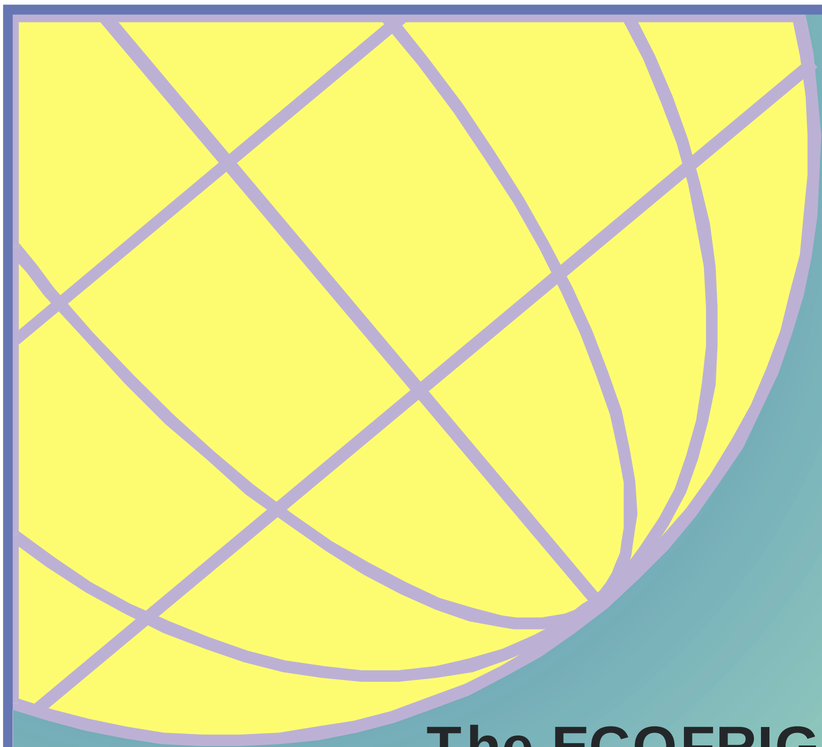

The ECOFRIG project

Achievements and Experiences
(1997 - 2001)

PREPARED BY

INFRAS
Consulting, Policy Analysis and Research
Gerechtigkeitsgasse 20
8039 Zürich, Switzerland

Team of Authors

Othmar Schwank
Nicole North
Stefan Kessler

An ECOFRIG publication

February 2002

The ECOFRIG project: Achievements and Experiences (1997 – 2001)

An input document for the conference on

Meeting Challenges in Change Over to Ecological Refrigeration

New Delhi, 5 - 6 March 2002

Authors:

- **Othmar Schwank**
- **Stefan Kessler**
- **Nicole North**

Prepared by:
INFRAS, Policy Analysis and Research
Gerechtigkeitsgasse 20, 8039 Zürich, Switzerland
Phone: ++41-1-205 95 95
Fax : ++41-1-205 95 99
e-mail: Zuerich@infras.ch
homepage: www.infras.ch

An ECOFRIG publication

Zürich, Switzerland

February 2002

Acknowledgements:

This document was produced as an input document for the Conference on Meeting Challenges in Change Over to Ecological Refrigeration to be held in New Delhi, India on 5 - 6 March 2002. The conference will be the formal closing event for the ECOFRIG project implementation activities in India.

INFRAS wishes to thank all contributors and their employees for helping to make the ECOFRIG project and in particular this document possible. Explicit thanks we would like to extend to Sukumar Devotta (National Chemical Laboratory, Pune), R.S. Agarwal (Indian Institute of Technology, Delhi), Richard Gerster (Gerster Development Consultants, Richterswil) for their much appreciated comments to the draft of this report, to Veena Joshi (Swiss Agency for Development and Cooperation) and Stephan Sicars (German Technical Cooperation, GTZ), Atul Bagai (UNEP) and C. Vishwanath (Ministry of Environment and Forests, India) for their encouragement and support at the level of the project steering committee for the experience documentation process. Also, we would like to thank all persons who provided us – through the interviews conducted by Richard Gerster in the fall 2001 – honest and fruitful feedback on the experiences made in project implementation and possible achievements of the ECOFRIG project activities. A special thanks is addressed to the agencies sponsoring the ECOFRIG project, the Swiss Agency for Development and Cooperation (SDC) and the German Technical Cooperation (GTZ).

Executive summary

The Global Challenge

Under the Montreal Protocol for the Protection of the Ozone Layer it was agreed that ozone depleting substances with a high ozone depleting potential such as chlorofluorocarbons (CFCs), are to be phased out by 2010 in developing countries. In developed countries this phase-out took place in 1995/1996.

India signed the Montreal Protocol in 1992. Under this Protocol India has been categorised as a Large Volume Consuming country due to its significant consumption of CFCs. In 1997 India consumed 6'705 Mt of CFCs. The refrigeration and air conditioning (RAC) sector is with its 2'961 Mt CFC[1] per year (Gargh 1999) the single largest consumer of CFCs in India. With regard to refrigerant, 96% of the consumption of Ozone Depleting Substances (ODS) in the RAC sector is CFC12.

Globally, there are two competing technologies for phasing out the use of CFC12 as a **refrigerant** in domestic refrigerators. The first technology is based on using hydrofluorocarbons (HFCs) such as HFC134a which is a synthetic fluid and a powerful greenhouse gas with a global warming potential of 1'300 CO_2-eq. The second technology uses hydrocarbon refrigerants (i.e. isobutane, HC600a) or the blend of propane and isobutane which are natural fluids. For phasing out the use of CFC11 as a **foam blowing agent** in refrigerators there are also two competing technologies: The first is based on a synthetic fluid, i.e. hydrochlorofluorocarbons (HCFCs) such as HCFC141b, the second is again based on a natural fluid, i.e. cyclopentane which is a hydrocarbon.

The hydrocarbon technology, also termed "greenfreeze", has been re-introduced on the European market in Germany 1993/94. The hydrocarbon refrigerants are flammable but have a number of environmental and performance merits over synthetic substitutes such as HFCs. Hydrocarbon refrigerants are not only fully ozone friendly, their contribution to global warming can also be taken into consideration. The most important advantage of hydrocarbon refrigerants in this context, however, is their compatibility with mineral oils. Today, the hydrocarbon technology is the leading technology among the more energy efficient refrigerator models on the European market. Three major

[1] 1997 data, figure does not include consumption as foam agent but only refrigerant.

Japanese manufactures (Matsushita, Toshiba and Hitachi) have also recently launched this technology for the production of refrigerators. The technology is now well established in the Western European domestic refrigerator market as well as in China, Indonesia, Australia, Lithuania and Cuba. The dissemination of the hydrocarbon technology has been catalyzed by the inclusion of HFC into the basket of greenhouse gases in the Kyoto Protocol that aims to globally reduce greenhouse gas emissions.

Design of the ECOFRIG project: environment friendly foam and refrigerant

Within this policy framework, an Indo-Swiss-German collaboration in ecological domestic and commercial refrigeration, the ECOFRIG project, started in 1992 with a technology focus on hydrocarbon refrigerants and foam blowing agents. The *rationale* of the ECOFRIG project has been to contribute to the establishment of a level playing field between synthetic fluids (e.g. HFCs and HCFCs) and the fully environment-friendly natural fluids such as hydrocarbons in the Indian domestic and commercial refrigeration sector.

In ECOFRIG project phase 1 (1994-1996[2]) the main focus of the project was on hydrocarbon (cyclopentane) foaming. As to date, most large manufacturers of domestic refrigeration appliances in India have applied this technology. Replacement of CFC11 as foam blowing agent by pentane blends has been achieved by all ECOFRIG partners in those factories eligible for funding under the Multilateral Fund of the Montreal Protocol. In 1996, an ECO-Refrigeration conference was held in Delhi with significant international participation. This conference helped to widen the information base on different aspects of the hydrocarbon technology in India.

Project phase 2[3] (1997-2001) mainly focused on introducing hydrocarbon refrigerants as working fluids. The project supported the phase-out of CFCs from production and servicing of domestic and small commercial refrigeration appliances and an assessment of the availability of hydrocarbon refrigerants on the Indian market. Three dual use charging facilities have been installed as integral parts of one assembly line at the premises of the ECOFRIG industry partners Godrej Appliances Ltd, Videocon Appli-

2 Swiss and German contribution 3 million CHF, industry contribution 1.5 million CHF. In addition, 500’000 CHF Swiss contribution for international networking.

3 Swiss contribution in phase 2 (1.3.1997 – 31.12.1999) was 1'550'000 CHF, the German contribution 1'600'000 DEM (equivalent to 1'310'000 CHF) and the industry partners contributed 1'100'000 CHF. Phase 2 extension until 31.12.2002 is funded by a Swiss contribution of 800’000 CHF (see also Table 1).

ances Ltd and Rockwell Industries Ltd. Some 13'000 hydrocarbon refrigerators have been manufactured in these facilities under pilot production arrangements until mid of 2001.

HIDECOR – challenges from the service front

The complete phase-out of CFC up to 2010 in India will face main constraints in the refrigeration servicing sector, as more than 20 million CFC based refrigerators will still be in use in 2003, when the use of CFCs is banned from manufacturing new appliances due to the phase-out schedule set by the Ozone Depleting Substances (Regulation) Rules, 2000 (MoEF 2000). Service enterprises are as yet ill prepared to adopt new and more demanding non-CFC technologies. Supporting micro and small enterprises (MSEs) that constitute the majority of servicing workshops is therefore important for two reasons: a) to support the Government of India in achieving the national CFC phase-out targets, and b) to enhance skills of these enterprises and their 60'000-70'000 technicians. Therefore, a HIDECOR[4] pilot phase project has been conceived during ECOFRIG phase 2 as an undertaking, complementary to the efforts under the Multilateral Fund of the Montreal Protocol. The HIDECOR main phase project, launched in 2001, is focusing on training MSEs not affiliated to manufacturer networks in six Indian states[5]. The project is to establish capacities in training institutions to promote good practices in the maintenance of CFC-free appliances.

Due to barriers emerging from tough competition in the domestic refrigerator market and the "wait and see" attitude on the part of key industries, the objectives of ECOFRIG phase 2 could not fully be achieved until the end of 1999. It was therefore decided to extend the project until the end of 2002 with the task to consolidate previous achievements, to properly hand over imported equipment, to provide research support, and to establish a documentation and dissemination process on experiences made.

Resources made available to ECOFRIG and HIDECOR are summarised in Table 1:

4 HIDECOR: Human and Institutional Development in Ecological Refrigeration.

5 Tamil Nadu, Karnataka, Andra Pradesh, Maharastra, Gujarat and Delhi.

Agreement Period	ECOFRIG Swiss/German contribution CHF	HIDECOR Swiss/German contribution CHF
ECOFRIG Preparatory Phase 1 1992 – 30.6.1994	510'000	
ECOFRIG Phase 1 1.7.1994 – 31.12.1996	3'500'000	
ECOFRIG Phase 2 1.3.1997 – 31.12.1999	2'860'000	Pilot phase 580'000
ECOFRIG Phase 2 extension 1.1.2000 – 31.12.2002	800'000	Extended pilot phase 700'000
HIDECOR Phase 1 1.1.2001 – 31.12.2004		3'993'000
Total	**7'670'000**	**5'273'00**

Table 1: Timeframe and budget overview of ECOFRIG project phases 1 and 2, ECOFRIG phase 2 extension and HIDECOR project.

For the purpose of an experience documentation and to perform an achievement and impact analysis of the ECOFRIG project, interviews with key actors were conducted during 2001. On the basis of the feedback received the following seven cases were selected for characterising factors of success and failure.

The case of the Godrej no-frost hydrocarbon refrigerator

In March 2000 the Executive Committee of the Multilateral Fund has approved the 2 million USD refrigerant conversion project of Godrej based on isobutane refrigerant. Godrej taking a refrigerant decision in favour of hydrocarbons is the result of technology transfer activities which go back to 1995 with a visit at the Liebherr factory in Germany. This successful example of technology transfer was taken up in the IPCC Special Report on Technology Transfer (IPCC 2001) and an investigation into technology transfer by IEA, UNEP and CTI (IEA 2001). A concept study on how to convert not only direct cooled models but also no-frost refrigerators to hydrocarbon refrigerant was first conducted in 1996. By 1998, the technology partner agreement under ECOFRIG phase 2 for the installation of a dual use pilot charging and leak detection line was agreed upon. In the same year a high level industry delegation visited Kelon, one of the largest refrigerator manufacturers in China, using the isobutane technology. By summer 1999, the Godrej foam conversion project sponsored by the Multilateral Fund/World Bank was completed, and the foam blowing agent CFC11 was replaced by a pentane/isobutane blend. By mid 2001, Godrej had completed the pilot production of some 13'000 hydrocarbon refrigerators using the charging facility installed under ECOFRIG phase 2. A new *Pentacool* line of refrigerators was launched. This line is designed for compliance with hydrocarbon refrigerant. It also comprises a 220l no-frost model based on hydrocarbon blend as refrigerant. For cost considerations and inadequate time availability to develop and test an HC600a line prior to 1.1.2003, Godrej decided to use hydrocarbon blend as a CFC12 substitute for a period of 3-5 years and with the intention of converting to isobutene at a later stage. This decision facilitates refrigerant supply and service training, because hydrocarbon blend is also used in the commercial refrigeration sub-sector.

Delays in the implementation of the Multilateral Fund/World Bank refrigerant conversion project[6] makes the charging facility established under ECOFRIG an essential prerequisite to timely launch non-CFC based Godrej models for being in compliance with the National Ozone Regulation.

The case of hydrocarbon refrigerant

The objective of establishing a commercial supply chain for hydrocarbon refrigerant is delayed by multiple barriers prevailing in a "chicken and egg" situation: As long as there is no demand from the industry for hydrocarbon refrigerant, no private investor will take the burden to build up a supply chain. The unavailability of the refrigerant, compressors and other components makes manufacturers hesitate to invest in this technology.

To start prototype testing during phase 1, limited quantities of hydrocarbon refrigerants were imported following procedures for "research". The standard procedures for import and handling of these substances had to be addressed in a second step. This was necessary as the Indian explosive rules are not compatible with any international or national standards outside India, and therefore it is not possible to use any standard refrigerant cylinder of international suppliers.

In collaboration with SHV, India design approval for a 5.5kg and a 12kg cylinder was obtained by the end of 1998 from the Chief Controller of Explosives. Some 800 kg of hydrocarbon refrigerant (of which 400kg were directly earmarked for ECOFRIG part-

6 Delays are caused by controversies on adjustment of the amount sanctioned to increase equity level. The 40% share that formerly belonged to Godrej's American joint venture partner GE has been taken over by the Godrej family.

ners) was imported in mid 1999. The oil price hike of 2000 caused heavy losses to the LPG business of SHV. The company decided to also withdraw from the hydrocarbon refrigerant business. When the spare stock still available with SHV India in November 2000 was purchased by manufacturers, the availability of hydrocarbon refrigerant for small enterprises dropped again back to zero. In February 2001 ECOFRIG again launched a project based import of 400kg hydrocarbon blend which reached the country in fall 2001. In the remaining months of 2002 steps will be initiated in cooperation with the HIDECOR project and interested market players to assure supply on a commercial basis.

The case of the calorimeter

This case study evaluates the experience gained in transferring hydrocarbon calorimeter technology from a German supplier to Kirloskar-Copeland, an Indian manufacturer of commercial compressors, and to Shree Refrigeration, a local firm contracted to build a calorimeter for the Indian Institute of Technology in Delhi (IITD) under licence.

This technology cooperation was started under ECOFRIG phase 2. The full transfer of technology from Germany to India experienced significant delays in project implementation as a result of underestimated technical problems faced in the cooperation with the German technology supplier. The calorimeter which was supplied to Kirloskar-Copeland enabled them to develop four models for hydrocarbon blend and to sell approximately 5'000 units up to the end of 2001.

As of January 2001, Shree Refrigeration had completed the assembly of a similar calorimeter unit for IITD on the basis of parts and equipment imported from the German technology supplier. Initial tests were conducted, but failed. Though significant efforts from the German party had gone into the development of this product, two problems had to be addressed to make the technology transfer sustainable:
A) The commissioning of the calorimeter supplied to Kirloskar-Copeland marked the starting point of the warranty granted by the German supplier BACHER for the parts which were intended to be used for the IITD calorimeter (e.g. essentials such as the software and the control part). This warranty expired in March 2001, leaving IITD as end user of the locally manufactured unit without warranty on some core elements of the equipment.
B) The software supplied from Germany could not be maintained locally in India. Therefore maintenance would be costly for an institution such as IITD, in particular as

no warranty cover was available as from April 2001 onwards. Therefore an alternative project was developed for the IITD calorimeter by the Indian company Shree Refrigeration. A major redesign allowed them to gain full control over all system components and parameters, in particular the software which is now of Indian make. Before the order was placed, Shree Refrigeration had demonstrated the viability of the new concept in a recently completed installation for an Indian industry customer. Factory acceptance was completed successfully by December 2001. The calorimeter will be commissioned at IITD in February 2002. The calorimeter tool shall put IITD into a position to implement research contracts from the industry side. An essential technology for testing hydrocarbon compressors was accordingly established in the public domain.

Research support

HFC134a was the most popular choice when the ECOFRIG project started. Hydrocarbon technology was looked at with great scepticism by most of the Indian actors. An R&D network including the research institutions participating was developed in steps to address technology data and designs matching Indian conditions. In this task research institutions played a highly crucial role.

The National Chemical Laboratory (NCL) in Pune

Today, NCL is an internationally respected competence centre in the field of hydrocarbon based performance and life testing. Besides the project support to NCL, also the industry has invested considerable amounts of funds into the development of hydrocarbon technology. Research responses under the ECOFRIG project emerged fast from an industry perspective. Key actors from the industry and from research institutions view the output of the adaptive research undertaken between 1994 and 2001 as a landmark achievement. The co-operation with industry changed the attitude on both sides. It made sure that the research was demand driven. The dissemination of results reached beyond the boarders of the country. In the specific field of hydrocarbon research, NCL is looked at as a global resource institution. As an individual institute without involvement in the ECOFRIG project this could not have been achieved. As a part of these efforts, 11 Master Theses by Post Graduates of the Pune and Shivaji Universities were under this research programme at NCL. Most of these students have either been absorbed by the industry or got scholarships for higher studies in the US.

The Indian Institute of Technology (IITD) in Delhi

The observation made for NCL applies also for IITD's research on performance of appliances. It was demand driven and was built upon industry co-operation. The institute created significant capacity to support small and medium sized industries from the commercial appliance sector. The results from comparative performance evaluation of appliances retrofitted with hydrocarbon and other blends may see a future demand from the national service sector strategy as well as from other developing countries which are in the process of evaluating HC based retrofit strategies. IITD sees a clear demand from the industry side for performance testing of hydrocarbon compressors. This demand can be met after the installation of a calorimeter which will be accessible from the public domain. One PhD study, around 20 master studies and eight B.Tech. studies and a number of internationally published research papers resulted from this research collaboration.

International networking

In order to reach the project's goal to establish a level playing field between synthetic and natural fluids, international networking has been a major tool. Within international networking activities a two pronged approach was followed, with (i) the organisation of workshops, seminars and international conferences or the participation in and contribution to such events, and (ii) the contribution to HC technology development and experience transfer to other countries. These networking activities allowed the enhancement of international exposure of Indian experts and contributed to disseminate at the international level adaptive research experiences which were gained under the ECOFRIG project. In the absence of such contacts the decision of Indian industries to opt in favour of hydrocarbon refrigerant would probably have been taken in favour of HFC134a following the example of multinationals operating in India.

As a reward for its fruitful efforts, the implementing agency for this project, INFRAS as well as Prof. R.S. Agarwal and Dr. Sukumar Devotta from the associated research institutions IIT Delhi and NCL Pune, have been selected to receive respectively the 1998 and 1997 U.S. Environmental Protection Agency's Stratospheric Ozone Protection Award.

Institutional structure and project management

The trilateral government project set up for the implementation of a parallel support scheme complementary to the Montreal Protocol was essential to the project's achievement in providing the institutional frame for a public private partnership. It was also crucial to gain the support on the side of GTZ for decisions which had been taken by the Joint Project Review Committee (JPRC) as the project's steering body. The interaction in the JPRC between the three governments and the industries finally helped to strengthen flexibility and empowerment of the JPRC which was seen as a rather unique set up within SDC and GTZ administrative frameworks. INFRAS entrusted as the member secretary of the JPRC has effectively acted as a bridge builder between the two cultures: industry and government

The JPRC thus emerged as a valuable platform for the implementation of a public–private partnership. Besides project matters, also issues relating to the implementation of the Montreal Protocol could here be taken up in an informal manner between the Government of India and the participating industry.

Success factors for building institutional capacity in India to meet challenges of the implementation of a multilateral environment agreement

The strategy of ECOFRIG phase 2 was embedded in a policy environment characterised by the Multilateral Frameworks of the Montreal and Kyoto Protocol, the market shares of non-CFC technologies in the international market and the dynamics in the Indian refrigerator market. Reviewing the ECOFRIG project activities and instruments applied within this policy environment, the following success factors were identified which shaped the collaboration culture, supported project implementation and paved ground for the achievements of this project:

- The trilateral government arrangement between India, Switzerland and Germany,
- A powerful institutional steering set-up,
- No hidden agenda of the participating governments,
- Interlinking different levels of action vertically,
- Motivated key stakeholders from the industry,
- Flexibility in implementation,

- Adequate funds for technology transfer,
- International network involving industries from industrialised countries,
- Personal commitment, skills and vision of research partners,
- The honest broker role played by INFRAS.

The challenges of project implementation have mainly been seen in:

- Supporting the Indian industry in the decision making processes for the **choice of technology** through enabling on-site visits in European and other companies, providing technical on-site consultancy through European specialists and industry representatives, organising local and international workshops, trainings etc.
- Enabling the **process of technology transfer** focussing on processes related to know-how, hardware equipment and the refrigerant by finding suitable technology partners, identifying suitable, cost-effective equipment for pilot production, adapting technologies to the Indian situation and establishing a reliable supply of refrigerant.
- The efforts undertaken in **capacity building, training, and education** in manufacturing, design of appliances, servicing, etc.
- The wide range of **information dissemination, marketing, promotion and international networking activities** for creating a sound knowledge basis for the hydrocarbon technology in India.

Conclusions

The ECOFRIG project helped to establish and mainstream technologies and technical knowledge with a promising potential for contributing to sustainable development in the Indian market. The capacity building on various levels including research institutions, training manuals for safe conversion of appliances, retrofitting and servicing as well as the continued availability of the services of INFRAS as a "clearing house" for technology information were instrumental to this.

An independent, external investigation (Gerster 2001) based on interviews with selected ECOFRIG project partners in India, Germany and Switzerland acknowledges the above-mentioned key success factors and recommends that the wealth of experience created by ECOFRIG should be used in a wider context, namely 1) in other countries besides India, and 2) by looking at the implementation of technology transfer under Multilateral Environment Agreements (MEAs) in a development perspective and vice versa.

The phase out of CFCs under the Montreal Protocol has – besides curbing the chlorine concentration in the upper atmosphere – also significantly contributed to the slowing-down of the growth rates of the aggregate global greenhouse gas forcing since the early 1990ies. Taking into consideration the still considerable global warming potential of HFCs as substitutes for CFC, the environmental additionality of the hydrocarbons as natural refrigerant technology has to be seen in the wider context of the global environment. The ECOFRIG experience therefore suggests the adoption of a more integrated view across the different MEAs. The related lessons which can be learned from the ECOFRIG project for technology transfer under MEAs are:

- The need for public-private partnerships at different levels for the diffusion of environmentally sound technologies.
- To include supportive efforts for building local capacities and skills in public and private institutions for choosing technologies, adapting them to local situations and integrating them into a national system.
- The need to diffuse new skills and technologies also to the small scale enterprise sector, e.g. involved in maintenance and service of appliances and equipments.
- The importance development assistance (ODA) through bilateral contributions can play in supporting the implementation of a MEA, in achieving remarkable international outreach, and in delivering also the needed political commitment to make such complex technology transfer processes a success.