Analysis of the Efficiency of European Domestic Refrigerators 1 Year After the Energy Label

Paul Waide, Benoît Lebot, and Sietze van der Sluiss, PW Consulting

The domestic refrigerator market in Europe is undergoing rapid change brought about by: the phase out of CFCs, pending legislation for minimum energy efficiency standards, and the introduction of a compulsory point of sale energy label. All of these changes have occurred in a different manner in Europe than elsewhere. In particular, the design of the European energy label utilises a psychologically orientated grading approach (A to G) that has not been tried on other markets. Furthermore, the near universal adoption of hydrocarbon refrigerants and foaming agents by German manufacturers may have significant implications for the energy efficiency of their appliances.

This paper presents the findings of the first comprehensive study on the change in energy efficiency of European domestic refrigeration appliances since the advent of the CFC phase out and energy labelling. The paper, reports early results from a study which is being performed for the Commission of the European Communities by a group of experts from different European agencies, and utilises an extensive sales-weighted data base of refrigerator energy data to track energy efficiency in different national markets.

It is shown that the European refrigerator and freezer market is evolving towards more efficient products and that the introduction of the energy label seems to be influencing appliance manufacturers to put higher efficiency appliances on the market. The phasing out of CFCs in refrigeration appliances does not appear to have caused less energy efficient products to enter the market, in fact, there is evidence of an opposite effect.

INTRODUCTION

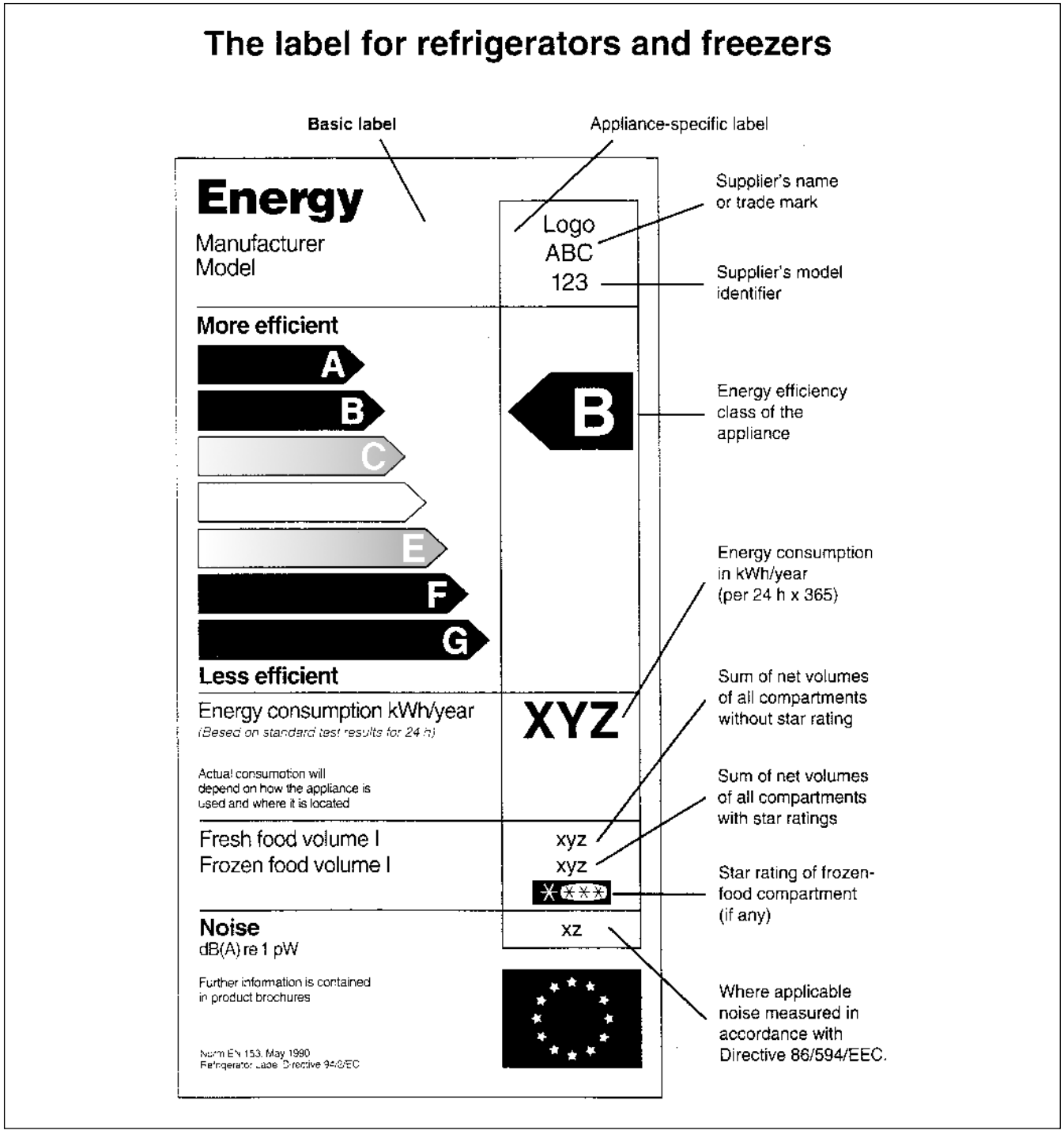
In 1994 the European Union passed implementing legislation for a domestic refrigerator energy labelling scheme[1]. This legislation obliged member states to enact the scheme at the national level by the beginning of 1995. However, manufacturers mostly began supplying the energy label with their refrigerator units in 1994 as they often did not know the point of sale of their products and some EU states were enacting the labelling legislation in advance of others. Although some EU states had conducted implementing legislation in 1994 a minority of states have still not officially implemented the refrigerator energy labelling scheme although in practice the label is often visible as retailers frequently choose to present it voluntarily.[2]

Like similar labelling schemes in the USA, Canada, Australia and elsewhere the EU energy performance label for refrigerators is a mandatory label that must be fixed on the front exterior side of each appliance presented for sale by a retailer. It must also be displayed on advertisements for refrigerators in mail order catalogues which can comprise a significant proportion of sales in some EU states. The refrigerator label was the first energy label to be implemented under the EU Energy Labelling Framework Directive[3] and is to be followed by labels for clothes washers, dishwashers and clothes dryers in 1996/7 and for other appliance types later.

Unlike energy labelling schemes in other regions the EU energy label grades the energy efficiency of each appliance from A (most efficient) to G (least efficient), see Figure 1. This gives the customer a strong statement on product quality which it is hoped will have deeper resonances with both customers, retailers and manufacturers than a simple relative energy consumption message. Additionally, the use of an efficiency grading approach provides a useful tool to allow tracking of the energy efficiency evolution of the market.

In contrast with the US energy label, running cost information is not presented directly although some European consumers are now given this information through locally based initiatives which make use of the consumption information given by the energy label. Besides an energy efficiency ranking the EU label gives data on: the annual energy consumption, the fresh food and frozen food compartment storage volumes, the compartmental storage temperature and freezing performance, and the compressor noise. This paper presents early findings on the impact of the EU label as an agent for transforming the efficiency of the European refrigerator market. Results from a number of different

Figure 1. *The Label For Refrigerators and Freezers*



national refrigerator databases are compared and the mechanisms of market change are explored.

THE EU REFRIGERATOR ENERGY LABEL

Technical basis of the label

The technical basis for the refrigerator label was defined in a 1993 assessment conducted for the European Commission by an *ad hoc* study group known as the Group for Efficient Appliances (GEA 1993)[4] which was formed by appliance experts from a number of national energy agencies. This study assessed the refrigerator product types available in the European Union and classified them into primary product groups according to their fundamental functional characteristics.

The product groupings used for comparative energy efficiency evaluations were determined following a statistical analysis of the energy behaviour of the primary product groups to determine which refrigerator types had inherent functionally derived differences in their energy performance. For each energy efficiency product group so defined, straight-line regressions of the refrigerator energy performance as a function of the 'adjusted' volume were conducted to allow energy efficiency evaluations to be made. The use of adjusted volume is a technical convenience which allows models with compartments of different volumes and internal operating temperatures to be treated on a common basis. The same approach is followed in North America and elsewhere but the compartmental volume adjustment coefficients differ between regions because of differences in the ambient test temperature and prevalent compartmental design temperatures.

The resulting EU Energy Label product classes, frozen food compartment volume adjustment factors and regression equations of average energy performance with adjusted volume are given in Table 1.

The energy label efficiency grades, A to G, are defined according to the level of the computed energy efficiency index, I, as shown in Table 2. For a given model of refrigerator the energy efficiency index, I, is defined as the measured energy consumption of the specific model E divided by the average consumption for a model of the same type and adjusted volume, E_o *as calculated using the equations in Table 1*. E is measured according to the European test protocol EN153. Defined in this way, a lower value of I corresponds to a higher energy efficiency and vice versa.

The annual energy consumption's reported in the EU refrigerator energy label are recorded using the European test procedure EN153 issued by CEN (Committee European de Normalisation). This test protocol is essentially identical to the ISO (International Standards Organisation) refrigerator energy, temperature control and freezing performance test protocols combined. As a result of the differences in the energy measurement test protocol, as well as different compartmental temperature settings, product features and storage volumes it is very difficult to make meaningful comparisons between European and North American refrigerator energy performance. Several studies[5] have attempted to make theoretical adjustments for these differences but confidence in the resulting formulations is not high.

European refrigerators differ from those found in other regions in the following ways:

- they are usually smaller than North American models and (to a lesser extent) Australian/New Zealand models, but are of comparable size to Japanese models and those found in most of the rest of the world;
- their design temperatures correspond to the ISO star system, which is not followed in North America, or Australia/New Zealand but is in most of the rest of the world;
- they are not likely to have 'convenience' features such as frost-free systems, anti-sweat heaters and through-the-door features;
- the fridge-freezers normally have the freezer compartment situated above the fridge compartment but side-by-side models are rare;
- models using hydrocarbon refrigerants and foam-blowing agents (e.g. isobutane and cyclopentane) in place of CFCs are becoming commonplace (about 40% of all new models); very few models use HCFCs while the majority are using HFC-134a;
- three-door (or more) models of fridge-freezer are unusual, but twin evaporator fridge-freezer models are common.

Some typical sizes and energy consumptions for the EU refrigerator types as existed on the market between 1990 and 1992 are indicated in Table 3.

Introduction of the label

The refrigerator energy labelling Directive was issued by the European Council of Ministers at the beginning of 1994 and was meant to be implemented in member countries by January 1st 1995 at latest. Refrigerators were the first product group to receive an implementing Directive for an energy

Table 1. *EU Refrigerator Product Classes and Average Energy Performance Regressions*

Product Class			
Description	GEA study Category No.	Ω	Average 1992 Electricity Consumption for a given adjusted volume, AV, in (kWh/yr)[1]
Freezers			
Chest Freezers	F1	2.15	0.446AV + 181
Upright Freezers	F2	2.15	0.472AV + 286
Refrigerators and Refrigerator-Freezers			
Refrigerator with 1-star FFC2	R1	1.00	0.643AV + 191
Refrigerator with 2-star FFC2	R2	1.55	0.450AV + 245
Refrigerator with 3-star FFC2	R3	1.85	0.657AV + 235
Refrigerator with 4-star FFC2	R4	2.15	0.777AV + 303
Refrigerator-Cellar	R5	2.15	0.233AV + 245
Refrigerator without FFC2	R6	0.75	0.233AV + 245

[1]Energy consumption is expressed in terms of the adjusted volume (AV): where $AV = \Sigma\ V_c \times W_c \times F_c$ summed over all compartments in the appliance; and V_c = the net volume of a given type of compartment in the appliance, W_c is the weighting coefficient for that type of compartment (equal to 1 for the fresh-food (5°C) compartment and equal to Ω for the non-fresh-food compartment) and Fc is a factor which equals 1.2 for no-frost compartments and 1 for other compartments. The value given by the formula is to be compared against the measured energy consumption under the European testing norm EN153.

[2]FFC = frozen food compartment, which refers to any compartment operating at −6°C or less. The number of 'stars' attributed to a FFC refers to the maximum compartment temperature and/or minimum freezing capacity; such that 1-star = FFC at ≤ −6°C, 2-star = FFC at ≤ −12°C, 3-star = FFC at ≤ −18°C and 4-star = FFC at ≤ −18°C and with a freezing capacity > 4.5kg/24 hours per 100 litres net volume; with a minimum of 2kg total.

label following the passage of the Framework Directive on appliance energy labelling in 1992. This was the result of a seventeen year political debate concerning appliance energy labelling in the European Community.[6]

Two refrigerator labelling scheme pilot projects were implemented in Denmark (DTI Energy 1994) and Scotland[7] at the beginning of 1994 to give some early information on implementation strategies and consumer impacts. The results reported from these pilot programmes were both positive. In the Danish scheme 85% of customers who had purchased a refrigerator during the scheme remembered having noticed the label. Sales personnel and customers alike were found to have a positive response to the label. The customers were said to find the label clear and easy to interpret. Energy consumption was said to be the second most important factor effecting the customer's choice of refrigerator after the purchasing price. Of those customers who had bought a refrigerator 74% claimed that the energy label had influenced their decision. Sales personnel felt that the energy label had increased the customers interest in appliance energy consumption and that customers were more inclined to purchase energy efficient appliances as a result. For the Scottish pilot programme the appliances were being sold by the local utility in their showrooms (utility showrooms have historically had about 15% of the white goods retailing market in the UK).

Table 2. *Energy Efficiency Grades Used in the EU Energy Label*

Energy Efficiency Index I (fraction)	Energy Efficiency Class
$I < 0.55$	A
$0.55 \leq I < 0.75$	B
$0.75 \leq I < 0.90$	C
$0.90 \leq I < 1.00$	D
$1.00 \leq I < 1.10$	E
$1.10 \leq I < 1.25$	F
$1.25 < I$	G

The pilot project was preceded by a staff training programme and some staff incentivisation measures (opportunity to win an energy efficient fridge-freezer). The energy efficiency evolution of Scottish Hydro's appliance stock over a ten month period is shown in Figure 2.

National implementation approaches

Implementation of the refrigerator energy labelling Directive has not occurred evenly across the member states of the European Union. Table 4 shows the date of the label implementation in different EU countries and shows that three countries have still not implemented the legislation at the national level which puts them in breach of EU law.

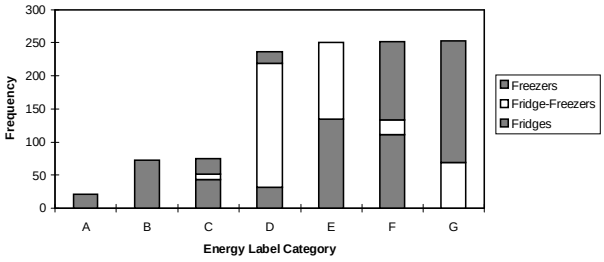
In some countries the label seems to be present in unadulterated form on almost all the refrigerators sold (e.g. UK, Germany, Netherlands, Denmark) while in others the application of the label by the retailers is not even. France is a good example of the latter behaviour where perhaps 60% of the models available on the market exhibit the label but

Table 3. *Typical Size and Energy Use of EU Refrigerator Product Classes*

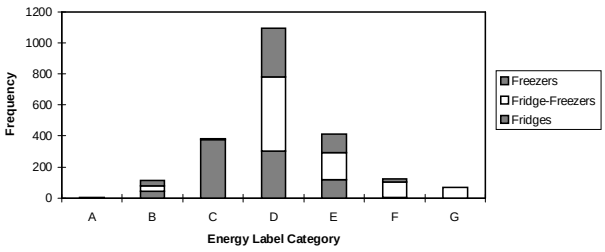
	Adjusted Storage Volume (litres)			Energy Consumption (kWh/year)[1]		
Category	Minimum	Maximum	Average	Minimum	Maximum	Average
F1	120	1250	636	155	1480	462
F2	80	975	358	210	1370	440
R1	75	300	151	180	435	274
R2	47	370	204	110	480	335
R3	130	405	192	180	585	367
R4	150	1050	355	305	1760	591
R5	47	375	185	95	477	294
R6	47	375	179	95	477	301

Source: database of 3771 models (about 75% of total on the market in 1991/2) assembled by GEA (1993).
[1]Energy consumption is the manufacturer reported value tested under EN153.

Figure 2. *Distribution of Scottish Hydro's Refrigerator Stock by Energy Labelling Category on 31st March 1994*



Distribution of Scottish Hdyro's Refrigerator Stock by Energy Labelling Category on 1st February 1995



with a large number of stores, especially the smaller independent retailers, not showing the label. Among the larger French retailers the response to the label has varied. Some of the less supportive retailers will: display the basic information but not using the EU label directly; apply certain parts of the label but not the whole label; or apply the label selectively on a model by model basis. At the other end of the scale there are retailers who not only display the label as intended but use the label as a marketing point in all their literature and operate staff sales incentive schemes which favour those that sell more energy efficient appliances.

Other EU policies influencing refrigerator energy efficiency

Aside from the energy label there are a range of other policy initiatives that are influencing refrigerator energy performance throughout Europe, namely: impending minimum energy efficiency standards legislation; procurement programmes and rebate schemes.

As of February 1996 the European Council of Energy Ministers were engaged in a debate with the European Parliament concerning the appropriate level and structure of impending minimum efficiency standards legislation for refrigerators and freezers. The Council of Ministers were arguing for standards set at a level designed to reduce the energy consumption of the average new refrigerator by 15% compared to the consumption of models in the GEA database (which used 1990 to 1992 data)(EU 1995).The European Parliament have been arguing for a minimum energy efficiency standards regime more consistent with the proposals in the GEA study, i.e. a short term standard set to produce energy savings of from 15% to 20% to be followed by a second set of standards set to produce energy savings of between 40% and 50%. If the two bodies continue to disagree the proposed Directive is likely to go into a formal arbitration procedure and could be concluded by the end of 1996. Manufacturers have been aware of the likelihood of minimum energy efficiency standards for refrigerators since 1992 when the Netherlands formally requested that the European Commission should draft a Directive proposal; thus, from a technical point of view, it is very difficult to disaggregate the influence that this factor has had on the efficiency evolution of the refrigerator market from the influence of the energy label.

Perhaps a less important but still noteworthy contribution has been made by the existence of some energy efficient appliance procurement programmes. In 1989 Sweden launched a very positive domestic refrigerator-freezer procurement programme (NUTEK 1994) which was the inspiration for the US 'Golden Carrot' scheme. This project gave an impetus to some European manufacturers to produce more energy efficient products. Denmark too launched an informal procurement programme in the 1980s which led to the creation of the famous LER-2000 refrigerator that was the most efficient on the European market for many years. Many countries are now involved in a co-ordinated procurement project through an international collaboration managed under the auspices of the International Energy Agency. Perhaps the most important European procurement project of all, although not directly concerned with energy efficiency, was the Greenpeace initiated programme guaranteeing thousands of orders for the development of a refrigerator which did not use ozone depleting substances or substances with high global warming potentials. This programme led to the development of refrigerators using hydrocarbon refrigerants and cyclopentane as the foaming agent, which have since been adopted as the standard technology by much of the European industry. The influence of this development on the energy efficiency of European refrigerators is discussed in section 4.

Since the early 1990s several rebate schemes for energy efficient appliances have also been enacted by many European governments and utilities. RWE, the largest German utility, ran a 100 million Deutsche Mark rebate programme over the past 3 years called KESS (Wuppertal 1995). The project involved giving a 100DM to every buyer of an efficient fridge, freezer, clothes-washer or dishwasher. In the Netherlands, a rebate programme is currently running for all residential customers. 150 Dutch Guilders are reimbursed to every buyer of an efficient fridge or freezer. A condition

Table 4. *Implementation of the Refrigerator Energy Label in the EU*

Country	Date Implemented[1]	Comments
Austria	26/7/1994	first country to implement label
Belgium	n.i.	federal structure has caused implementation problems
Denmark	1/1/1995	fully implemented with strong supporting campaigns (Pilot 1994)
Finland	1/6/1995	some supporting campaigns
France	1/10/1995	implemented by the state but only implemented by about 60% of retailers, some strong supporting campaigns (Pilot Nord-Pas De Calais region)
Germany	n.i.	implementation of the label is blocked at federal government level but in practice it is widely implemented by retailers
Greece	21/12/1994	
Ireland	17/5/1995	some supporting campaigns
Italy	n.i.	not implemented
Luxembourg	Yes	Date not known
Netherlands	19/8/1994	fully implemented with strong supporting campaigns
Portugal	1/4/1995	state sponsored TV campaigns to support label
Spain	28/7/1995	features in the national utility DSM programmes
Sweden	1/9/1995	strong supporting campaigns
United Kingdom	1/1/1995	wide retailer implementation, some local supporting campaigns and recently (April 1996) nation-wide advertisements (Pilot 1994)

[1]n.i. = not implemented; the situation as of February 1996.

limiting the HCFC or HFC content of the appliance was included in the rebate scheme. Similar schemes which make use of the efficiency classifications given in the energy label now exist in Spain and the UK.

All these various programmes are helping the promotion of more energy efficient refrigerators and freezers in Europe.

TRENDS IN EU REFRIGERATOR ENERGY EFFICIENCY

For the first time it has been possible to attain extensive sales-weighted energy data of the EU refrigerator market. This data which is for the year 1994 covers ten of the fifteen EU countries and represents 93% of the total EU market. The results of an analysis of the average energy efficiency index by product group is given in Table 5 (TNO 1996). From this data we can see that the 1994 stock of fridge-freezers and of 3-star refrigerators is significantly more efficient than the average of the 1990 to 1992 data used as the basis of the energy label efficiency index; while the chest freezers are significantly less energy efficient. The latter difference is almost certainly caused by the unrepresentative distribution of models used to define the original energy efficiency regressions defined in Table 1 and the fact that this data was not sales-weighted. Of course for the purposes

Table 5. *Sales-Averaged Energy Efficiency Index Distributions of the 1994 New Refrigerator Stock (TNO 1996)*

Category[1]	R1	R2	R3	R4	R5 & R6	F1	F2
Austria	91.7	92.8	87.4	90.0	85.0	103.0	85.5
Belgium	103.6	100.0	96.3	96.9	99.8	108.5	100.8
Denmark	86.1	86.1	92.1	92.0	89.3	83.7	94.7
France	98.9	109.1	96.1	94.4	102.3	113.3	103.6
Germany	95.5	102.7	83.2	82.7	85.8	73.3	80.7
Italy	104.6	99.0	102.5	94.9	124.1	128.8	103.3
Spain	91.9	93.8	100.1	93.2	111.4	121.7	106.6
Sweden	90.8	126.1	80.8	94.3	84.1	101.3	93.1
Holland	98.0	92.4	88.3	90.8	88.0	115.3	93.4
UK	94.5	88.2	94.2	87.5	97.9	149.8	112.9
All	99.8	97.8	88.3	92.1	93.66	113.8	96.1

[1]The categories correspond to those given in Table 1; where the method of calculating the energy efficiency index is also explained.

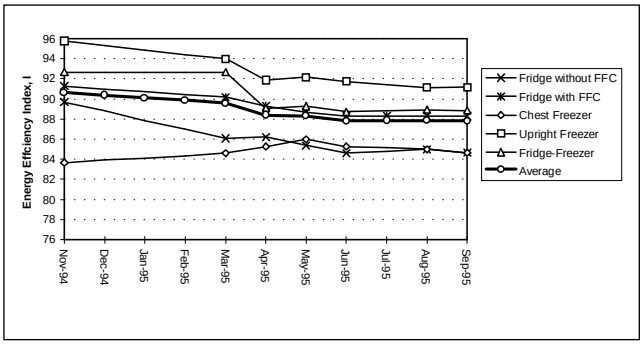
of defining classifications in an energy label it is not self-evident that one should define average efficiency performance using the average sales-weighted performance rather than the average performance of the models available for sale; even if the former data is necessary to understand the real energy transformation of the market.

The sales-weighted energy efficiency of the 1994 stock of upright freezers, 1 and 2-star refrigerators, and refrigerators without frozen food compartments is within 4% of the average value of the 1990 to 1992 data used for the energy label. We can therefore conclude that the energy efficiency calculation used for these stocks is adequate. If we were to assume that the GEA database of 1990 to 1992 models is directly comparable to the 1994 database then the 1994 EU market is on average 4% more energy-efficient than the 1990 to 1992 markets.

The most detailed national market data indicating the change in refrigerator energy efficiency since the advent of the Energy label is available for Denmark and Germany. In Denmark, the Danish Energy Agency has maintained a sales-weighted, bi-monthly or monthly, database that tracks refrigerator sales within the energy label efficiency categories for a group of retailers covering about 40% of total Danish refrigerator sales. Results are shown in Figure 3.

From this we can see that the Danish market was already more energy efficient than the EU average defined in the energy label regressions, and that between November 1994 and September 1995 the energy efficiency of the market had improved by a sales-weighted average of 3.14% to reach a

Figure 3. *Development in the Average Energy Efficiency of Danish Refrigerators*



level 12.2% more energy efficient than the EU (non sales-weighted) average in 1992.

Of course refrigerator electricity consumption in Denmark only represents a small proportion of the total EU refrigerator consumption, which is dominated by the four most populous EU countries, see Figure 4. Thus, it is of general interest to examine the trends in the largest markets.

One interesting question to answer is the extent to which it is reasonable to assume that the energy efficiency distribution of models on the market is a good proxy for the true sales-weighted energy efficiency distribution? Some indication is given for the Italian and German markets in Figures 5 and 6. These figures show that the availability of models has a reasonable correspondence to sales but that there are slight differences between the tendencies in the two markets. In Italy there tend to be more higher efficiency models available than people will buy while in Germany there tend to be more low efficiency models available than people will buy.

Figure 4. *Estimated Refrigerator Electricity Consumption by EU Country in 1992: from GEA (1993)*

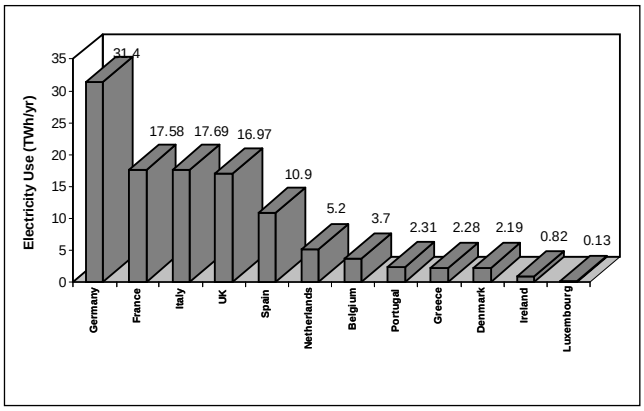


Figure 5. *Comparison of the Energy Efficiency for all 1994 Italian Refrigerators between Sales-Weighted and Model Frequency Distributions*

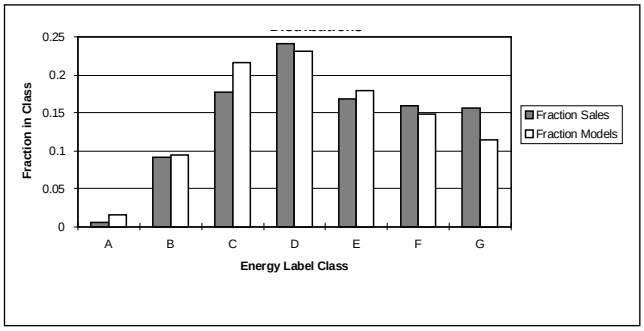


Figure 6. *Comparison of Energy Efficiency for all 1994 German Refrigerators between Sales-Weighted and Model Frequency Distributions*

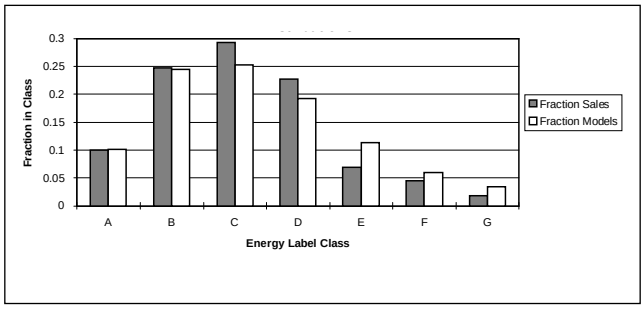


Figure 7 compares the energy efficiency distributions of three major national refrigerator markets. The 1994 German market is significantly more energy efficient than those in Italy or France.

In Germany as in Denmark the refrigerator market has made substantial energy efficiency improvements since the introduction of the energy label,[8] see Figure 8. In aggregate terms the 1995 German refrigerators are on average 13.7% more energy efficient than the 1993 German refrigerators. This represents a clear acceleration over historical efficiency improvement levels (Geiger *et al*, 1992).

Figure 7. *Energy Efficiency Distributions of the 1994 German, French and Italian Refrigerator Markets*

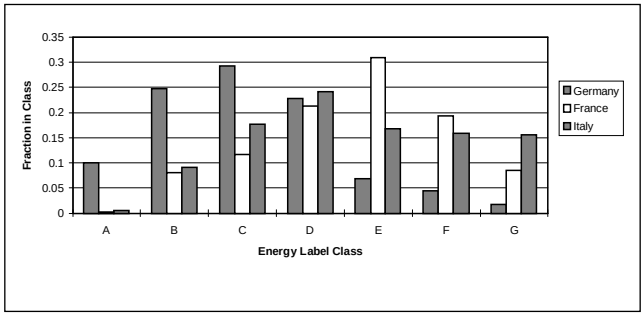
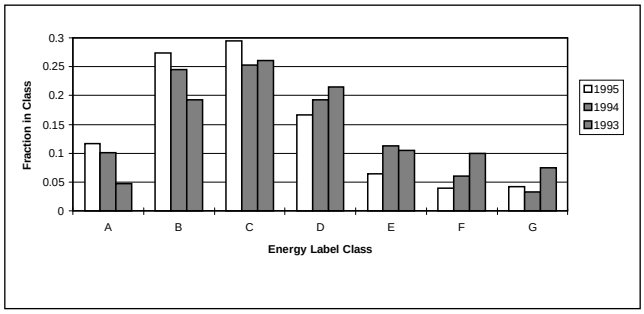


Figure 8. *Evolution of the Efficiency of the German Refrigerator Market Since the Introduction of the Energy Label*



The same information is shown for France in Figure 9 except without the 1995 data which is not yet available. Although the French market is starting from a less energy efficient base there is some improvement in its energy efficiency between 1993 and 1994. The label was only introduced in 1995 but manufacturers were aware of its pending implementation much earlier and may have begun to modify their products in response as soon as 1994.

In most other European markets there is still a lack of consistent historical data with which to make comparisons, although it is believed that this type of analysis will become easier in the future as formal databases using the energy label's efficiency index become established.

THE IMPACT OF CFC PHASEOUT ON REFRIGERATOR CONSUMPTION

Data from Germany clearly indicates how that market has responded to the phase-out of CFCs. Figure 10 shows the frequency of different refrigerant and foaming agent combinations as found on the German market in 1995. Over half the models on the 1995 market use neither CFCs nor HCFCs, nor HFCs as either the refrigerant or the foaming agent. None of the 1995 models use CFCs but about 3% use HCFC-142b or HCFC-141b as the refrigerant. The hydrocarbon refrigerants, isobutane or a propane/isobutane mixture are used in 55% of models while 43% of models use HFC-134a as the refrigerant. Pentane is by far the most common choice of foaming agent appearing in 82% of models; the remainder all use HFC-134a.

Figure 11 shows the situation which existed for new models on the German market in 1993 and with some 1994 data. At this time the majority (68%) of models were using CFCs both as the refrigerant and the foaming agent although HFC-134a and some hydrocarbon using models became available in 1994.

When we compare the distribution of new German models in different energy labelling classes in 1993 and in 1995, see Figure 8, it is shown that the non-CFC containing models are generally significantly more energy efficient than their CFC containing predecessors. Furthermore, the refrigerators using hydrocarbon refrigerants and foaming agents are generally the most energy efficient appliances on the European market. This impression is confirmed in Figures 12 and 13 which show the distribution of refrigerator energy efficiency by the type of refrigerant and foaming technology in use for 1993 and 1995. This interesting finding does not necessarily imply that there is any fundamental technical reason why

Figure 9. *Evolution of the Efficiency of the French Refrigerator Market Since the Introduction of the Energy Label*

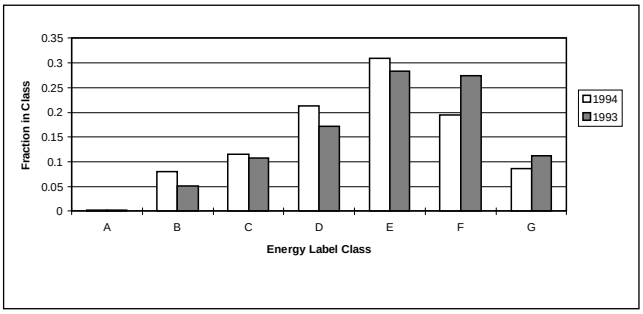


Figure 10. *Frequency of German 1995 Refrigerators By Combination of Refrigerant and Foaming Agent*

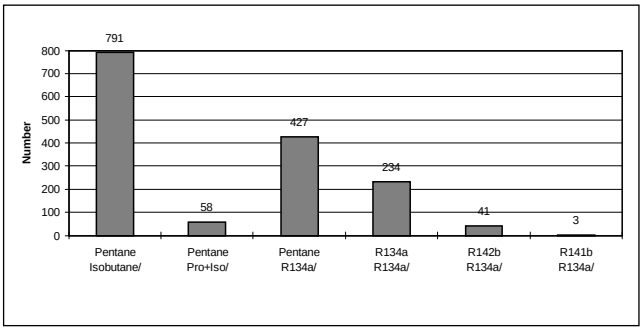


Figure 11. *Frequency of German 1993 Refrigerators By Combination of Refrigerant and Foaming Agent Types*

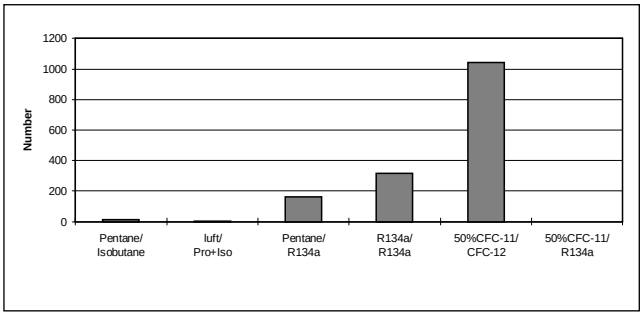


Figure 12. *Energy Efficiency Distributions for all 1995 German Refrigerators by Combination of Refrigerant and Foaming Agent*

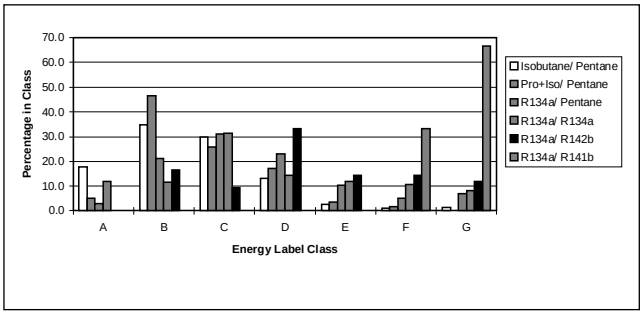
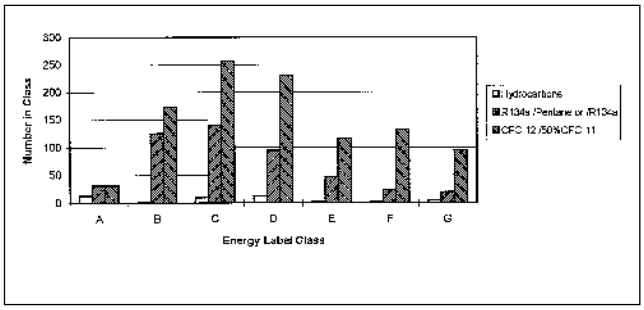


Figure 13. *Energy Efficiency Distributions for 1993 German Refrigerators by Combination of Refrigerant and Foaming Agent*



the use of the hydrocarbon technology should lead to higher levels of energy efficiency. The correlation between the use of hydrocarbon technology and higher energy efficiency levels may be the result of a wide range of factors, not least perhaps a perception on behalf of manufacturers that consumers who are likely to favour a refrigerator because it is using hydrocarbon technology may also favour higher energy efficiency. It is also likely that when manufacturers converted their production facilities to use hydrocarbon technologies they took the opportunity to simultaneously upgrade the energy efficiency of their products; perhaps through the use of micro-cellular foams, higher efficiency compressor units, better design of the cooling circuit, etc. Nonetheless, it is clear that the use of hydrocarbon technology is not a handicap to the production of high energy efficiency products.

Unfortunately, similar data is not available for other European national markets many of whose manufacturers are tending to use HFC-134a both as the refrigerant and the foaming agent.

THE EU LABEL: HOW IS IT TRANSFORMING THE MARKET?

As has been demonstrated, the European refrigerators and freezers market is evolving towards more efficient products. The introduction of the energy label, as designed for European customers, clearly has an influence on appliance manufacturers and designers and seems to be pushing them to put on the market more efficient appliances. Retailers also share responsibility to assure the success of the energy label though their response to presenting and marketing the label has been quite varied. The level of heightened-demand from purchasers for energy efficient products is not yet clear but demand has been shown to increase when labelling has been implemented in conjunction with targeted promotional campaigns. Furthermore, as consumers knowledge of the label increases there is growing evidence of changing purchasing behaviour. Contrary to many previous expectations the phasing out of CFCs in refrigeration appliances does not appear to have caused less energy efficient products to enter the market. Nonetheless, there is still a long way to go before the large potential energy efficiency improvements that have been identified in various studies are attained.

ACKNOWLEDGMENTS

The authors would like to thank the support of the SAVE programme of the European Commission (DG-XVII) and to ADEME, the French energy and environment agency.

ENDNOTES

1. EU (1994).

2. As of February 1996 Germany had not implemented the refrigerator energy labelling scheme.

3. EU (1992).

4. *Study On Energy Efficiency Standards for Domestic Refrigeration Appliances:* The Group for Efficient Appliances (1993).

5. Pederson (1992), Bansal & Kruger (1994), Harrington (1994), Waide & Lebot (1995).

6. Waide and Lebot (1995).

7. DTI Energy (1994) and Scottish Hydro Electric PLC (1994).

8. Although the energy label legislation has not been formally implemented in Germany all German manufacturers supply the label with their products and it appears that German retailers display the label almost universally.

REFERENCES

Bansal, P.K. & Kruger, R. (1994) ‘‘A comparative study of testing standards for household refrigerators/freezers’’ to appear in *International Journal of Refrigeration* Dept. of Mech. Eng., Uni. of Auckland, New Zealand.

DTI Energy (1994) *Pilot Project for Introduction and Use of the EU Energy Labelling of White Goods in Retail Trade* Final Report, DTI Energy for the Danish Energy Agency and the European Commission (Save programme: XVII/ 4.1031/93-007).

EU (1992) Council Directive 92/75/EEC: Framework Directive on the Mandatory Energy Labelling of Household Appliances, Commission of the European Communities, Brussels, Belgium, issued 22nd September.

EU (1994) Council Directive 94/2/EC of January 21st 1994 implementing Council Directive 92/75/EEC with regard to 'Energy Labelling of Household Electric Refrigerators, Freezers and their Combinations' (*OJ* No. L 297, 13.10.92), Commission of the European Communities, Brussels, Belgium.

EU (1995) 'Proposal for a European Parliament and Council Directive on Energy Efficiency Requirements for Household Electric Refrigerators, Freezers and Their Combinations'. DG-XVII, Commission of the European Communities, Brussels, Belgium.

GEA (1993) *Study on Energy Efficiency Standards for Domestic Refrigeration Appliances*. Group for Efficient Appliances, DG-XVII of the Commission of the European Communities, Brussels, Belgium, March.

Geiger, B., Kleeberger, H., & Wagner, U. (1992) 'Future structure development in domestic power consumption', in *Use of Efficiency Standards in Energy Policy*, Conference Proceedings 4–5 June 1992, IEA/Ademe, Sophia Antipolis, France, pp107–14.

Harrington, L. (1994) 'Appliance Energy Efficiency in Australia', presented at Energy Efficiency Business Week, Prague, Czech Republic, 8–10 Nov.

NUTEK (1994) 'Competition led to extremely energy efficient fridge-freeze' Dept. of Energy Efficiency, NUTEK, S-117 86, Stockholm, Sweden.

Pedersen, P.B. (1992) *Engineering Analysis Concerning Energy Efficiency Standards for Refrigerators and Freezers in Denmark* dk-TEKNIK for the Danish Energy Agency and Norwegian Water Resources and Energy Administration, Denmark. ISBN 87-7782-028-2, February.

Scottish Hydro (1994), 'Energy Labelling for Fridges and Freezers' , presentation delivered by Scottish Hydro for DG-XVII of the European Commission at the SAVE Contractors Workshop: Promotion of Energy Labelling, 29/30 June 1995, Oxford, UK.

TNO (1996) *Analysis of Energy Efficiency of 1994 Domestic Refrigeration Appliances: Part A: Analysis of 1994 Market* TNO Institute of Environmental Sciences, Energy Research and Process Innovation for the Commission of the European Communities, DG-XVII, SAVE Contract no. XVII/4.1031/E/95-005, rue de la Loi 200, B-1049 Brussels, Belgium.

Waide, P. & Lebot, B. (1995) *Refrigerators and Freezers: Market Characteristics, Energy Use, and Standards Harmonisation: Final Report* prepared for the International Energy Agency and presented at the Experts Meeting on International Harmonisation of Energy Efficiency Standards, 30-31 May, Paris.

Wuppertal (1995) *Evaluierung des KesS-Programms der RWE Energie AG*, Wuppertal Institut, für Klima, Umwelt, Energie GmbH, Döppersberg 19, 42103 Wuppertal, Germany.