a transfer path established for technology transfer. However this applies to the compressor in particular. Where it regards reliability, this will be an interaction of the manufacturing process of the appliances (which process has to be carefully analyzed for both refrigerants HFC-134a and HFC-152a), and the compressors provided. It may easily be that there will be needed some kind of consultancy or technical assistance in case of reliability problems (which may be due to certain phenomena in the production process). This should be ascertained.
The project proposes a very limited time interval for the phase that concerns the testing of (probably efficiency and) reliability. It may easily be that in the testing a problem occurs, that could have been avoided when the production process would have been a little bit different. Whether it will be taken into consideration then to start again is not clear from the proposal, but it may complicate matters. It should be more clearly described in the proposal. Testing is proposed in the US and in China; it is recommended to describe the aim of the testing in the USA, and who will be involved.
The compressor manufacturers will have preliminary data on efficiency and reliability of both refrigerants. Some data could maybe already be given here.

Taking into account that phase 1 is a R&D phase, emphasizing that this phase 1 should aim at the selection of a reliable and efficient refrigerant, observing that more information on efficiency and reliability can already be obtained from the

compressor manufacturers involved (which will more clearly outline the project or the points that need to be emphasised),
and emphasising that there has to be agreed upon a continuing relationship with the compressor manufacturers which could be called consultancy or technical assistance in order to solve possible reliability problems that may occur in the production of phase 1 and 2,
the project should be eligible for funding under the Montreal Protocol.

Relevance and adequacy of the information provided

The project description proposes financing for a phased development and production of refrigerators containing HFCs or a blend in the circuit and HCFC-141b in the polyurethane foam. The phased approach is in agreement with the OORG recommendations. The first phase should have an emphasis on reliability, and there should be transfer within the framework of an existing relationship.

However, taking into account the experience the Americold company -that is the HFC-152a compressor supplier- has as far as HFC-134a is concerned, it will be this company that can already make preliminary statements regarding the reliability and specific other properties of both compressor types, i.e. HFC-134a and HFC-152a. It will also be the Americold company that can make statements regarding the compressor efficiency of HFC-152a and HFC-134a.
This information could be used in further testing.

The fact that a chemical manufacturer is involved in the conversion to HCFC-141b, is in principle OK. Can there be given an estimate of the costs involved in the conversion from CFC-11 to HCFC-141b, and in the conversion from HCFC-141b to cyclopentane. What would be the costs involved in a direct conversion from CFC-11 to cyclopentane (if possible via a 50% CFC-11 step) ?

Technical soundness

It is much more the compressor than the refrigerant that determines the efficiency. Preliminary indications can be had from the suppliers. These data should be used in an evaluation provided that both substitutes prove to be equally reliable.

What is important in the first phase is reliability of the product. This implies that the manufacturing process (and the detailed processes involved) will determine whether -together with these compressors- the product is reliable. This assumes that there has to be a continuing relationship with the compressor manufacturer during the testing of the product.
It applies actually to phase 1, but certainly also to phase 2. Here actually a difficulty arises. Since the compressor manufacturer has no experience with appliance production of HFC-

152a, unsolvable questions may arise. There is no solution here.

The time schedule presented mentions that tests will be done in China and in the US. Who will do the tests in the USA and is this "testing the reliability of the product" ? Or the efficiency (University of Maryland perhaps, whicch University can never do reliabilityand life testing). Should the refrigerators not be given to an institute that does accelerated life testing ?

From the testing, is it expected that the result of stage 1 is one refrigerant choice for the three climate classes of refrigerators used in China ?

Cost effectiveness

This is not applicable to the testing stage proposed. However, it would be good to add more detailed information how the cost (investment) estimates have been determined. Is there a component for the supply of the compressors and an amount for, say, technical assistance ?
What is the cost estimate for the tests performed in the US and in China ?

Eindhoven, 14 May 1993

L.J.M. Kuijpers