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Greenfreeze: Environmental Success by Accident and Strategic Action

Jobst Conrad

1. Introduction

This article summarizes the history of the atmosphere safe refrigerator on the basis of the material listed below (including the description of the case by one of the main actors, Greenpeace).¹ It analyses the reasons and specific conditions making this history an environmental success story. Since the history is a rather straightforward one and has been reported in great depth, a secondary analysis of this type nevertheless deserves attention for the empirical reconstruction it offers.

After outlining the historical context in which the chlorofluorocarbon-free refrigerator is to be situated, we will follow the greenfreeze story through its various actor-specific phases, then indicating outcomes and prospects, and the actors and interests involved. On this basis, the success story, namely the development of the eco-fridge and its penetration of the market, can be explained in terms of skilful strategic action by the environmental organization Greenpeace on the one hand and an atypical combination of chance events and circumstances on the other. This will permit a number of conclusions to be drawn on the possibilities of improving environmental protection in industrial production and products.

2. The Historical Context: Refrigerators and Chlorofluorocarbons (CFCs)

In households, food was hardly stored at all in technical cooling devices until the 1930s. At that time, refrigerant processes in industry and commerce used various substances, such as ammonia, carbon dioxide, isobutane and others. After the discovery of CFCs in 1929/30, they penetrated the market in the 1930s, and especially after about 1950 were used as coolants and as propellants in aerosols, in plastic foams, and in solvent cleaners because of their ideal properties of stability and low reactivity, nonflammability, nontoxicity, odourlessness, colourlessness, low heat conductivity, etc. From 1955 to 1974 the production of CFC 11

1 The author is grateful for the information material provided by Chris Rose, Greenpeace U.K.

and CFC 12 increased tenfold from 83.900 t to 851.200 t (Jacobi 1989: 45).² Refrigerators became standard cooling devices in European households during the 1960s, as did home freezers during the 1970s and 1980s.

In 1973, the destructive potential of CFCs for the atmospheric ozone layer was detected by American chemists, a discovery that was followed up by further investigations in this respect. Precisely because of their technically beneficial chemical inertness, CFCs threaten the environment because they accumulate in the upper atmosphere, thus contributing to depletion of the ozone layer and to the greenhouse effect. With the justification that definitive scientific evidence was lacking, it took some 15 years until international political agreement could be reached in various ozone protocols in Vienna (1985), Montreal (1987), London (1990) and Copenhagen (1992) (cf. Oberthür 1993) not only on limiting CFC production, but also on gradually phasing it out by the year 2000. In 1992, the CFC halon ban ordinance became effective in Germany, requiring CFCs to be phased out by 1995.

Overall, industry's (strategic) reaction to the environmental problematique of CFCs can be divided into different phases characterised by a wait-and-see attitude, by resistance, and by adaptation. This resulted in an early voluntary reduction of aerosol propellants in the late 1970s and early 1980s when substitutes were relatively easily available; in opposition to mandatory public regulations; in efforts to buy time and to push through specified exemptions for further CFC production, in phasing out CFC production, and in developing partly related substitutes and technologies, such as hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HFCs) and their recycling in order to maintain profitability in fields where CFC had formerly been used. Certainly, the way in which different companies reacted within this range varied considerably according to the field of CFC application, to the industrial sector (e.g. the chemical industry, the household appliance industry), to their national and economic circumstances, and to their business strategy.

3. The Greenfreeze Story

3.1. *HFC 134a as a Chlorine-Free Coolant Substitute Developed by the Chemical Industry*

In the field of coolants, the chemical industry concentrated in the late 1980s on testing HFC 134a as a CFC substitute with no ozone depletion potential and a

2 Excluding Eastern countries, China, India, and Argentina.

lower greenhouse warming potential than CFCs, although some HCFCs (CFC 22, CFC 141b) have also been developed and are in use as substitutes.

In Germany, the large chemical company Hoechst was involved in this internationally coordinated process. In 1991 DuPont (USA) and ICI (United Kingdom) started HFC 134a production at a date earlier than that agreed between the 14 largest CFC producers, leading to considerable controversy among them. Hoechst, as the first multinational chemical company to abandon CFC production by 1995, decided in 1991 to manufacture the coolant R134a in Frankfurt and, following a communication-oriented approval procedure including discussion with environmental groups, received permission to build a new production plant in 1992. The purpose was to supply producers of all kinds of refrigerating plant with R134a, which is provided including recycling in a corresponding recycling network with the aim of minimizing its contribution to the greenhouse effect (in collaboration with users and public authorities) and of distinguishing Hoechst from competing chemical companies. In addition, Hoechst announced in 1993 that it would not charge royalties on R134a substitution of CFCs by developing countries. Because of considerable investment in developing, producing and recycling R134a, Hoechst now has a vested interest in selling this coolant on a large scale, even if some fields of application prove unprofitable, such as the future market for domestic refrigerators.

German refrigerator producers essentially agreed to use R134a as a new refrigerant in about 1990/91. As an (informal) limited group of major manufacturers within the ZVEI, the German Central Association of the Electrical Engineering Industry, essentially Bosch, Siemens, Liebherr, AEG, Electrolux, Bauknecht, and Miele³ have considerable economic clout in imposing agreed general technical systems on the market and in undermining technically feasible alternative options by various methods, including their consultative influence on standardization and certification quangos such as the DIN (German Institute for Standardization) or TÜV (Technical Control Association).

In principle and if recycling is ensured, HFC 134a as a coolant can be considered a reasonable technofix though expensive environmental solution. However, meeting the various requirements in the way of sophisticated technology and handling is unlikely to be practicable under present socio-economic conditions, especially in developing countries.

3.2. The Refrigerator Manufacturer DKK Scharfenstein and German Reunification

In the former GDR, the company Deutsche Kühl- und Kraftmaschinen (DKK Scharfenstein) was the leading household appliance manufacturer, having pro-

3 Miele does not manufacture, but only sell refrigerators.

duced refrigerators for 50 years at an annual rate of up to a million. Due to the scarcity of CFCs and the high cost of importing them, CFC-free cooling and insulation devices had enjoyed a long tradition in East Germany. Thus DKK Scharfenstein used extruded polystyrene for refrigerator insulation.

With German reunification, the company ran into severe economic problems with a huge, almost 80% drop in sales between 1990 and 1992, and a deficit of DM 85 million in 1991 as compared to DM 71 million in turnover. It hoped to be taken over by the Bosch-Siemens-Hausgeräte GmbH, the largest West German refrigerator manufacturer, and also looked into converting to R134a. However, negotiations to this effect between the Treuhand, the state holding agency in charge of selling off former East German enterprises, and Bosch-Siemens failed, because the latter was not interested in the Treuhand proposal to take over the whole of DKK Scharfenstein including an unprofitable washing-machine factory. Instead Bosch-Siemens opened a new factory in Swabia. No other investor having been found, the Treuhand announced in July 1992 that the company was to be wound up.

3.3. CFC-Free Coolant Developed by University Medical Scientists

In 1988, the provisional head of the university institute of medical microbiology at Düsseldorf, Professor Rosin and his staff, lacking research funds for urgently needed cooling apparatus, decided to build the needed equipment themselves. Because of the environmental hazards associated with CFC 12 and HFC 134a, they experimented with mixtures of propane, butane and isobutane and, without being experts in cooling technology, developed the so-called Dortmund mixture as a simple and effective coolant. After their move to the Dortmund Institute of Hygiene, they installed it in a refrigerator in 1990, which had by the way to be declared a laboratory device to prevent withholding permission due to lacking TÜV seal or VDE safety approval. The scientists promptly received an environmental prize for their discovery in 1991, and a large cold-storage plant using the Dortmund mixture went in operation already in late 1991.

However, when in 1991 Professor Rosin, now head of the Dortmund Institute of Hygiene, presented the cooling technology to West German refrigerator manufacturers and the German environmental protection agency, it elicited no interest from industry professionals and strong scepticism with regard to energy consumption rates and coolant flammability, although refrigeration experts were well aware that for decades hydrocarbons like pentane and butane had been used successfully as coolants in large industrial refrigeration facilities. Indeed, and hardly surprising for a new process technology, the first tests with the Dortmund mixture in late 1991 indicated higher electricity consumption in unadapted conventional refrigerators, whereas the flammability argument has to be considered a marginal

one given the low amount of about 20 g of propane-butane mixture needed, roughly equivalent to the content of two cigarette lighters. Energy parity should be within easy reach, as further tests by the Dortmund scientists indicated in early 1992. At the same time, a workshop of experts organized by the industry trade newspaper "Kälte und Klima" to help HFC 134a to a breakthrough also showed enormous technical difficulties in introducing it as a substitute, what makes its use in less developed countries particularly problematic (Greenpeace 1993: 2).

3.4. *Purposive Intervention by Greenpeace*

True to its tradition, the environmental lobby organization Greenpeace followed a strategic combination of information campaign, publicity generation action, and, increasingly, lobbying intervention in 'involuntary partnership'. Chris Rose of Greenpeace described his organization's motives as follows:

Concerned that governments and businesses would achieve the final phase out of CFCs by taking the easy option of using the 'drop in' HFCs and HCFCs – resulting in large scale atmospheric pollution –, . . . we set out to prove that in one sector which was particularly crucial to the use of HCFCs and HFCs – refrigeration – that there were important alternatives which were not being put into practice (Rose 1993:5 f.).

The organization was opposed environmentally half-hearted, technofix solutions to the ozone problem favoured by industry and government and was accused by the chemical industry of delaying a CFC phase-out through its opposition to HCFCs and HFCs. At that stage Greenpeace learned of the Dortmund mixture from press reports, and was also contacted by technicians from the Dortmund Institute of Hygiene in 1991. The two parties agreed on a joint test project in March 1992.

Looking for a company to carry out further tests on the Dortmund mixture, Greenpeace initially contacted DKK Scharfenstein in February 1992, knowing that it used CFC-free insulation for its rather long-lived refrigerators. In the course of intensive negotiations, Greenpeace (according to the organization itself) "succeeded in persuading DKK Scharfenstein to enter into a collaborative project" in May/June 1992, indicating the large market potential of an atmosphere safe refrigerator and its corresponding economic significance for the company in view of its precarious situation (Greenpeace 1993: 3).

3.5. *Development and Strategic Marketing of the Eco-Fridge; Treuhand Support; West German Refrigerator Manufacturers' Counter-Strategy*

Having an efficient development division at its disposal and in collaboration with the Dortmund scientists, DKK Scharfenstein was in the following months able to tackle the various problems to be solved in producing a competitive greenfreeze,

such as better energy efficiency, user safety, coolant stability, improved and space-saving insulation. Providing DM 26,000, Greenpeace commissioned the company in July 1992 to develop a series of CFC and HFC-free refrigerator-prototypes using a propane/butane coolant and pentane-foamed polystyrene as insulation.

Also in July, Greenpeace and DKK Scharfenstein presented the greenfreeze project at a joint press conference despite the initial ban by the Treuhand. In August 1992, Greenpeace started "an extensive publicity campaign" (spending about DM 100,000) calling for advance orders for Greenfreeze, and the support of Environment Minister Töpfer was solicited (Greenpeace 1993: 3). Also in August, considerable progress was made in improving the energy efficiency of the eco-fridge; the Ministry of the Environment recommended the project and called on the Treuhand to support it; a mobile version of the eco-fridge was presented at embassies of developing countries in Bonn and afterwards "on tour" all over Germany. A sample poll commissioned from the Emnid Institute showed 77% of Germans favoured an eco-fridge. Neckermann, a large mail-order company, placed advance orders for 20.000 eco-fridges. Furthermore, in 1992 Greenpeace presented greenfreeze prototypes all over Europe, attracted remarkable public interest and international press coverage. At a meeting of the signatory states to the Montreal Protocol in Copenhagen, UNEP chairman Tolba mentioned the refrigerator as a good example of innovative development which could be especially useful to Third World countries (Greenpeace 1993: 5). DKK Scharfenstein presented the positive results of its development work to the ZVEI in November, and the TÜV, the German technical control quango, awarded the 'safety approval' seal for the greenfreeze KT 1370 RC model in December. By the end of 1992, before the first eco-fridge became available on the market, more than 70,000 advance orders had been received by Greenpeace, an unprecedented event in this branch of industry.

Of special importance for the successful development and sale of the eco-fridge were Greenpeace's talks and negotiations with the Treuhand. Thus, at the joint press conference in July 1992, three days after the Treuhand's announcement that DKK Scharfenstein was to be liquidated, the agency agreed after long controversy not to stop the project. According to Greenpeace, one month later, and four days after Environment Minister Töpfer called on the Treuhand to support the project, representatives of the organization met the liquidator appointed by the Treuhand and agreed on close collaboration to make Greenfreeze a success. A further six days later, the Treuhand announced that it wanted to maintain production at DKK. This meant a guarantee of 540 jobs until the end of 1993 and included an investment of DM 5 million for the development of the eco-fridge. Greenpeace was offered the opportunity to buy the company, but refused due to its principle of maintaining independence from any business interest. In Novem-

ber 1992, after successful sales negotiations, the Treuhand was able to announce that DKK was to be bought by The London East German Investment Trust, a Berliner Bank consortium, and the management. The company was renamed Foron (Greenpeace 1993: 3 f.).

During this period, the second half of 1992, West German refrigerator manufacturers, and to some degree Hoechst, were pursuing a strategy to undermine the viability of greenfreeze and to back the CFC substitutes favoured by them, namely HFC 134a as a coolant and HCFCs in insulating foam. Thus on behalf of ZVEI, they gave a "voluntary commitment" to the German minister of the environment in July 1992 to phase out CFCs in refrigerators, excluding the DKK Scharfenstein ZVEI representative from this declaration. Hoechst attacked the Dortmund mixture as allegedly too energy intensive. In a joint communiqué to the refrigeration trade, the seven West German refrigerator manufacturers used the same argument. The use of propane/butane was said to be technically unfeasible. According to Greenpeace, the organization was able to prevent the further dissemination of the communiqué of the big seven by consensus (Greenpeace 1993: 4).

Parallel to its publicity campaign and cooperation with DKK Scharfenstein, Greenpeace (as it reports) continued efforts to discuss and demonstrate the advantages of an atmosphere safe refrigerator and the disadvantages of HFC 134a with industry, especially other refrigerator manufacturers, as well as public authorities. Thus, in October 1992 "a Greenpeace advertising campaign called on West German manufacturers to switch to propane/butane" (Greenpeace 1993: 4). Greenpeace representatives visited the Bosch-Siemens household appliance company and the Liebherr company for an exchange of views and constructive talks on technical issues. Similarly, crucial representatives of relevant international organizations were addressed, such as UNEP specialist committees or the Ozone Operating Resource Group (OORG) of the World Bank, who advise their organizations and developing countries on CFC phase-out issues and recommend substitutes considered suitable.⁴

3.6. Successful Introduction and Market Penetration of Greenfreeze; Refrigerator Producers Change Sides

In February 1993, Foron presented its first refrigerators without CFCs or HFCs at the Domotechnica in Cologne, the world's biggest domestic appliance fair. The deputy minister for the environment formally awarded the 'Blue Angel' eco-label to Foron for its refrigerator. Greenpeace reports:

4 The chairman of OORG, an employee of Philips research laboratories, thus told Greenpeace in November 1992, that propane/butane coolants are not considered an acceptable alternative for developing countries, in particular because of their flammability in services.

Less than five months after their joint prophecies of doom, Bosch-Siemens, Liebherr and Miele present refrigerators which work with isobutane as the coolant and pentane as the foam-blowing agent. Liebherr and Bosch-Siemens announce that they were converting the insulation of all their appliances to pentane-blown foam. AEG and Electrolux, and also the mail-order company Quelle defend the climate killer 134a with colourful ecological advertising (Greenpeace 1993: 5).

Greenpeace replied to AEG's motto that "Only one can be first" with a banner saying "AEG – one has to be last". In March 1993 the first CFC and HFC-free refrigerator was produced at Foron. The company announced the first three star icebox for the autumn. Greenpeace declared the successful conclusion of collaboration with Foron. Meanwhile the Eiskalt company presented a commercial beer cooler using natural gas.

Interestingly, when it became clear that the market introduction of greenfreeze by Foron could not be stopped, refrigerator producers were able within a few months to offer eco-fridges themselves for prices similar to those for R134a-cooled ones, having previously asserted that it would take years⁵. Now they tried to outdo Foron by developing and marketing improved versions of the eco-fridge as well as hydrocarbon-based refrigerator freezers and home freezers even before Foron. Thus, Bosch-Siemens now offered the world's most energy-efficient hydrocarbon refrigerator, using only 0.1 kWh/24h per 100 litres. Bayer AG and its subsidiary Hennecke GmbH developed a cyclopentane foam-blowing technology for insulation, a tremendous change in the polyurethane industry, already adopted by most refrigerator manufacturers, and AEG is experimenting with vacuum insulation as well.

In order to offer standard-size refrigerators without losing utilizable space or consuming additional energy, efficient thin-wall insulation had to be developed to replace the conventional CFC-containing PUR technology. This explains why hydrocarbon-based freezers were developed and marketed later than refrigerators. For larger cold-storage plants such as secondary cooling systems in supermarkets, ammonia is an appropriate CFC-free coolant well-known to industry, if its toxicity is kept well under control, whereas the Dortmund mixture needed in larger quantities is less suitable because of its flammability. Ammonia cooling techniques are currently also being further developed by industry and lobbied for by Greenpeace. Thus, if ammonia and propane/butane coolants would successfully cover the whole range between large and small cooling systems, there would be no further technically justified need for HFC 134a.

Greenpeace continued its efforts to propagate greenfreeze in 1993 by meeting manufacturers and public servants in other industrialized countries, such as the United States, Canada, Australia, Japan, Italy, Denmark, the Netherlands, and the United Kingdom, and in developing countries, China in particular. Green-

⁵ "ICI had said in 1991 that it would take a decade" (Rose 1993: 9).

peace reports that pressure from the organization also induced World Bank experts to discuss the use of hydrocarbons for refrigeration again in May 1993 (Greenpeace 1993: 6). Following Greenpeace's presentation in April 1993, the Chinese government showed interest in joint ventures with German manufacturers to produce the eco-fridge, the technology of which is neither patented or subject to licence, for a home market expected to expand strongly in the coming decades from 30 million to 300 million refrigerators. Having concluded its collaboration with Foron, Greenpeace now propagates eco-fridges from different companies.

Foron, which also received one half of the German Environmental Prize of DM 1 million from the German Environmental Foundation in June 1993, sold – apart from traditional refrigerators and other household appliances like washing machines – around 35,000 eco-fridges within three months after commencement of sales. For 1993 a turnover of DM 100 million was expected, and for 1994 Foron hoped to make a profit again with a turnover of DM 250 million.⁶

By the end of 1993, all refrigerator producers in Germany offered CFC-free refrigerators, partly based on hydrocarbons and partly on R134a.⁷ German refrigerator manufacturers also introduced the eco-fridge in several European countries, such as Italy, Austria, Denmark, the Netherlands, and the United Kingdom. They are equally willing to cooperate with refrigeration companies at all levels from distribution to pure technology transfer. After "the success of hydrocarbon fridges in Europe, companies all over the world are testing and investigating the technology" (Greenpeace 1993: 7), followed by the corresponding announcement and launch of greenfreeze, in, for example, the United States, Australia, New Zealand, Japan, and South Korea.

In view of the market potential and the particular suitability of hydrocarbon-based refrigerators for developing countries, because their technology is easy to handle, requires no high-tech equipment and creates no dependency on imports or expensive licences or substances, the German government took steps to capture the huge export potential of greenfreeze and made – in the context of the Multilateral Fund of the Montreal Protocol – about DM 5 million available for the transfer of hydrocarbon refrigeration technology to developing countries in 1994. In so doing it is backing the pertinent export strategies of German refrigerator producers.

6 As a consequence of its still unfavourable economic situation, the management refused in August 1993 to increase employee salaries in late 1993 to 80% of the West German level in conformity with collective wage agreements.

7 But HFC 134a seems to be only another transitional substance, as now admitted by even the biggest producers of household-refrigeration appliances.

4. Results and Prospects

Why can the greenfreeze story described above be considered an environmental success? In a \$ 12 billion a year world market for refrigerators, mostly using CFCs for cooling and insulation, with prospects of further expansion due to growing demand in Third World countries, the substitution of CFCs by environmentally-friendly substances agreed on internationally in the Montreal Protocol, is of enormous (world-wide) importance. If CFCs were ever to be fully recycled without consequential negative secondary environmental effects, which is highly improbable in practice, they would be as environmentally compatible as the relatively expensive and technically demanding recycled substitute HFC 134a without ozone depletion potential. Since, especially in Third world countries, comprehensive recycling cannot be expected in this case either, hydrocarbons are currently the only ecologically acceptable substitutes, as long as the use of refrigerators for cooling purposes is taken for granted.

An ecologically optimized refrigerator must be free from CFCs, HCFCs, HFCs and similar halogenated hydrocarbons; use less than 0.2 kWh/24h per 100 litres; be long-lived and therefore offer ease of repair; be constructed with a view to recycling and disposal; save materials and energy by recycling resources from old devices; and be manufactured by clean production methods with low-emission surface treatment and optimized production processes (Hofstetter 1992: 358).⁸

The eco-fridge has made considerable progress in this direction. The environmental improvements due to its hydrocarbon-based coolant and insulation are not gained by mere problem-shifting, perhaps with the exception of flammability, and should not be offset by future growth in demand for refrigerators because of their ease of disposal by simple incineration.⁹ Whereas the use of the Dortmund mixture as coolant was no significant innovation because propane and butane are well-known coolants, the development of efficient thin-wall insulation material by cyclopentane foam-blowing technology represents a massive technological change.

Once developed, the eco-fridge appears to be spreading with considerable rapidity. Moreover, related fields of CFC application have been stimulated to enhance the development and installation of environment-friendly substitutes. HFC 134a is increasingly referred to and considered as an only transitional substitute.

Whereas market penetration by the eco-fridge can be plausibly assumed, it is still uncertain whether it will fully replace refrigerators containing R134a or

8 As the concept of the eco-fridge "Fria" by Tischner at the Wuppertal Institute for Climate, Environment and Energy indicates, which was fully designed according to ecological criteria in 1993 and is to be developed as prototype in 1994, quite innovative (alternative) technical options still appear to be feasible to meet such criteria.

9 This need not apply with regard to other fridge components such as enclosure units.

remain one of a number of refrigerator options with a limited share of the market. Certainly, the combination of growing environmental awareness and greenfreeze publicity have contributed markedly to its (global) propagation.¹⁰ The eco-fridge is thus likely to survive, which is less certain in the long run for the pioneering company Foron, with about a 5% share of the German refrigerator market as compared to Bosch-Siemens' 25%. But Foron has started to develop other more environment-friendly appliances, too, because of its involvement in the eco-fridge. After marked resistance in the beginning, German refrigerator manufacturers proved quite capable of learning to alter strategy quickly and to modify their position flexibly to meet changing market conditions.

5. Actors and Interests Involved

In describing the actor constellation in the greenfreeze story with the resulting pattern of interest consideration, one can distinguish four central actors, quite a number of significant ones, with a few on the periphery. The central actors were Greenpeace, Foron (the former DKK Scharfenstein), the Treuhand, and the scientists developing the Dortmund mixture. The main interest of Greenpeace was to develop and market greenfreeze for environmental purposes. Foron wanted to survive as a production unit and had to be convinced that the eco-fridge was its last chance to survive after takeover negotiations with Bosch-Siemens had failed. The Treuhand had the task of selling DKK Scharfenstein while retaining much of its industrial potential and labour force or of winding up the company. Greenpeace finally succeeded in convincing the Treuhand that the eco-fridge would serve this purpose. The environmentally-conscious university scientists were forced to build their own cooling apparatus for an underfunded research project and, in so doing, developed the Dortmund mixture. Without their commitment under these specific restrictive conditions, the environmental success story would not have happened. Only afterwards did they become interested in promoting the broader use of the product by industry as a coolant. For a variety of reasons, these central actors thus cooperated in an effective division of labour with the aim of successfully developing and marketing the eco-fridge.

Significant actors were West German refrigerator producers;¹¹ the chemical industry, in particular Hoechst, both favouring HFC 134a as a CFC substitute and opposing greenfreeze development in 1992; the mail-order company Neckermann

10 In a longer term perspective, future innovative concepts for an eco-fridge, such as "Fria" mentioned above, may well substitute the current greenfreeze as the latter now tends to substitute CFC-cooled refrigerators.

11 They would hardly have regretted DKK Scharfenstein – as a competitor on the refrigerator market – being liquidated by the Treuhand.

and (ecologically-concerned) consumers making advance orders for the eco-fridge still to be developed; the Federal Ministry of the Environment in favour of phasing out CFCs, having issued the CFC halon ban ordinance in 1991, and therefore partly supporting greenfreeze development; the new owners of Foron, who were certainly interested in the success of the eco-fridge; the media, who reported favourably on Foron and Greenpeace's efforts, and an environmentally-aware public, interested in this news. In sum, the strategies of the significant actors exercising some influence on the evolution of the greenfreeze story were partly in line with and partly opposed to those of the central actors. The resulting pattern of interest consideration became more complex, but did not prevent successful development of greenfreeze in spite of the opposing actors being to a certain extent in a stronger position.

The peripheral actors to be mentioned include the TÜV, awarding the 'safety approval' seal to the eco-fridge; other users of CFCs or their substitutes; waste management institutions dealing with junked refrigerators and the disposal and recycling of CFCs; and international organizations with development objectives such as the World Bank or UNEP with their special CFC-related committees. These peripheral actors had no real vested interests in the eco-fridge and have to be considered only in so far as their behaviour also contributed to the conditions deciding the success or failure of greenfreeze.

In sum, the actor constellation and the interest consideration pattern show some, though not unequivocal bias in favour of the introduction of the eco-fridge.

6. Analysis and Conclusions

In examining the reasons for and the dynamics of the successful greenfreeze story, one thus observes a combination of chance events and circumstances, of skilful strategic action by the environmental organization Greenpeace, of socio-cultural and structural framework conditions, of mutually compensatory behaviour by significant actors, and of changes in strategy by important actors. This combination of success story determinants are to be understood as the necessary interplay between different levels of influencing variables, which cannot simply be reduced to a more clear-cut, straightforward explanation.

As *chance events or circumstances* contributing to or even making this environmental success possible in the first place, one can list

- The successful involvement of medical scientists as non-experts in cooling technology, motivated by reduced funds for a research project and ending in the development of the Dortmund mixture,
- The withdrawal of Bosch-Siemens from DKK Scharfenstein takeover negotiations, without which the development of greenfreeze in Germany may well have been prevented,

- Past conditions in the GDR, which induced DKK Scharfenstein to use CFC-free polystyrene insulation in its refrigerators and focus on their longevity, which in turn attracted Greenpeace in search of a company willing to develop greenfreeze,
- The coincident decision of Greenpeace to concentrate on refrigeration in its CFC-related campaigns and interventions; without this decision, or if it had been taken much later or earlier, Greenpeace would hardly have had the chance to bring together the scientists and DKK Scharfenstein and to invest considerable resources in this commitment.

Greenpeace played a central and coordinating role in the greenfreeze story and was able to act strategically, making full use of favourable opportunities as they occurred (see sections 3.5 and 3.6). Without its purposive intervention, strategic marketing, coordinating efforts, and effective lobbying, the environmental success would not have come about.

According to Chris Rose, Greenpeace saw its role in this 'partnership' in:

- Acting as a point of access for technologists who were shunned by the refrigeration industry,
- Finding and briefing the former East German refrigeration company, which was about to be liquidated, and putting them together with the technologists,
- Confronting and fending off the majors in the market (including referral to the German cartel authorities),
- Pressurising the German government to give financial support to the former East German company, and
- Publicising and promoting the product which was developed, including advertising it to GP supporters and collecting 70,000 'advance orders' as 'proof' that a market existed.

Greenpeace has no financial interest in these fridges and has of course spent money in the campaign, including on developing prototypes: we are not in this as fridge manufacturers (Rose 1993: 8).

The following *socio-cultural and structural framework conditions* can be considered crucial for the evolution of the greenfreeze story:

- At the socio-cultural level, environmental awareness is rather pronounced in Germany and may have impacts on people's behaviour significant for industry. It therefore led to public concern due to the media coverage of the eco-fridge, which also without substantial public pressure influences purchasing decisions, and was perceived as relevant by the actors involved.
- In particular, global environmental problems have gained general social recognition in Germany since the late 1980s with a predominant attitude in favour of phasing out CFCs and similar 'climate killers'.
- Within the chemical and appliance industries, a clear orientation towards substitution of CFCs by related substances, in particular by R134a, became

prevalent about 1990/91, implying strong resistance to alternative (technological) options outside this relatively well-defined range.

- Finally, in view of the severe economic problems and backwardness of the former East Germany, there exists a favourable attitude towards East German companies such as Foron that show promise of becoming profitable and saving jobs.
- At the structural level, it has to be acknowledged that in Western societies the media are usually able to make a (controversial) topic into a public issue, so that industry or government can hardly avoid confidential arrangements such as industry's bias in favour of R134a being aired in controversial public debate.
- The socio-cultural orientation towards phasing out CFCs has its legal basis in the Montreal Protocol and the CFC halon ban ordinance, setting limits to industry's margin of action.
- The development of the eco-fridge did not pose fundamental technical problems but only practical ones, which could be solved in a relatively short time span, so that the product could be introduced on the market in less than a year.
- The alternative hydrocarbon-based cooling and insulation of the eco-fridge does not entail additional production costs so that it is competitive.
- The Treuhand disposed of sufficient public financial resources to be able to afford DM 5 million for the development of the eco-fridge.

Mutually compensatory behaviour by significant actors resulted on the one hand from the counter-strategies of West German refrigerator producers, and partly of Hoechst, and on the other from the 70,000 advance orders, particularly by Neckermann, from Treuhand support, from the interest of the new owners of Foron in a profitable refrigerator business, and especially from Greenpeace's eco-strategic behavioural orientation.

Important actors altered their strategies during the evolution of the environmental success story in 1992 or 1993, at least partly due to additional information and changing circumstances. The Treuhand was thus persuaded to support the development of the eco-fridge by DKK Scharfenstein. Only after initial scepticism and reserve the minister of the environment became favourable towards greenfreeze. West German refrigerator manufacturers wanted to be in on the business with greenfreeze in their own right when they recognized that they were unable to prevent it. Once collaboration with Foron had been concluded, Greenpeace recommended buying eco-fridges from the West German producers it had previously criticized and publicly attacked for their counter-strategy.

What conclusions about the prospects for improving environmental protection in industrial production and products may be drawn from the greenfreeze story?

1. Environmental achievements are likely to depend on the gradual but rapid development and marketing of the technologies on which they are based.
2. Environmental success stories frequently depend on the cooperative division of labour among a small number of central actors.
3. But the same central actors may no longer be necessary for the diffusion process. Thus, the future success of greenfreeze does not depend on Foron's continued successful presence in the refrigerator market, which now depends primarily on the quality of its marketing efforts.
4. Without external pressure, industrial companies associated in a corporate milieu have insufficient incentive to effect real (innovative) changes to a still profitable system.
5. The implicit formative and veto powers exercised by such corporate industrial milieux may be overcome by public debate, and even more so by public pressure in conjunction with strategic action and constructively organized alternative options propagated by (environmental) lobby groups.
6. If its profits are perceived to be at risk, industry is able to react quickly and to assume substantive positions from its adversaries.
7. In addition, many influencing factors have to lead to mutually reinforcing (dynamic) interplay for a social process to become an environmental success story.

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