LBL-31936
UC-350

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

ENERGY & ENVIRONMENT DIVISION

Presented at the International Appliance Technical Conference, Lafayette, IN, May 5-6, 1992, and to be published in the Proceedings

Status of European Appliance Standards

I. Turiel and B. Lebot

May 1992

For Reference

Not to be taken from this room

ENERGY & ENVIRONMENT DIVISION

LBL-31936
Copy 1
Bldg. 50 Library.

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

LBL-31936
UC-350

STATUS OF EUROPEAN APPLIANCE STANDARDS

Isaac Turiel and Benoit Lebot

May, 1992

This work was supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Building Technologies, Office of Codes and Standards, of the U.S. Department of Energy under Contract No. DE-AC0376F00098. The opinions expressed in this paper are solely those of the authors and do not necessarily represent those of LBL, DOE, or AEME.

Status of European Appliance Standards

Isaac Turiel

Lawrence Berkeley Laboratory
Building 90-4000
Berkeley, CA 94720
(510) 486-6493

Benoit Lebot

Agence de L'Environnement et de la Maitrise de L'Energie

500 Route des Lucioles
Sophia-Antipolis
06565 Valbonne, France
(33) 93 95 79 44

ABSTRACT

The European Community (EC) recently commissioned a study of the impact of potential appliance standards on electricity consumption in the twelve EC nations. This study looks at refrigerators, freezers, dishwashers, clothes washers, and clothes dryers. The impact of minimum efficiency standards on electricity use over the time period from 1995-2010 is estimated. The results of this study were presented to the EC in September of 1991. Revisions were made to the draft report and final copies sent to all interested parties.

The member nations of the EC will soon consider whether they wish to implement uniform energy efficiency standards that would take effect in 1995. The results of the study described above will be presented and the political considerations will be discussed. In addition, data describing the appliance market in Europe will be presented.

INTRODUCTION

In 1986, the Council of Ministers of the European Communities adopted the goal of improving end-use energy-efficiency by 20% before 1995. However, in 1988 and 1990, surveys of initiatives taken by member states revealed that the objectives could not be fulfilled unless more effective programs were established. In 1989, the Council adopted the PACE program, an action plan for the efficient use of energy, which includes energy labeling

and the introduction of efficiency standards on household appliances. During the same year, the EC established an objective to stabilize the emission of CO_2 at its 1990 level by the year 2000.

In 1991, the French Agency for Energy Management (AFME) performed an analysis of the European appliance market for the Directorate General for Energy (DGXVII) of the Commission of the European Community[1]. This study estimated the electricity savings that would be derived from energy efficiency standards for five residential appliances; these are: refrigerators, freezers, clothes washers, clothes dryers and dishwashers. Since the greatest energy savings would come from standards for refrigerators and freezers, member countries are first focusing their attention on these products.

Towards the end of 1991, the Danish Energy Agency (DEA), the Netherlands Agency for Energy and Environment (NOVEM), and the French Agency for Energy Management (AFME) decided to harmonize their national efforts on appliance energy efficiency. The three national agencies created a consortium, the Group for Efficient Appliances (GEA). The goal of GEA is to carry out technical and economic analyses for efficiency standards on refrigerators and freezers for the whole EC. In late 1992, GEA plans to present the Commission of the European Community with a report detailing the analysis as well as proposed efficiency standards for European household refrigerators and freezers.

This paper will discuss the market for domestic appliances in the European Community, results of the completed AFME study for the European Community, and the process of establishing standards in the EC.

THE EUROPEAN APPLIANCE MARKET

The population of the twelve EC nations (325 million) is greater than the U.S. population (250 million). There are approximately 125 million households in the EC nations and less than 100 million in the U.S. Therefore, the appliance market is potentially larger in the EC than in the U.S. As more countries join the EC, its market will continue to grow. In 1988, total EC electricity consumption was equal to 1,615 GWh; the average residential use was equal to 26% of the total, with a range from 22 to 35% for individual countries. The energy use of the five appliances comprises 9.4% of all

electricity use in the EC; therefore, attention has initially been focused on these appliances.

Four appliance manufacturers account for more than 50% of the major electric appliances produced in Europe. Table 1 lists the 10 largest appliance manufacturers and their percentage of the total European market[2]. They account for 80% of the European market. The products included in these statistics are: refrigerators, freezers, dishwashers, clothes washers and clothes dryers.

Table 1 Principal European Appliance Manufacturers

Company	Country	% of Market
Electrolux	Sweden	20.5
Whirlpool/Philips	Netherlands	11.5
Bosch/Siemens	Germany	11.0
Merloni	Italy	10.0
Candy	Italy	5.5
AEG	Germany	5.0
GEC Hotpoint	England	5.0
Thomson	France	5.0
Miele	Germany	4.0
Ocean	Italy	2.5

Saturations for the five appliances under consideration for efficiency standards are shown in Table 2. Except for Greece and Portugal, refrigerator ownership is essentially at maximum. Freezer saturations range from 18 to 70%. Clothes washer saturations are much higher than clothes dryer saturations and dishwasher saturations are low, ranging from 4 to 35%.

Table 2 Appliance Saturations in EC Member Nations

	BE	GE	DK	SP	FR	GR	IR	IT	NL	PO	UK
Re	98	96	99	94	97	74	92	99	98	83	93
Fr	60	58	64	18	42	25	21	22	47	28	38
CD	35	21	21	4	10	2	12	4	15	2	34
CW	95	91	91	92	86	69	77	94	90	43	89
DW	24	35	35	10	30	4	10	22	10	7	9

Unit production figures for 1987 for appliances produced within Europe are shown, for the five appliances being studied, in Table 3[3]. Production in Japan and the United States is shown for comparison. European production is highest for three of five product types.

Table 3 Production Figures for Five Appliances

Product	Europe	U.S.	Japan
Refrig	10.486,000	6,207,000	5,079,000
Freezer	4,086,000	1,283,000	101,000
Dryer	2,322,000	4,545,000	449,000
Washer	10,682,000	6,166,000	4,857,000
Dishwash	3,078,000	4,026,000	78,000

In 1989, the four largest EC nations, France, Germany, Great Britain, and Italy, produced 9,191,000 refrigerators and purchased 8,216,000 refrigerators. For the EC as a whole, purchases of refrigerators have now reached over 12 million per year; combination refrigerator-freezers account for 83% of the total. The difference between production and purchases is accounted for by imports and exports. For example, Italy exported far more refrigerators than they imported and the reverse is true for England. In the future, as trade barriers are relaxed, appliances should move more freely across borders.

RESULTS OF AFME STUDY

Overview

In the latter part of 1991, the AFME published the results of their study for the European Community. They found that 390 TWh (11% of total) could be saved over the time period from 1995-2010. These savings would be accomplished through energy efficiency standards for the five product types studied. In 1990, total electricity consumption of domestic refrigerators, freezers, clothes washers, clothes dryers, and dishwashers for the twelve EC nations was estimated at 152 TWh. These five appliances account for 26% of residential consumption and 9% of total EC electricity consumption.

Since the vast majority of predicted savings from energy-efficiency standards would come from refrigerators and freezers, the rest of the paper focuses on those two product types.The AFME study estimated that 306 TWh (78% of total) of electricity savings would come from refrigerator and freezer standards commencing in 1995. The GEA will be concentrating their near term standard-setting efforts on these two appliances only. It is important to note that, throughout Europe, the same test procedure is used for measuring the energy consumption of refrigerators and freezers[4]. We now turn to the methodology used to determine the standards and the energy savings for these two appliances.

Methodology

There are two methods of obtaining energy efficiency standards for refrigerator-freezers. One is a statistical approach and the second is an engineering approach. Even before initiating either approach, test procedures must be established for measuring energy consumption of affected appliances. Secondly, data on the efficiency and characteristics of all models available for sale need to be collected and analyzed. When gathering data, it is important to confirm that the same test procedure was used for all data collected. For example, the U.S., Japan, and Europe all use different test procedures to measure refrigerator energy consumption. As mentioned earlier, all EC members use the same ISO test procedure. This essential fact makes uniform standard setting for the EC possible.

A statistical approach involves collecting efficiency

data for the product of interest and setting a standard level based on eliminating some percentage of the models being offered at the time of the analysis. This approach was used to set the 1990 U.S. energy efficiency standards for refrigerators and freezers. The 1990 standard was set by consensus between manufacturers, environmental, and consumer groups and passed into law by the U.S. Congress in 1987[5]. This method is not as complex and time consuming as the engineering approach which was used in setting the 1993 U.S. energy efficiency standards for refrigerators and freezers.

Figure 1 shows the 1990 and 1993 U.S. standards for a top-mount auto-defrost refrigerator-freezer. Also shown are energy use and adjusted volume for all models listed in the 1989 Directory of Certified Refrigerators and Freezers published by the Association of Home Appliance Manufacturers (AHAM). It can be seen that in 1989, there was a wide range of energy consumption for the same adjusted volume and that many inefficient models could no longer be manufactured after January 1, 1990. The 1993 standards, established by the Department of Energy, (DOE) are significantly more stringent than the 1990 consensus standards

The U.S. DOE engineering analysis produces manufacturing costs for improving the efficiency of a baseline model. The engineering analysis is described in detail in another report[6]. Each design option is analyzed separately (and in combinations later) to obtain energy consumption (often through use of a simulation model) and incremental cost to manufacture the more efficient product. Other components of the standards analysis produce retail prices, life-cycle cost curves, national energy savings, manufacturer impact assessment, and environmental assessments. All of these analyses are used to set standard levels by the DOE.

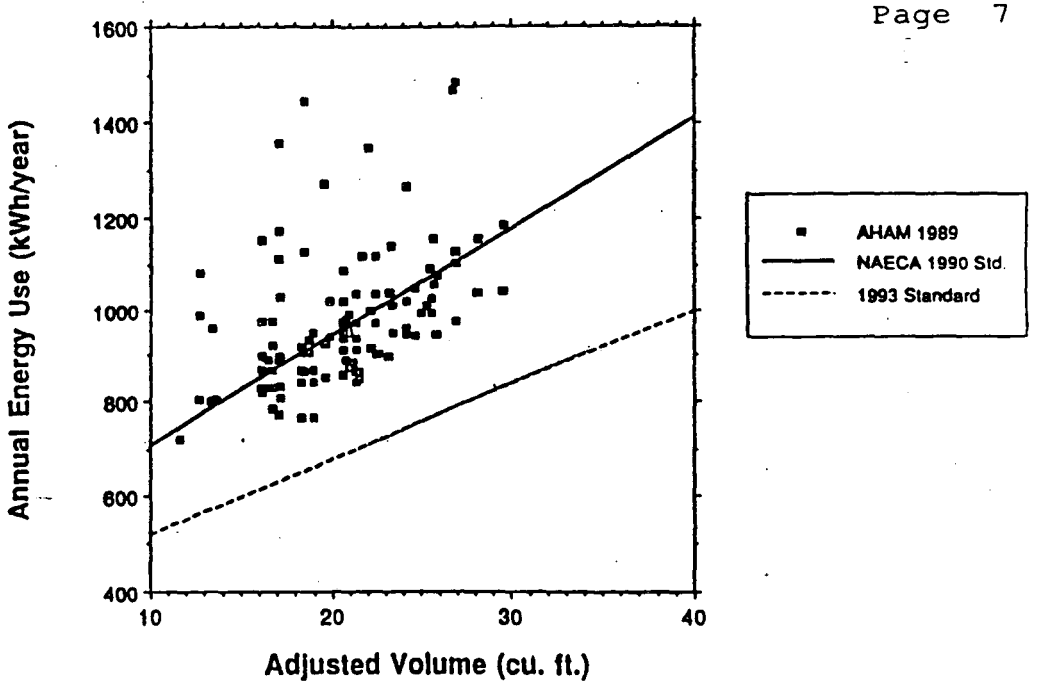

Figure 1: Energy use versus AV for a T-M A-D refrigerator-freezer

In the AFME study, energy consumption data were gathered for refrigerators and freezers of different types. For European refrigerator-freezers, a star system is used to designate the freezer temperature. Table 4 shows the four categories of refrigerator-freezers sold in Europe and the adjusted volume (AV) for each category. The adjusted volume accounts for the greater temperature difference between ambient (25°C) and freezer temperatures than between ambient and fresh food compartment temperatures. It is equal to the sum of fresh food volume plus the product of the freezer volume and the AV coefficient (see Table 4).

Table 4 Four Categories of Refrigerator-Freezers

Categories	Frz Temp(°C)	Frz Temp(°F)	AV Coeff
1 Star	- 6	21.2	1.55
2 Star	- 12	10.4	1.85
3 Star	- 18	-0.4	2.15
4 Star	- 18	-0.4	2.15

Analysis

Figure 2 shows 4 star refrigerator-freezer data for models sold in 1990, collected from France, the Netherlands, and Germany. The objective of the data analysis is to determine potential energy efficiency standards (as a function of adjusted volume) and to estimate their impact on the model offerings and electricity consumption. For a typical capacity (350 liters of adjusted volume), energy use ranges from a minimum of about 375 to a maximum of 750 kWh/yr. It is apparent that a simple linear relationship between energy use and adjusted volume would not correctly describe all of these data. The correlation between these two variables is too weak. For most of the range of adjusted volume values, there is a factor of two variation in energy use at constant adjusted volume. The reason for this is, that there are several characteristics of these refrigerator-freezers that are varying in addition to the adjusted volume; for example, insulation thickness and compressor efficiency. Otherwise, a better fit between energy use and adjusted volume would be expected.

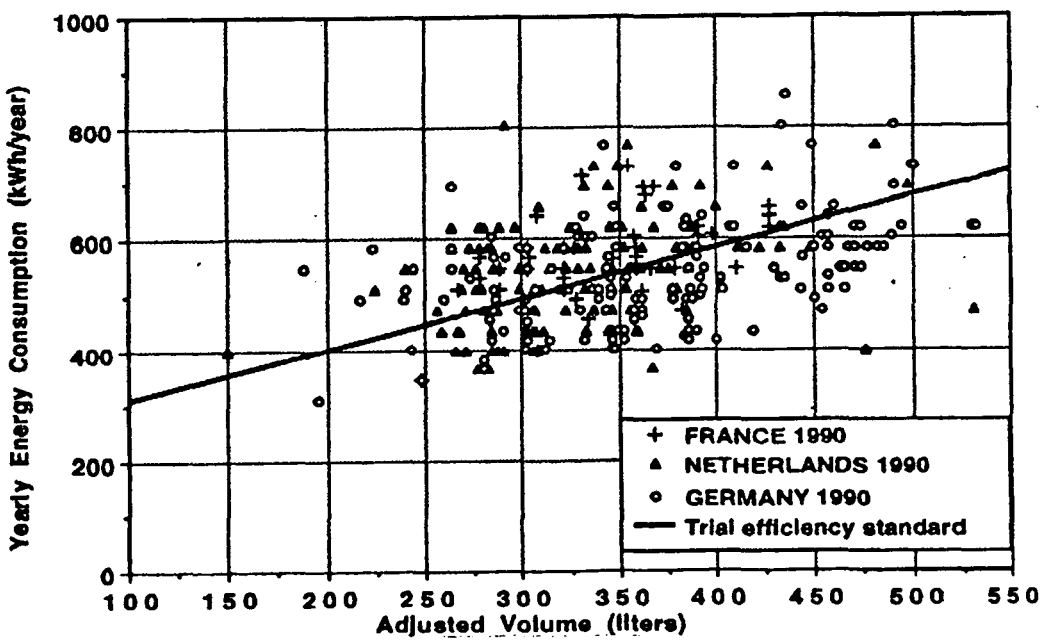

Figure 2: Energy use versus AV for 4* refrigerator-freezers on the European market.

In order to develop a relationship between energy use and adjusted volume, manufacturers were contacted so as to identify 4 models with different adjusted volumes, but similar characteristics otherwise. A simple linear regression was performed for these four models with different adjusted volumes for both the one and four star categories. The results follow,

$$1 \text{ Star: } E = 174 + 0.667*AV$$

$$4 \text{ Star: } E = 216 + 0.915*AV$$

where E equals energy use in kWh/yr and AV is the adjusted volume in liters. These regression lines represent the baseline, or the present market. In Figure 1, if the solid line were the standard, all points above the line represent models that will have to be upgraded or eliminated from the market.

An important issue is the uniqueness of the regression equation. One could analyze another series of models with equal (but different from the first series) compressor and insulation properties and obtain a somewhat different linear equation. Additionally, analysis of data from an individual country could lead to a different result. For example, the dashed line represents a linear equation obtained by NOVEM for refrigerator-freezers sold in the Netherlands. On the other hand, analysis of the German data by AFME led to the same result as for the full data set. An approach which, to some extent, avoids the subjectiveness of the statistical approach is described below.

An engineering approach was also used in the AFME study. A four star refrigerator-freezer, using 516 kWh/yr, with 325 liters of adjusted volume was analyzed using five design options. The results of this analysis are shown in Table 5. One option, aerogel insulation, was eliminated from the table because its payback period (19.2 yrs) was considered to be too long. This analysis was performed using data from French manufacturers. It is possible that different costs could have been obtained through other manufacturers. In order to address this potential problem, GEA has undertaken a task to gather manufacturer cost data from all European manufacturers.

Table 5 Cost-Efficiency for Refrigerator-Freezers

Level	Design	Energy Use (kWh/yr)	Cost (ECU)	Payback (yrs)
0	Baseline	516	----	----
1	0+Eff Comp	449	10.0	1.6
2	1+Door Ins	420	15.7	1.8
3	2+Wall Ins	361	52.8	3.5
4	3+Imp Leak	331`	78.5	4.6

The design options are as follows: the first is a direct intake compressor, the second is an increase in door insulation thickness by 15mm, the third is an increase in wall insulation thickness by 15mm and 30mm in the refrigerator and freezer compartments, respectively, and the fourth is a reduction in door leakage. Details of these design options can be found in the AFME report. The cost and payback periods are both cumulative, relative to the baseline model. For payback period calculations, the electricity cost is 0.0928 ECU/kWh, where ECU are European Community units. The life-cycle cost minimum occurs at level 3.

Energy Savings

An end-use energy consumption model was used to project energy savings from efficiency standards[7]. The assumptions were that the baseline equations above would be the initial standard in 1995, level 2 would be the 1997 standard, and level 3 the year 2000 standard. If the standards defined above (and other standards for freezers as given in the AFME report) were applied to the EC as a whole, total energy use of refrigerators and freezers would stabilize at the 1990 level by the year 2000 and then drop. In 1990, all the refrigerators and freezers in the EC consumed about 100 TWh. Over a 15 year period, these efficiency standards would save 306 TWh; that is equivalent to the 1990 electricity consumption of the United Kingdom.

SUMMARY

Uniform efficiency standards for the European Community

now seem to be likely. Two or three years ago few who were knowledgeable about the process would have thought so. Some of the steps remaining are analysis of manufacturer cost data from all major manufacturers in the EC market, incorporation of these data in the engineering analysis, establishment of appropriate standards, and approval by the EC. The criteria for standard setting would have to be agreed upon by all members. They could be based upon technical feasibility by the effective date of the standards and economic justification (life cycle cost and payback period analysis). Approval of the standards by each member would clearly involve input from manufacturers located in their respective countries. An EC member would not want to disadvantage manufacturers in their own country relative to other EC members. Each member nation will want to analyze the impact of proposed standards on the model offerings of local manufacturers.

ACKNOWLEDGMENTS

This work was supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Building Technologies, Office of Codes and Standards, of the U.S. Department of Energy under Contract No. DE-AC0376F00098. The opinions expressed in this paper are solely those of the authors and do not necessarily represent those of LBL, DOE, or AEME.

REFERENCES

1. Lebot, B., A. Szabo, and H. Despretz, 1991. "Etude sur la reglementation des performances energetiques des appareils electromenagers", AFME, October, 1991.

2. Eurostat, "Energie 1960-1988", 1990. ISBN 92-826-16967.

3. Appliance Magazine, page 7. November, 1989.

4. Household refrigerator-freezers-Characteristics and test methods, International Organization for Standards, ISO/DIS 8187.3, 1988.

5. National Appliance Energy Conservation Act 1987. Public Law 100-12, March 17, 1987.

6. I. Turiel et al., 1990. "U.S. Residential Appliance Energy Efficiency: Present Status and Future Directions", ACEEE 1990 Summer Study, Vol 1.213-234.

7. Lebot, B. et al., Op cit. page 21-32.

LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
TECHNICAL INFORMATION DEPARTMENT
BERKELEY, CALIFORNIA 94720