United Nations Development Programme

Global Environmental Facility

Project Document for PDF Funding (Block B)

Country:	People's Republic of China
Focal Area:	Climate Change
Project Title:	China Energy-Efficient CFC-Free Refrigerator Proposal
Project Financing:	US$5-6 million (GEF funding TBD)[1]
Co-and Associated Financing:	US$5.8 million (China, US, MPF)
Requesting Agency:	UNDP
Block:	PDF Block B
PDF Funding Requested:	$250,000
Block A Grant:	No
Convention Ratification:	January 5, 1993

SUMMARY PROJECT OBJECTIVES AND DESCRIPTION

1. The overall objective of this project is **to promote the adoption of energy-efficient designs and technologies in the refrigerator industry in China** under Operational Programme #1 of the GEF Climate Change Operational Strategy to complement CFC phaseout work planned for under the Montreal Protocol. Strategically, the objective is to alter the path of investment in China's refrigerator industry towards new energy-efficient CFC-free designs which are attractive to consumers while at the same time assisting the government of China in fulfilling its obligations under the FCCC related to stabilization of GHG emissions.

2. To achieve this strategic objective, the project will address (i) a range of issues concerning market and commercial barriers to development, consumer acceptance of new refrigerator designs, energy pricing policy, standards and labeling, capacity building, and technical outreach to other refrigerator manufacturers, and (ii) will provide assistance to one refrigerator factory in the development of an energy-efficient CFC-free model and to one compressor factory for the introduction of a high-efficiency (COP 1.4+) compressor to China, both of which are well advanced in their plan for conversion from CFC (Annex 1). The project will also include additional activities to develop a plan for the transformation of the refrigerator industry in China. The latter component, involving industry transformation, is envisaged to encompass an open bidding and selection process whereby successful factories would have access to alternate financing options to undertake conversion to energy efficient designs, along with some technical assistance; further work on remaining policy and barrier removal issues. Investigation will also be undertaken to determine the feasibility of additional funding for support of project activities at other factories through the development of a manufacturer-targeted rebate program as part of an incentive package. The final selection of partners for the larger project in China will, inter alia, take into account their status with respect to CFC conversion to ensure cost-effectiveness and complementarity between the MFP activities (CFC conversion) and the proposed energy efficiency activities. Total requirements for incremental GEF funding for the project will be determined upon completion of PDF Block B

[1] Part of the PDF activity will consist of determining an appropriate level of GEF funding for this project; there will concurrently be an investigation into the feasibility of determining addition funding for support of project activities at other factories through the development of a manufacturer-targeted rebate program as part of an incentive package.

activities, including examination of all financing sources and modalities for the larger transformation project (IFC, ADB, GEF, private sector etc.)

3. Electricity consumption in the Chinese residential sector has grown at an annual rate of 16.1 percent over the period 1980-1993, while residential energy use has risen from 3 to 12 percent of total electricity consumption. Within the residential sector, it is estimated that refrigerators account for approximately 50% of all electricity consumed by home appliances. Chinese refrigerators are currently less efficient than current technology allows, consuming on average more that 2kWh/liter/year (compared to less than 1.5 Kwh/liter/year for similar designs manufactured in Europe and Korea). At current levels of power consumption and production levels, refrigerators produced over the next decade will require an additional 39 billion Kwh of energy annually, which would necessitate an estimated power generation capacity of 6,750 MW (costing in 1993 terms of over US$2 billion); if production levels increase, as they are expected to, additional power generation capacity required will be significantly higher.

4. Work undertaken by the University of Maryland and the Beijing Household Electric Appliance Research Institute using modified versions of current production models demonstrate that by introducing these new energy-efficient designs, cost-effective energy savings of 40-50% can be obtained while at the same time **maintaining low incremental manufacturing costs and minimizing price increases to consumers,** thereby promoting a win/win situation.

5. Most of the major Chinese refrigerator manufacturers are currently planning CFC conversions with the assistance of the Montreal Protocol, either to hydrocarbons or to HCFCs. The Montreal Protocol Fund does not allow for funding of energy efficiency measures beyond measures necessary to maintain the unit energy consumption in the face of CFC conversion. Since CFC conversion alone may result in a net decrease of 1-3% in energy consumption if system design is appropriately modified (see Annex 2) as well as offering opportunities for additional energy efficiency measures at lower cost than would otherwise be the case, one aspect of this program is to take advantage of planned changeovers to introduce new energy-efficient designs and technologies that would provide an estimated energy savings of an additional 40-50% in energy consumption. These savings are to be achieved through the use of high-efficiency compressors, thickened insulation, improved gaskets, increased evaporator and condenser surface area, and optimization of system operation. Associated activities such as the development of a labeling program, efficiency standards, and a manufacturer incentive program, would overcome market and commercial barriers to the successful marketing of such models. These barriers include uncertainty over consumer acceptance of new designs, lax domestic efficiency standards; and higher manufacturing costs. Existing energy efficiency standards and increasing standards of living have driven new domestic R&D efforts not towards energy efficiency but towards development of energy-consuming features, such auto-defrost refrigerator models and ice makers. This trend emphasizes the importance of **working in conjunction with currently planned CFC conversions** to establish the technical and commercial viability of energy-efficient CFC-free designs.

6. Production of household refrigerators in China currently stands at about 8 million units per year spread among over 40 companies; the top ten firms, however, account for about 75% of production and 85% of sales. In 1992, the stock of household refrigerators totaled 39 million, up from only 4 million in 1985 (38% p.a. growth). In urban areas, where incomes are on average 3 times higher than in rural areas, penetration of refrigerators reached 57 per 100 households in 1993, up from 7 in 1985; this figure has reached 100 in Beijing, and over 90 in Shanghai and Zhejiang. In contrast, penetration in rural areas per 100 households stood at 3 in 1993. As the market has grown, consumers have become more demanding in terms of quality, reliability, and service. A recent market survey in Beijing, Guangzhou, and Shanghai indicated that new buyers are most focused on the quality of the refrigerator but are highly attracted by new technology and potential for energy

savings. Although additional work on consumer awareness and education will be necessary to widen acceptance of higher-cost energy-efficient refrigerators, these survey results from well-developed urban markets are favorable to marketing of high quality, reliable, energy-efficient refrigerators.

7. **Global Benefits** from facilitating the introduction of energy-efficient designs in China as a result of this project will reach 35 million TCE, assuming a 50% penetration of the market with energy-efficient models, without taking into account greenhouse gas reductions attributable to CFCs replaced. Achieving the strategic objectives of the project will therefore result in a highly cost-effective use of GEF funds. Initial estimates are that unit abatement costs, with replication, would fall to about US$0.30 per TCE.

8. USEPA has funded activities in China and in the USA in conjunction with the US-China Refrigerator Project since 1989, when USEPA established a cooperative agreement with the Beijing Household Electric Appliance Research (BHEARI) for US$525,000 over a three year period. This money was used to build institutional capacity at BHEARI and initiate research and development of energy-efficient substitutes for the CFC substances used in Chinese household refrigerators. This project will build upon the experience and work undertaken by USEPA in China to date. The U.S.- China Refrigerator Project began in November 1989 with an EPA expert mission to China which toured seven refrigerator factories in six cities and began discussions with Chinese government officials for a joint project to combine non-CFC refrigerant, non-CFC foam, and energy efficiency. In 1990, project agreements were reached, and testing began of six refrigerators with six separate working fluids. Also in 1990, USEPA established and funded a training program at the University of Maryland for refrigeration engineers from the Beijing Household Electric Appliance Research Institute (BHEARI). In 1991, USEPA sponsored a training program for BHEARI engineers in the USEPA Refrigerator Analysis Model (ERA), a software tool developed by USEPA to calculate energy efficiency implications of alternative CFC replacement technologies, and three Chinese factories (Haier, Shangling, and Zhongyi) began production of initial laboratory prototypes. Based on the results of these prototypes and discussions at a project workshop in November 1992, the Haier prototype was selected for further development. The Montreal Protocol Executive Committee approved funding for continued prototype development in June 1993, and subsequent work in 1993 and 1994 focused on construction and continued refinement of advanced prototype units at Haier. USEPA will serve as a collaborating agency on this project.

9. An initial batch of 200 intermediate prototypes were built in December 1993 using thick-walled HFC-141b insulation and HCFC, HFC, and hydrocarbon refrigerants and refrigerant mixtures. Based on testing of these prototypes and international progress in movement to zero ODP foam blowing agents, final prototypes were produced in early 1995 using cyclopentane foam and isobutane refrigerant. These prototypes are currently undergoing field testing lasting into early-to-mid 1996, but they also require much additional work involving design, safety, and manufacturability testing. Agreement was reached between USEPA and the German GTZ to jointly fund the Montreal Protocol portion of the Haier conversion, which was approved by the Montreal Protocol Executive Committee in March 1995, thus achieving the synergy between CFC phaseout and energy efficiency improvement. Chinese project participants and UNIDO developed a project proposal for conversion of Jiaxipera Compressor Factory to isobutane in order to provide a local source for compressors for the project, while U.S. and Chinese project participants developed a proposal for GEF funding for implementation of energy efficiency measures in conjunction with the CFC phase-out at Jiaxipera, Haier, and other refrigerator factories.

10. A main goal of this **"barrier-removal"** project under Operation Programme #1 of the GEF Operational Strategy for Climate Change will be to demonstrate the win/win nature of energy efficiency investments to manufacturers, consumers, and lending agencies so as to ensure private sector sustainability of the project approach beyond the period of GEF support. The project falls

directly within **Operational Programme #1 of the GEF climate change operational strategy.** In addition, the project contributes to meeting goals under **GEF Ozone Focal** area, in that it will complement, but not duplicate, efforts being undertaken under the Montreal Protocol. These efforts include:

- estimate the scope for refrigerator factory energy-efficiency conversion projects in China that are not being implemented due to a number of barriers
- completely identify all the barriers to energy-efficient refrigerator conversions being undertaken in China
- propose specific measures to remove these barriers
- estimate the transaction costs of such removal
- demonstrate the sustainability of win/win investments in energy-efficient refrigerators in China after the period of GEF support has ended
- estimate the overall financial requirements and time horizon for complete conversion of the refrigeration industry in China
- demonstrate how the programmatic benefits will be monitored and the sub-programme evaluated

11. The **main barriers** to be overcome by this project are the market, commercial and technical risks associated with the acceptance of new models by manufacturers in China, uncertainty of consumer acceptance and market penetration, disassociation of costs and benefits owing to remaining (yet declining) energy price distortions, the lack of developed standards and labeling programs, and overall uncertainty concerning the commercial viability of the proposed models. The proposed PDF Block B grant will be used in order to prepare the project and to make a strong case that the project really will be able to overcome the identified barriers. In addition to examining GEF funding for the later transformation project, IFC, ADB, private sector (including utilities), and other financing modalities will also be examined. The goals of the technical assistance and policy-related component of the project for which GEF will finance the incremental costs will be as follows:

- developing and implementing refrigerator standards and refrigerator labeling program, along with a marketing effort to inform Chinese consumers of the advantages of energy-efficient refrigerator models. This will include ascertaining levels of consumer acceptance and identifying market barriers;
- strengthening the technical acceptance of energy-efficient CFC-free refrigerator designs through the development and execution of a training and outreach program targeted at refrigerator manufacturers;
- minimizing the market and commercial risks stemming from the disassociation of costs and benefits through development of energy efficiency incentive programs including, among other possibilities, a manufacturer-targeted rebate program for achieving energy-efficiency standards;
- completion of design, safety, and manufacturability testing for a commercially viable energy-efficient CFC-free refrigerator designs, including assistance in the design and transfer of high-efficiency CFC-free compressor technology; and
- developing a plan and undertaking work to identify and secure addition funding resources for a larger transformation project targeted at the overall refrigerator industry. This would include identifying any remaining incremental costs associated with removing market and investment barriers that would prevent private sector sustainability of the project over the long run.

DESCRIPTION OF PROPOSED PDF ACTIVITIES

12. The PDF Block B grant would be used to undertake the following activities:

- review of the options and actions for development of refrigerator standards criteria and creation of a refrigerator labeling program;
  assess options for the design of an awareness campaign to promote the energy-efficiency standards and labels;
- evaluate the market barriers to be addressed in the design of a consumer acceptance and marketing program including, in particular, energy-efficiency standards;
- assess the impact of electricity pricing policy on and interest of utilities or other relevant organizations to participate in the design of an incentive-based rebate program for achieving energy efficiency standards;
- assess the future sustainability of manufacturing energy-efficient refrigerators and compressors;
- finalize work on the design, testing, and manufacturability of refrigerator designs providing an estimated 40-50% energy savings after adoption of CFC-free refrigerants;
- develop criteria for identification of refrigerator and compressor manufacturers to carry out redesign and manufacture of CFC-free energy-efficient refrigerators and compressors;
- calculate incremental and baseline costs and co-financing needed;
- undertake investigation into the feasibility of determining additional funding for support of project activities at other factories through the development of a manufacturer-targeted rebate program as part of an incentive package.
- identify experts and materials needed to carry out technical outreach and training project for refrigerator manufacturers;
- identify experts and testing agencies throughout China to carry out design review and testing for energy-efficient refrigerator models;
- determine national and regional support institutions to be targeted for dissemination of project results;
- develop initial plan for assessing the costs and targets of technical assistance activities and future investment activities and identification of funding sources;
- establishment of **Project Steering Committee** to include representatives from NEPA, NCLI, ADB, USEPA, World Bank, IFC, UNIDO, UNDP, and Executing Agencies of the MPF in China;
- prepare a project brief for GEF project funding through UNDP.

ELIGIBILITY

13. China has signed and ratified the FCCC (5 January 1993) and is participating in the restructured GEF (16 May 1994), and is therefore eligible to receive GEF funding. This program is specifically eligible for GEF funding as a barrier-removal project under Operational Programme #1 of the GEF Climate Change Operational Strategy. The project is also consistent with Interim Guidance for Programming of GEF Resources which emphasizes GEF support for energy efficiency projects related to capacity building for institutions which have the potential to disseminate energy-efficient technologies and practices widely and in a self-sustaining manner.

14. The project is also linked closely with the **GEF Ozone Focal Area** and complements China's Country Plan for CFC phase-out under the Montreal Protocol. Under the Montreal Protocol, funding for energy efficiency improvements is not permitted. However, by taking advantage of the synergy available through targeting those manufacturers currently planning to undergo CFC conversion with Montreal Protocol Fund support, **energy-efficiency improvements of an estimated 40-50% can be realized, duplication of effort is avoided and global environmental benefits are enhanced in a more cost-effective manner.** Finally, the project

addresses an important industrial sector which has not yet been targeted by GEF, and a country which will play a crucial role in global climate change mitigation. It is estimated that with industry replication and market penetration of 50%, GHG abatement will reach about 35 million TCE.

NATIONAL LEVEL SUPPORT

15. Consultations between UNDP, USEPA, IFC and the Chinese Government have indicated that additional non-GEF funding may become available for the project following completion of PDF Block B activities. The project is consistent with China's Agenda 21, the Country Plan for CFC phase-out, the CFC Substitute Strategy for the Chinese Refrigerator Industry, and China's Ninth Five-Year Plan (1996-2000) for economic development. It has also been approved for inclusion in the National Plan of Environmental Protection Approval for China and is accorded a high priority by the government. The project has been in **China's GEF pipeline for the past two years** and is one of the highest priorities of the Government of China for GEF support. The project will assist China to meet its plans for sustainable energy production and consumption, which is specified in Chapter 12 of China's Agenda 21 Plan, by decreasing overall electricity demand.

16. This project builds upon the findings of the GEF pilot phase project **Issues and Options in GHG Emission Control in China.** One of the conclusions of this report was that, given the rapid growth in the Chinese consumer sector, improvements in the energy-efficiency of household appliances (such as refrigerators) was an area which could yield major energy savings for the economy while at the same time mitigating substantial amounts of carbon emissions.

JUSTIFICATION FOR PDF GRANT

17. A PDF grant is necessary to lay the foundation for the full-scale project, to identify and target the appropriate experts, resources and policies, and to test and confirm the appropriateness of the approach. In addition, a PDF Block B grant will allow for investigation of other funding sources, including multilateral institutions, national institutions, and the private sector, for a larger industry transformation project.

TIMETABLE

18. It is intended to complete all PDF activities in this proposal by February/March 1996 in order that a GEF project can be prepared for submission to GEFOP in March 1996 and to the GEF Council in April 1996. Owing the high level of initial activity undertaken to date, project experts and consultants have been fully mobilized and are prepared to begin work immediately upon approval of the PDF grant. Upon successful completion of the PDF-supported activities and identification of funding sources (including GEF) for the project, it is expected that the project would be completed within 3 years.

BUDGET

19. The requested PDF Block B grant of US$250,000 would be used in support of in-country and international activities in support of the China Energy-Efficient CFC-Free Refrigerator Proposal. PDF-funded activities would include initial identification and assessment of market barriers, investment barriers, and in-country experts; review of policy options and barriers, preparation of market, outreach, and labeling programs, identification of additional design and testing organizations, and incremental cost assessment. The following table presents the expenditure categories and budget allocations for the proposal PDF Block Grant.

Budget

Expenditure Category	PDF Block B Cost Allocation
Local Experts and In-Country Activities	$60,000
International Consultants, International Activities, including travel	$147,000
Full Incremental Cost Calculations	$10,000
Project Brief & Project Document Preparation	$15,000
Project Support Services (Including Executing Agency Support Costs [8%])	$18,000
Total PDF Block B Request	**$250,000**
US Government/Government of PRC Contribution (In Kind):	$70,000
Total Cost	$320,000

PDF OUTPUTS

a. UNDP/GEF Project Brief including recommendations for development of the standards and labeling program and assessment of the market barriers to be addressed in the design of a consumer acceptance and marketing program and manufacturers incentive program, and preliminary assessment of the likelihood of success of this program;
b. Identification of additional experts and organizations to participate in technical outreach, training, and testing programs;
c. Determination of national and regional support institutions to be targeted for dissemination of project results;
d. Establishment of criteria and selection of participating compressor factory for technical assistance in redesign and production of energy-efficient compressors and selection of refrigerator factory;
e. Full calculation of incremental costs and determination of baseline costs and activities, and cofinancing;
f. Initial plan for assessing the costs and targets of related investment activities and identification of funding sources;
g. Draft project document

EXPECTED DATE OF PREPARATION COMPLETION

February/March 1996

Annexes

1- Details on Haier Refrigeration and Jiaxipera Compressor Factory
2- Letter from Liebherr-Hausgerate GMBH and Bosch-Siemens Hausgerate GMBH emphasizing that there are little, if any, energy efficiency gains from direct conversion to CFC to hydrocarbons
3- UNDP clarifications on issues raised by UNEP, and World Bank at last GEFOP

Lawrence Berkeley National Laboratory
University of California
1 Cyclotron Road, MS 90-4000
Berkeley, CA 94720

Memorandum

To: Nileema Noble
From: David Fridley
Date: 30 November 1995
Re: Baseline Energy Consumption

The two targeted factories are the Haier Refrigerator Factory in Qingdao, Shandong, and the Jiaxipera Compressor Factory in Jiaxing, Zhejiang. The following summarizes the situation with regard to energy consumption of their products before and after CFC conversion, and the impact of energy efficiency measures proposed for each factory's products.

1. Haier Refrigeration Factory.

The baseline model for conversion is the Haier BCD222 (indicating a manual defrost, fresh-food and freezer model). At Haier, CFC conversion has been underway at the same time as energy efficiency measures have been tested and implemented, so it would be more useful to provide you with the entire breakdown of efficiency gains and losses that have taken place in the development of the prototype now in field testing. The figures come from Haier directly; they summarized this process as well (on a different model of refrigerator) at the CFC Conference in Washington, DC in October 1995:

- Baseline energy consumption: 1.364 kWh/day
- Thicker thermal insulation (energy efficiency): 14% improvement in energy efficiency
- Replacement of original 1.1 COP compressor with imported COP 1.3 compressor (energy efficiency): 18% improvement
- Modification of door gasket (energy efficiency): 5% improvement
- Conversion to isobutane refrigerant (CFC conversion): 4% improvement
- Replacement of COP 1.3 compressor with imported COP 1.45 compressor (energy efficiency): additional 4% improvement
- Conversion to cyclopentane foam blowing agent (CFC conversion): 3% reduction in energy efficiency
- Additional 5mm insulation (energy efficiency): 2% improvement
- Increase surface areas of evaporator and condenser (energy efficiency): 3% improvement

The net result of these measures lowered average daily consumption of the refrigerator from 1.364 kWh/day to 0.726 kWh/day, or a 47% increase in energy efficiency. It is hoped that after final testing and design modification, the full 50% target will be reached. As you can see, a net 1% of the 47% gain in energy efficiency is derived from conversion from CFCs to hydrocarbons (+4% for isobutane, -3% for cyclopentane). The loss with cyclopentane is due to the higher K factor of the material (i.e. increased thermal

conductivity) compared with CFC-11.

1. Jiaxipera Compressor Factory

The Jiaxipera Compressor Factory has not yet begun to implement conversion measures. In October 1995, its proposal for Montreal Protocol funding was reviewed, and the project was put in a special "priority" status for consideration at the November meeting. I am currently unaware of the result of the meeting, but have contacted the offices of several of the relevant MP officials to get an update.

The MP funding would support the conversion of the compressor factory from use of CFC-12 to isobutane. This conversion would be accompanied by a 2-6% improvement in energy efficiency. I am attaching for your reference an article by Delmar Riffe, engineer at Americold (a division of Electrolux, from whom Haier has obtained high-efficiency hydrocarbon compressors), in which he notes in conclusion (p. 3): "Calorimeter testing of several R-600a compressors tends to confirm, within the limits of experimental error, that the theoretical prediction of a 6% efficiency improvement is an actual reality. *Actual test results indicate only about 2% improvement* but it is believed that with a little more compressor optimization the 6% will be realized."

We have been talking with Electrolux about the possibility of transfer of a high-efficiency compressor design to implement at Jiaxipera; this would raise the baseline efficiency from a COP of 1.1 to 1.45 for a gain of 32% in energy efficiency. Again, of this 32%, about 2% could be attributed to the conversion from CFCs to hydrocarbons.

I hope this clarifies the situation with regard to CFC conversion, energy baseline measures, and the distinction between energy efficiency improvements and gains and losses from conversion to hydrocarbons at the two factories.

Memorandum Annex 1 (continued)

To:	**Nileema Noble**
From:	**David Fridley (signed)** **Lawrence Berkeley National Laboratory** **University of California, Berkeley**
Date:	**December 1, 1995**
Subject:	**Haier factory conversion**

I would like to take this opportunity to update you on the status of the Haier factory conversion based upon conversations with Mme. Yang Mianmian, Vice President of Haier, whom we met with during the recent CFC Conference in Washington, DC.

With the assistance of Liebherr of Germany, Haier converted one of their foam-blowing lines to cyclopentane in July of this year. The next stage of the conversion is to install the isobutane refrigerant line, which will begin in December this year or January 1996. In any case, they expect the line to be installed, tested and in operation no later than the end of January 1996.

With the installation of the cyclopentane and isobutane equipment, the CFC conversion work at Haier will be completed. As you know, at the same time that Haier has been planning the CFC conversion work, our team has been working with them in the design and prototyping of a CFC-free energy efficient model that reduces average power consumption by 50%. The initial batch of prototypes has been produced and is currently being field tested in Beijing, Shanghai and Guangzhou. In addition to the field tests, however, there are several additional steps that need to be undertaken to ensure that the design is robust, that the model achieves the highest safety standards, and that it is manufacturable in conditions of mass production. These tests, of course, are ones that any prudent manufacturer would undertake. It is our hope that these tests can be funded soon in order for Haier to move forward in production of the energy-efficient models.

As is likely the case with many complex projects involving the coordination of activities among numerous parties, there have been some minor delays in the timeline of the work at Haier, but it is obvious from the experience there that the approach of coordinating efforts in improving energy efficiency with CFC conversion is sound. It is on this basis that we have prepared the PDF proposal to support continued work in this area

ANNEX 2

Letter October 16 1995
From Mr. Wiest, Liebherr-Hausgerate GMBH (Originals Follow)

TO: Mr. Alan Fine, University of Kentucky

The conversion from CFC 11 and CFC 12 to cyclopentane and isobutane was followed only by very small changes in energy consumption.

Replacing CFC 11 in the foam we found that there is a little increase in energy consumption (3-4%).

The conversion of the refrigerant CFC 12 to isobutane is difficult to assess, because of the improvement of the efficiency of the compressors in the same period.

In any case, there is no disadvantage due to the change of the refrigerant.

At the CFC-Conference in Washington, our company will be represented by Mr. Hahn.

The presentation of Mr. Hahn will take place in the conference session "air conditioning and refrigeration: hydrocarbons in refrigeration and residential air condition". Wednesday 25th, 2:45-4:15pm.

Sincerely,
Liebherr-Hausgerate GMBH

I.A. signed (Wiest)

Fax Bosch-Siemens Hausgerate GMBH 9/10/95
From: Dr. Udo G. Wenning
To: Mr. Alan Fine

REF: Energy consumption of hydrocarbon appliances, your fax of Oct. 4 1995

Dear Alan,

The only published data on energy consumption are from Liebherr (attachment). The show the possibility to decrease energy consumption by up to 7,8% using 600a as refrigerant. We have similar results which are not in the public domain. On the other hand switching to cyclopentane increases k-Factor by about 5% and energy adaptation of compressor and heat exchanges etc. Maybe we meet in Washington as I will also attend the CFC Alternatives Conference.
Best Regards
(attachments - next page)
(signed Wenning)

Tabelle 4.1 Meflergebnisse an Kuhigeraten (Auszug)

TABLES

Kaeitemittel bzw Gemisch-Zusammensetzung und Fuellgewicht	gaom Hubvo. Verifchter in cm3	Energie-verbrauch in kWH/d	Energie-verbrauch in %

4.2.3. Kuehligeraete mit 3-Sterne-Fach

Die Ergebnisse des "3-Sterne-Fach Geraets" decken sich mit denen des "Ruckwand-Verdampfer-Gerats"
Auch hier wurden bei einer analogen Messtreihe alle moeglichen Kombinationen von Kaelternmitteln (und Mischungen) und geometrischen Hubvolumen ueberprueft.

Der Guenstigste Energieverbrauch wuerde auch hier mit R 600a erzielt. Da jedoch bei 3-Sterne-Fach-Geraten theoretisch noch die Moeglichkeit einer Verdampfer Optimierung fur ein Kaeltermittle-Gemisch besteht, wurde in einer welteren Versuchsreihe ermittelt ob das Verhalten eines nichtazeotropen Gemisches in einem solchen Geraet ueberhaupt definiert gesteuert werden kann.

table 4.2.2 Kuhlgerats
table 4.2.3 Kuhl.... 2 Sterne Fach

BOSCH-SIEMENS HAUSGERÄTE GMBH

Produktbereich Kälte, Fabrik Giengen

Fax-Mitteilung an / Fax-Message to	UK University of Kentucky
Name	Mr. Alan Fine
Abteilung / Department	Program Manager, Insulation Materials
Ort / Location	Lexington, KY
Fax	0-01 - 606 323 19 29
Seitenzahl / Number of Pages	incl. dieser Seite 3 incl. this page

Datum	09.10.95
Unser Name	
Name	Dr. Udo G. Wenning
Abteilung / Department	EG
Ort / Location	Postfach 12 20 89537 Giengen/Brenz
Telefon / Phone	+49 (0) 7322/92-2543
Fax	+49 (0) 7322/92-2999

Ref.: Energy consumption of "hydrocarbon" appliances;
your fax of Oct. 4, 1995.

Dear Alan,

the only published data on energy consumption are from Liebherr (attachment). They show the possibility to decrease energy consumption by upto 7,8 % using 600a as refrigerant. We have similar results which are not in the public domain. On the other hand switching to cyclopentane increases k-Factor by about 5 % and energy consumption by up to 3 %. The overall change is negligible depending on the adaptation of compressor and heat exchangers etc. Maybe we meet in Washington as I will also attend the CFC Alternatives Conference.

Best regards,

Udo

Attachments

FINE2.DOC

Seite 1/1

LIEBHERR-HAUSGERÄTE GMBH

Telefax

an Fax Nr. 001 60 63 25 19 29 Anzahl der Seiten 1 (incl. Deckblatt)

Liebherr-Hausgeräte GmbH · Postfach 1161 · D-88411 Ochsenhausen

☐ gemäß telefonischer Absprache ☐ zum dortigen Verbleib
☐ zur Kenntnisnahme ☐ zur Erledigung
☐ zur Bearbeitung, bzw. Prüfung ☐ mit der Bitte um Anruf

University of Kentucky
Mr. Alan Fine

Ihre Zeichen / Ihre Nachricht vom	Telefon/Durchwahl	Telefax	Datum	Bearbeiter/in
	(07352) 929- 331	(07352) 929- 476	October 16, 1995	Mr. Wiest

TE2777/95-mw/kh

Dear Mr. Fine

The conversion from CFC 11 and CFC 12 to cyclopentane and isobutane was followed by only very small changes in energy consumption.

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At the CFC-Conference in Washington our company will be represented by Mr. Hahn.

The presentation of Mr. Hahn will take place in the conference session "air conditioning and refrigeration: hydrocarbons in refrigeration and residential air condition", Wednesday 25th, 2 to 4 pm.

Sincerely

LIEBHERR-HAUSGERAETE GMBH

i.A.

Wiest

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Responses to 23 October GEFOP Comments on the PDF Annex 3

I.UNEP comments.

1. *A more detailed description of the project is required to ensure that GEF is not funding what is or could be funded by either the Multilateral Fund or the US EPA bilateral. For example, it should be clear that GEF will only pay for the costs of the conversion specific to energy efficiency and unnecessary for the transition to CFC-free fridges. The factory conversion to non-CFC refrigerant and foam, including full incremental cost calculations should be approved by the MF, leaving only the costing of the energy efficiency adaptations for GEF.*

In the case of the Haier plant, the Montreal Protocol-funded activities included the conversion of the foam line to cyclopentane (with a reported loss of 5-8% efficiency) and conversion of the refrigerant to isobutane. The conversion to isobutane could, theoretically, increase efficiency by up to 6%, but actual tests have generally resulted in 2% gains. In total, the MPF-funded CFC conversion to hydrocarbons does not result in any energy efficiency gains. Haier, however, has decided to use high-efficiency imported compressors with a COP of 1.4-1.5 in their new hydrocarbon models, increasing efficiency by 15-20%. The purchase of these compressors, however, was not part of the cost calculations presented to the MPF and is being funded from other sources. The efficiency gains to be funded by the GEF do not include any CFC-related activities. In particular, the proposed GEF-related activities include thickening of the insulation, increasing the size of the condenser, redesign of the evaporators, optimization of operation time, and redesign of the door gasket. These non-CFC related activities result in a reduction of energy consumption of 50% over the base model.

2. *We would like further clarification of the PDF justification. The US EPA has already funded, through the MF, the conversion of a factory to produce 200 prototypes of an energy efficient CFC-free fridge. The research done by the University of Maryland was part of this project. Therefore, the identification of experts, manufacturers, and testing agencies for the fridge conversion should have already been done. Much of the testing and design was done in the prototype phase.*

In the work on prototype development, a number of technical experts and expert groups were identified and participated in the project. These included Dr. Alan Fine of the USEPA/University of Kentucky, the University of Maryland (Dr. Reinhard Radermacher) and the Beijing Household Electric Appliance Research Institute (BHEARI) in Beijing. In addition, testing locations include the Underwriters Laboratory in Illinois, BHEARI, and Liebherr of Germany. It is expected that all or most of these groups would continue to contribute in the next phases of the project. However, what is necessary under the next phase of the project, and for which PDF support has been requested, is identification of possible experts and institutions in China in addition to the one organization (BHEARI) in Beijing. This would include regional testing centers in western, Yangzi region, and southern China as well as identification of Chinese experts in refrigeration in these various regions and in other institutions (also in support of the activity on developing technical outreach program). It is not expected that this would be a major portion of the PDF activities, but it an activity necessary to ensure that the bulk of future work will be and can be done in China.

3. *Energy efficient appliances may not translate into substantial, if any, cost savings for consumers due to extreme price subsidies. Therefore, the identification of market barriers and options for their removal should involve the Department of Energy. PDF proposal should make more clear what steps it will take to identify and reduce market risk, particularly the existing energy policy framework.*

In an initial market survey done by Ogilvy and Mather looking at the consumer attitudes towards energy-efficient refrigerators, the results show that consumers are indeed attracted by the prospect of lower electricity costs afforded by an increase of 50% in a refrigerator's energy efficiency, but that this is generally not the most desired feature of a refrigerator (top on the list was quality and reliability). Currently, the prices consumers pay for electricity vary enormously around China, so the calculation of financial return will vary as well. For example, in Jinan, Shandong, one kilowatt-hour of electricity for residential use costs ¥0.22, while in Shenzhen, Guangdong, the price is ¥0.50 (1994 prices). A consumer in Jinan, therefore, would realize an annual savings of some ¥60 while a consumer in Shenzhen would save about ¥130, equivalent to about 20-25% of an average worker's monthly take-home pay. Electricity prices do remain subsidized, but the government has been moving towards raising the price to market-related levels commensurate with production costs, which will result in residential prices some 2 to 3 times higher than current levels in many areas. (For example, some areas of Beijing now have adopted a pricing scheme whereby the first 80 kWh of electricity is provided at ¥0.30/kWh and higher amounts are priced at ¥1.00/kWh.) Assuming a high consumer discount rate, the impact of such subsidies to consumers is to increase the payback period and reduce the attractiveness of purchasing energy-efficient appliances, despite the attractive return on an economic basis to the economy as a whole. This disassociation of costs and benefits is a major element of market risk.

The PDF will be used to identify all the elements of market risk and to formulate a strategy to reduce market risk given China's macroeconomic and policy climate. One option, for example, would be to create a manufacturer's rebate program for CFC-free energy-efficient refrigerators, allowing them to bring down the first cost of these models to consumers. This fund could be a replenishable fund, paid into by utilities or other sources, and paid out to manufacturers, or a one-off funded pool used to encourage the increase in production and sales of energy-efficient models in anticipation of lower future costs from economies of scale of production (and in anticipation of higher residential electricity prices). As part of the process to identify these market risks and to understand the current policy and likely changes in future policy, the project team will work with China's State Planning Commission, Ministry of Electric Power, NEPA, and NCLI. China no longer has a central ministry of energy, so it will be necessary to work with a number of agencies in order to properly identify all the elements contributing to market risk.

4. *As the feasibility of energy-efficient fridges has been shown through the US/GTZ bilateral, we require further clarification about the need to research technical risk.*

In order to minimize technical problems associated with development of an energy-efficient refrigerator, the project has chosen to incorporate proven and tested methods, such as thicker insulation, larger evaporator and condenser surface area, and improved door gaskets. These elements alone are feasible and effective, but taken together, particularly in combination with the use of isobutane refrigerant, the ultimate manufacturability and safety of these models have yet to be tested.

Internationally, standards and testing procedures for refrigerators using flammable refrigerants are still under development (IEC 335-2-24, Committee Draft of July 1995, comments due 31 December 1995), from which proposed standards in the US and Germany have been drawn. It will be necessary during the upcoming PDF and project stages to ensure that the Chinese models fully accord with these international standards. Moreover, there has not yet been an assessment of technical problems in the prototypes from the field testing, and these results are not expected before the first or second quarter of 1996. Further design and development work will be needed as well to apply these test results. From the point of view of the manufacturer, there is considerable technical risk assessment yet to be done.

5. *The funding of incremental risk on this project may require a policy discussion as to how to determine the level of incremental versus normal commercial risk.*

All manufacturers face a level of commercial risk associated with the introduction of new technology and new models. In the case of the CFC-free energy-efficient refrigerator, this commercial risk is increased owing to uncertainties with flammable refrigerants and the acceptability (aesthetically and practically) of the cabinet redesign for energy efficiency. As these would be the first refrigerators of their kind available for the Chinese mass market, these risks must be considered in the evaluation of incremental commercial risk.

6. *The proposal should clarify why it is necessary to demonstrate through the conversion of three factories.*

Given the market, commercial, and technical risks associated with this project, it is necessary to ensure that a 'critical mass' of CFC-free energy-efficient refrigerator be developed, tested and marketed. Under a typical conversion scenario, only the leading production model for a factory would be fully converted (with the assumption that further conversions, upon success of the project, would be undertaken by the factory itself), totaling some 250,000 units per factory, for a total of about 750,000 units available to the market. This is equivalent to about 10% of the current Chinese market, and is considered a sufficient 'critical mass' to successfully demonstrate the commercial viability of the new product. At the same time, China currently has no high-efficiency compressor manufacture and no manufacture of hydrocarbon compressors. In order to ensure a reliable and less costly supply of high efficiency compressors (which alone accounts for about 15-20% of the energy savings in the refrigerator), one compressor factory would be converted as well. The minimal economic size of this compressor factory is 750,000 to 1 million units per year. Through conversion of three refrigerator production lines, the viability of the compressor factory would be ensured as well.

In the revised PDF, however, the scope of the project has been reduced to one refrigerator factory and one compressor factory. This change in timing will likely result in higher commercial risks for the compressor factory, as its market will be less assured. Stage two of the project will in essence complete the "demonstration project" as originally conceived: that is, of achieving a "critical mass" of refrigerator production in the Chinese market.

The demonstration effect of this project goes beyond the refrigerator sector. The successful introduction of energy-efficient refrigerators into the Chinese market would have a 'knock on' effect on the commercial refrigeration, air conditioning and other appliance sectors as well, where energy

efficiency has not yet become a focus of development.

During the first phase of the project to be developed with PDF support, however, the focus will be on technical assistance, capacity building, education programs, and labeling, standards development, and marketing to ensure that the prototypical CFC-free energy-efficient design work done to date is indeed manufacturable, safe, and replicable to other factories. Part of the work during the PDF stage will be to determine the best approach to achieving the results of the demonstration project (3-factory conversion) and to explore various funding mechanisms for achieving that goal.

7. *The proposal should specify what is meant by energy efficient. China has run tests of three types of CFC-free fridges to determine energy efficiency. Although less energy efficient, China decided to build prototypes of HC fridges as lower GWP.*

"Energy efficient" in this proposal is strictly defined to include only those improvements in design, system operation, and technology choice that leads to a decrease in energy consumption beyond any change in energy efficiency attributable to CFC conversion funded under the Montreal Protocol. The goal of this project is to increase energy efficiency over the base model refrigerator by 50%. The feasibility of achieving this goal has been demonstrated in the prototype stage. In addition, the goal of this project has been to reduce GHG emissions on a TEWI basis, for which energy efficiency is key.

I. World Bank Comments

1. **Energy-Efficiency of CFC-free Technology**.

This issue will be addressed by the materials being prepared by Alan Fine. The main concern is that of 'coincidental benefits' derived from CFC conversion. These 'coincidental benefits' or incidental have been shown to be nil or only slightly positive, even in the transfer of 'state of the art' technology through the MF. In the case of Haier, conversion to hydrocarbons necessitated the use of hydrocarbon compressors. They have chosen to use the high-efficiency imported Americold design with a COP of 1.4-1.5, affording them a 15-20% gain in efficiency. The incremental costs associated with this change in compressor use, however, is not fundable by the MF, nor was it including in the incremental cost calculations in the original MF proposal. Other incremental costs associated with efficiency gains though the use of thicker insulation, system redesign, gasket improvement and other optimization work is not fundable by the MF as well.

2. *It is not clear whether the most energy-efficient CFC-free technologies cost more than those with 'average' energy efficiency; if they do cost more, then this proposal would develop a strategy that would effectively subsidize the incremental cost due to energy efficiency in a few selected enterprises.*

Strictly in terms of CFC conversion, refrigerator manufacturers can change from R12 to R600a or R134a with no or little change in energy efficiency; thus, achieving significant energy efficiency gains (50%) does require a retooling and conversion that results in higher costs to the manufacturer. From prototypes developed already by Haier, this cost is estimated to be in the range of some US$30-40 per refrigerator. Although in the initial stages there will be in effect a subsidization of these incremental

costs, the degree to which these costs will be higher, and the mechanism through which they may be subsidized, is not clear. PDF funding is being sought in order to better clarify these incremental costs and to develop a program to lower these costs to the consumer that is tied in with efforts related to energy sector policies, electricity pricing, labeling, and marketing promotion.

3. **Dynamics of the Chinese Refrigerator Market**. *In general, the Chinese refrigerator manufacturers tend to be cash-rich and the dynamic enterprises have made technological innovations with no external financial help—one enterprise has adopted isobutane-refrigerant, cyclopentane-foaming technology on its own. There are also a growing number of joint ventures in this industry, and the leading Chinese firms have many contacts and access to technology. The "cash-rich" supply side of the equation is made possible by a relatively price inelastic market where consumers are willing to spend more to get a "modern" (though not necessarily energy-efficient) refrigerator. These factors suggest that dynamic enterprises will be able to adopt energy-efficient technologies on their own.*

This is difficult to answer as stated, since there is a generalization from the example of ONE (out of 40+) Chinese factory adopting isobutane/cyclopentane on its own (Kelon C a very dynamic and one of the leading refrigerator manufacturers in China. Kelon's energy efficiency gains have also taken advantage of the work done at Haier and introduced during visits to Haier and various conferences in China by U.S.-China project participants. Kelon is now applying for MPF funds to retroactively support the conversion) to the conclusion that the industry as a whole is cash-rich and can adopt energy efficiency on its own. This appears to repeat the confusion between CFC conversion and energy efficiency, and it also makes the assumption that there are no market, price, technology or commercial barriers or distortions in China to the adoption of energy efficiency; indeed, the absence of other World Bank comments on the need for the labeling, standards, marketing, technical assistance and capacity building activities proposed for the project suggests that they do agree that these barriers exist. In addition, there is also the assumption that "dynamic enterprises" would adopt these measures on their own, despite the fact that these are the very companies that are putting the most effort into development of new frost-free models with other higher-energy-consuming features such as ice makers, for which there is growing consumer demand. Finally, there is no evidence in hand to indicate that the factories are all cash-rich, but the continued consolidation and downsizing of the sector suggests otherwise. There is a legitimate concern that grant money going to China be used in the most efficient way possible, and that grant money not be used in the case of manufacturers being able and willing to borrow or use their own funds for energy efficiency conversions. This is one of the assumptions underlying the concept for stage two of the project, but it is first necessary first to demonstrate a tested final prototype and initiate development of high efficiency compressors before developing a program whereby a mix of grant technical assistance and loans can be used to promote energy efficiency investments in the rest of the sector.

4. **Strategy to Promote Energy Efficiency.** *In the final analysis, this proposal seeks to develop a strategy that would provide a demonstration effect for the adoption of energy-efficient technologies through the subsidization of new technologies in a few plants. It is*

highly likely that this subsidy would either flow to technologically stagnant enterprises, or would be absorbed by free-riders. If it flows to technologically stagnant firms, then these same firms would again be inefficient (compared to industry average) a few years hence—as they will have no incentives to continually upgrade the new technology adopted by them now.

This concern somewhat contradicts the previous point; generally, "cash-rich and dynamic" enterprises are not technologically stagnant. In fact, the most technologically stagnant and mismanaged of the refrigerator manufacturers have since closed down or been bought out by other firms (Snowflake being a good example). As in the previous point, however, the concern over the recipient of funding is legitimate. In the stage-one proposal there is little money flowing directly to manufacturers aside from funding for prototype development and initiation of compressor development—the bulk of the funding supports the activities that are necessary to ensure that replication can take place smoothly and cost-effectively. As for the rest of the sector, the initial stage-two proposal concept is not to ask for all grant funding of factory conversion on the assumption that success in stage one would prepare conditions and create incentives for manufacturers to undertake conversion through other financing mechanisms. Moreover, the manufacturers who do receive grant funding for technical assistance in the second stage will be chosen by an open and transparent bidding process that will ensure that funding does not go to those enterprises without the incentive and wherewithal to upgrade.

5. *A more efficient energy-efficiency promotion strategy would be to put in place a process that enables the establishment, monitoring and continual upgrading of efficiency standards. At the present time, when the entire industry is being "forced" into technological change (because of the Montreal Protocol), the energy-efficiency enhancement strategy should form a component of a sectoral technological change strategy.*

The underlying assumption here appears to be that the top-down implementation of tighter standards would force the factories to upgrade, but the results of discussions on standards to date and other experience show that this is probably not a realistic approach in China. One major problem is that standards in China are generally developed in a way that allows the weaker manufacturers to meet the standards without undue financial hardship. In many cases, the manufacturers themselves propose the standards, which are then reviewed by the National Technical Supervisory Bureau for approval and implementation. Once implemented, however, enforcement is not necessarily thorough. China also allows exemptions to national standards for manufacturers who produce and market in limited geographical regions. These are called "enterprise" standards and are generally worked out between producer and consumer, then submitted to the NTSB for approval. The Chinese, however, have indicated that they plan to update their standards over the next few years, so it is timely to begin working with them to ensure that these revisions are significant and can add another element to the changing environment promoting energy efficiency in the refrigerator sector. The World Bank

comments state that "At the present time, when the entire industry is being 'forced' into technological change (because of the Montreal Protocol), the energy-efficiency enhancement strategy should form a component of a sectoral technological change strategy." This is **precisely** what we are hoping to achieve; this, however, is a necessary but not sufficient component of the project scope, given the numerous other barriers and disincentives to energy efficiency investments.