EUROPEAN EVALUATION EXPERIENCE

Paul Waide
PW Consulting, UK

ABSTRACT

Monitoring and evaluation is a critical element in an optimised appliance standards and labelling programme. The EU began their current appliance energy efficiency programmes in 1992 and have made a partially coherent monitoring and evaluation assessment from 1994 onwards. In some regards the EU monitoring and evaluation programme is a useful model of how such actions can be performed but there are still many areas in which the process could be improved. This paper discusses the type of monitoring and evaluation actions which have been conducted in the EU, presents the key findings and offers a critical appraisal of the evaluation effort conducted to date. Recommendations are made concerning how the programme might be improved and an analysis of the lessons learnt that could be applicable to other appliance standards and labelling evaluations is presented.

1. INTRODUCTION

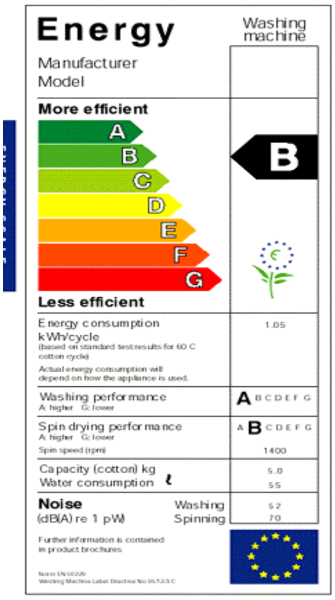
1.1 POLICY MEASURES AND GOALS

Where previously EU Member States had considerable freedom to initiate their own appliance and equipment efficiency regulations, the advent of the European Single Market in the early 1990's necessitated that the European Commission take a proactive role in developing harmonised energy efficiency regulations for equipment throughout the EU in order to satisfy Community strategic, environmental and societal goals while preventing barriers to trade.

Since the launch of the PACE (1989) and SAVE (1992) programmes a great effort has been made to transform the efficiency of the residential and commercial appliances and lighting market in the EU. An energy labelling framework[1] Directive for household appliances was introduced in 1992 (Council Directive 92/75/EEC) and was followed by implementing Directives for refrigerators and freezers[2] (Commission Directive 94/2/EC), clothes-washers (Commission Directive 95/12/EC) (Figure 1), tumble dryers (Commission Directive 95/13/EC), washer-dryers (Commission Directive 96/60/EC), dishwashers (Commission Directive 97/17/EC) and household lamps (Commission Directive 98/11/EC). More energy label implementing Directives are planned for: electric storage water heaters, room air conditioners, electric ovens and possibly televisions in the near term, while the current labels for cold appliances and clothes-washers are pending revision. In the medium term new labels are proposed for heat pumps, domestic hot water boilers, central heating circulation pumps, gas instantaneous water heaters, and reflector lamps.

In addition to labelling, mandatory minimum energy performance standards (MEPS) have been introduced for cold appliances (Council and Parliament Directive 96/57/EC, in force from 3.9.99), liquid or gas-fired hot water boilers (Council Directive 92/42/EEC, in force from 31.12.97) and fluorescent lamp ballasts (Council and Parliament Directive 2000/55/EC, in force from 21.11.2000). New MEPS are currently under consideration for room air conditioners and domestic gas and electric ovens. Upgraded MEPS are being considered for cold appliances and hot water boilers.

[1] Framework legislation is used to empower a process, such as the issuance of energy labels, rather than mandating a single action such as the inssuance of a specific energy label.
[2] Hereafter the term 'cold appliances' is used to apply to all types of domestic refrigerator, freezer and combinations thereof.



The European Commission has been prepared to enter into voluntary agreements[3] with industry providing suitably ambitious efficiency improvements can be delivered and since 1996 a number of voluntary agreements have been concluded with manufacturers of televisions and VCRs, washing machines, dishwashers, electric storage water heaters, audio equipment and external power supplies.

New agreements are under discussion for integrated decoder devices (set top boxes) and could also be negotiated for room air conditioners and ovens if MEPS are not applied.

The Community's broad goals in enacting energy efficiency measures for these products have been to:

curb CO_2 and other greenhouse gas emissions in line with the Community's commitments under the Kyoto protocol
give greater transparency to the energy operating costs of energy intensive residential and commercial equipment in order to address perceived market imperfections increase the energy security of the Community

Figure 1. The EU clothes washer energy label

1.2 EVALUATION TYPES, OBJECTIVES AND TARGETS

A number of evaluations have been conducted on behalf of the European Commission to determine the effectiveness of their equipment energy efficiency programmes. These evaluations have been divided into two primary types:
the quantified assessment of energy consumption, efficiency levels, CO_2 emissions and other pertinent market and stock indicators such as life cycle costs (impact evaluations)

the largely qualitative appraisal of programme implementation (process evaluations)

Impact evaluations are aimed at determining whether the equipment market and stock are on course to reach Community energy, environmental, economic and performance targets. Process evaluations are aimed at determining the extent to which policies have been properly implemented and in what way their implementation may need to be improved. Both types of evaluation are essential to determine the overall impact of the energy efficiency policy measures although the evaluations have often had a variety of additional purposes and results.

[3] 'Voluntary agreement' is a term used to apply to a formal agreement reached between the European Commission and key industry representatives (usually via a dominant manufacturers' association)) under which the industrial signatories agree to attain specific energy efficiency targets for the products they produce within a given time frame. In practice this can act much as minimum efficiency standards do in that manufacturers agree to stop producing products with an efficiency level of less than a minimum efficiency value or it can involve attaining fleet average efficiency production targets.

[4] 'Voluntary agreement' is a term used to apply to a formal agreement reached between the European Commission and key industry representatives (usually via a dominant manufacturers' association)) under which the industrial signatories agree to attain specific energy efficiency targets for the products they produce within a given time frame. In practice this can act much as minimum efficiency standards do in that manufacturers agree to stop producing products with an efficiency level of less than a minimum efficiency value or it can involve attaining fleet average efficiency production targets.

Impact evaluations of policy impacts and effectiveness require suitable indicators to be identified as benchmarks. The EU has orientated its equipment efficiency policy measure impact evaluations toward the assessment of pertinent and tangible indicators that are realisable within the limits of the SAVE programme. One such indicator, who's use has been informally adopted in the EU, has been the rate at which the market moves toward the average product efficiency level associated with the least life cycle cost for the consumer. The level of CO_2 emissions associated with a given product and more problematically the energy and CO_2 savings attributable to the policy measures are other relevant indicators.

Indicators that appraise the energy and efficiency characteristics, measured under standard test conditions, of products offered for sale on the market are known as 'leading indicators' in that they will eventually enter the stock and be translated into related *in situ* energy consumption levels and CO_2 emissions. These latter parameters are known as 'lagging indicators' because they are determined by the energy consumption trends of the whole stock of products in use which necessarily lag behind those for new products entering the stock. The availability of required data necessarily determines the nature of the programme evaluations which can be conducted. In the EU the conduct of evaluations using leading and lagging indicators has been possible because the required data sources have been identified for many, but not all, products.

2. LEADING INDICATOR PROGRAMME EVALUATIONS AND IMPACTS

Leading indicators regarding the: energy consumption, efficiency, price and implied life cycle costs have been gathered for a variety of new products based upon measurements made under standard test conditions. For some products and in some years only technical data for products on the market has been gathered but for others comprehensive sales-weighted data has been assembled.

2.1 DATA USED IN QUANTITATIVE IMPACT ANALYSES

Sales-weighted analyses for cold appliances, clothes-washers, washer-dryers and household lamps

Three combined technical and sales databases containing relevant energy and market data of cold appliance, clothes washer and washer-dryer models from up to 11 of the most populous EU countries have been established and analysed (PW Consulting & ADEME 1998 & 2000a). The cold appliance database, which contains 82581 records for sales active models, includes the annual sales, price and technical characteristics of cold appliance models sold on the European market between 1994 and 1997. The countries represented in the database cover from 89% to 95% of EU cold appliance sales depending on the year. On average each national sales panel covers 83% of the market and thus per model sales data are available that collectively account for from 74% to 79% of all cold appliance sales in the EU according to the year. Similar data has been gathered for the clothes-washer and washer-dryer markets.

Establishment of the databases was achieved by unifying two types of appliance database. Country specific appliance market data listing annual sales and price by model were purchased from market research companies. For cold appliances technical data on models offered for sale in the EU from 1994 to 1997 was gathered from several sources but principally the European white goods manufacturers' association, CECED. The resulting technical database contained entries on many thousand seemingly unique cold appliances available for sale in Europe between 1994 and 1997, although some of these are likely to be duplicates. CECED also supplied technical databases of clothes washer models on the market in 1996 and 1997 and washer-dryers in 1997. Unification of the disparate technical and sales data was achieved using unique software developed to match identical models between the market (sales) and technical databases.

These databases are being expanded to include more recent data and other products such as household lamps; however, as the use of completely current data is very costly the Commission has opted to analyse market data that is one to two years out of date in order to reduce data acquisition costs. To gain a more immediate insight into the state of the appliance market non-sales-weighted model technical data supplied by the manufacturers' associations is used. Similarly, when a product is first being analysed as a candidate for new Community policy measures non-sales-weighted model technical data is always gathered to establish a picture of the energy characteristics of the market. This data is often subsequently used as a benchmark to establish how far the market has evolved once policy measures have been implemented.

Other products and data sources

Aside from the sales-weighted technical data gathered for washer dryers and more recently household lamps there have been no quantified sales-weighted market data evaluations for other energy using equipment types. Instead technical databases have generally been supplied by industry associations. In addition when voluntary agreements have been negotiated signatory manufacturers agree to report production-weighted energy and efficiency data pertaining to their own products to an appointed independent auditor who is charged with compiling aggregate results for the industry as a whole. This has been the case for clothes-washers, TVs, VCRs, and domestic electric storage water heaters and will apply for audio equipment and external power supplies. Interestingly the production-weighted energy and efficiency trends reported for clothes washers have been in remarkably close agreement with the sales-weighted trends reported in section 2.3.

2.2 COLD APPLIANCE MARKET TRENDS

Energy efficiency trends

The GEA published a report on energy-efficiency standards for domestic refrigeration appliances in 1993 (GEA 1993), providing the first attempt to assemble a Community-wide assessment of the efficiency of the cold appliance market. The GEA assembled and analysed a database containing 3699 cold appliance models that were offered for sale between 1990 and 1992 in Germany, France, the Netherlands, Denmark, Italy, Spain, Portugal and the UK. For some of these countries only a small number of models were available, while for others the contribution was much larger. Statistical analysis of this database was used to define cold appliance product categories and the average performance regression lines that are used in the current energy-labelling scheme. Since that time far more comprehensive cold appliance model and sales data have become available as reported in section 2.1. The European major household appliances association, CECED, has also assembled a database, containing energy-related technical details but no sales information, of its members' domestic refrigeration products for every year since 1996. Products produced by CECED's members account for ~90% of the cold appliances sold in the EU.

Table 1 summarises the market annual average cold appliance energy efficiency index (EEI) for the EU and individual Member States since pre-labelling and minimum energy performance standards times to 1999, the year in which the MEPS came into force. The calculation of the 'energy efficiency index' for these and other products is described in the parallel paper by Lebot, Waide and Newman (2001).

The shaded rows contain non-sales-weighted data, i.e. average values computed from model technical databases assuming that all models in the database have equal sales. The non-shaded rows contain fully sales-weighted values. The values in 1999 are shown twice: the 1999 [1] value is the average efficiency of all models offered for sale in the CECED database for 1999 and includes models that would be prohibited from sale by the MEPS Directive from 3 September 1999 onwards. The 1999 [2] value indicates the average efficiency of the models in the CECED database if the models that fail to comply with the MEPS levels are excluded. The market average new cold appliance efficiency trends for the EU given in Table 1 are shown graphically in Figure 2.

Table 1. Cold appliance sales-weighted annual average energy-efficiency indices (EEIs) (%) for 1992–99.[1,2]

	EU	Aus	Bel	Den	Fra	GB	Ger	Ita	Nl	Por	Spa	Swe
1999 [2] [3]	74.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999 [1] [4]	79.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

1998	82.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	88.1	81.4	87.7	87.9	91.7	99.8	75.5	94.7	80.5	NA	91.5	86.4
1996	91.8	85.5	95.6	91.3	98.1	101.8	78.3	97.0	84.3	104.0	98.2	92.2
1995	93.9	87.9	97.0	93.1	101.6	103.4	80.6	99.3	88.2	106.3	100.5	95.0
1994	96.1	89.4	99.4	95.3	104.7	103.3	84.7	101.7	92.3	108.8	99.6	97.2
1990–92 (GEA)	102.2	NA	NA	92.8	103.9	108.9	96.6	105.1	99.0	121.4	101.0	NA

1 The sales-weighted data for 1994 to 1996 include a small percentage of sales of cold appliances with unknown EEIs and assume that all these appliances have an EEI at the border of the F and G classes (i.e. I = 125). Missing values for some countries in specific years (Austria, Belgium, Denmark, Portugal, Sweden) have been estimated by assuming the relative sales-weighted efficiency of their markets is the same as in later years in which data are available. The GEA data have been further weighted such that the 'sales' contribution of each category of cold appliance to the aggregate national EEI is equivalent to the market shares of each category in the nearest year for which sales data are available and also so the national shares of the EU market are consistent with those in 1994–96. The 1997 data are sales-weighted but have not been corrected in this way since there is a very small share of models with unknown sales. *Source:* PW Consulting & ADEME (2000a).

2 Neither the 1998 and 1999 data nor the GEA data for 1990–92 are sales-weighted. The 1998 and 1999 data are derived from the CECED cold appliance energy database, which covers at least 90% of the cold appliances on the EU market in the respective years.

3 Derived by considering only those models for sale in 1999 that would pass the minimum energy performance standards (MEPS) requirements implemented in September 1999.

4 Covers all cold appliances for sale in 1999, including those that would not pass the MEPS requirements implemented in September 1999.

These data indicate that there has been a pronounced improvement in the energy efficiency of new cold appliances for sale in the EU since the time of the GEA study. The average cold appliance for sale at the beginning of 1999 used 22.5% less energy to perform the same task as one for sale in 1990–92. The average energy-efficiency index (EEI) of cold appliances on the market in 1990–92 is estimated to have been 102.2%, while the average of the models in the CECED 1999 database that satisfied the September MEPS was 74.8%. This represents a 27% improvement in efficiency in relative terms over the same period, which is equivalent to an average annual energy-efficiency improvement over the intervening period of ~4.3% per year. It is speculative to say exactly how much, if any, of this improvement might have occurred had the EU energy labelling and MEPS Directives not been enacted, but most probably the bulk of the improvement would not have occurred without them.

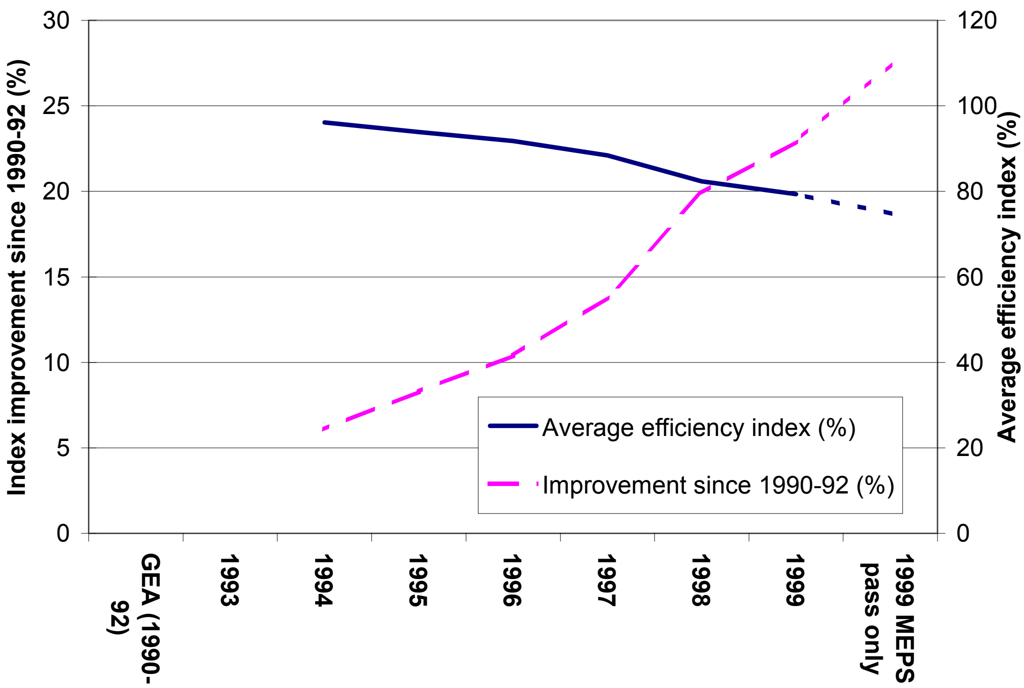


Figure 2. Market average new cold appliance energy-efficiency indices in the EU from 1990–92 to 1999.

Figure 3 illustrates the evolution of the European cold appliance market by energy-label class since the time of the GEA study. Although the data in Figure 3 mix sales-weighted and non-sales-weighted market-offer data, the comparison appears to be valid as there is only a fairly small difference between the sales-weighted and model-weighted labelling distributions for 1996 and 1997.[5]

Between the time of the GEA study, which was used to define the current labelling system, and 1999, there was an average cold appliance efficiency improvement of two labelling classes, such that the greatest number of models were in the B and C classes as opposed to the D and E classes, respectively, for the GEA database. Furthermore the share of A-class appliances increased from 1.8% in 1990–92 to 15.6% in 1999, while over the same period the share of D to G rated appliances declined from 74% to under 14%. The strongest efficiency improvements appear to have occurred between 1992 and 1994, between 1997 and 1998, and again from 1998 to 1999. It can only be conjecture as to why these trends occurred the way they have; however, it is probable that the improvement from 1992 to 1994 resulted from a general repositioning of the market in anticipation of the introduction of labelling and MEPS, while the increase in improvement from 1997 to 1999 was driven partly by the then-pending MEPS and partly by the improving implementation and impact of the energy label.

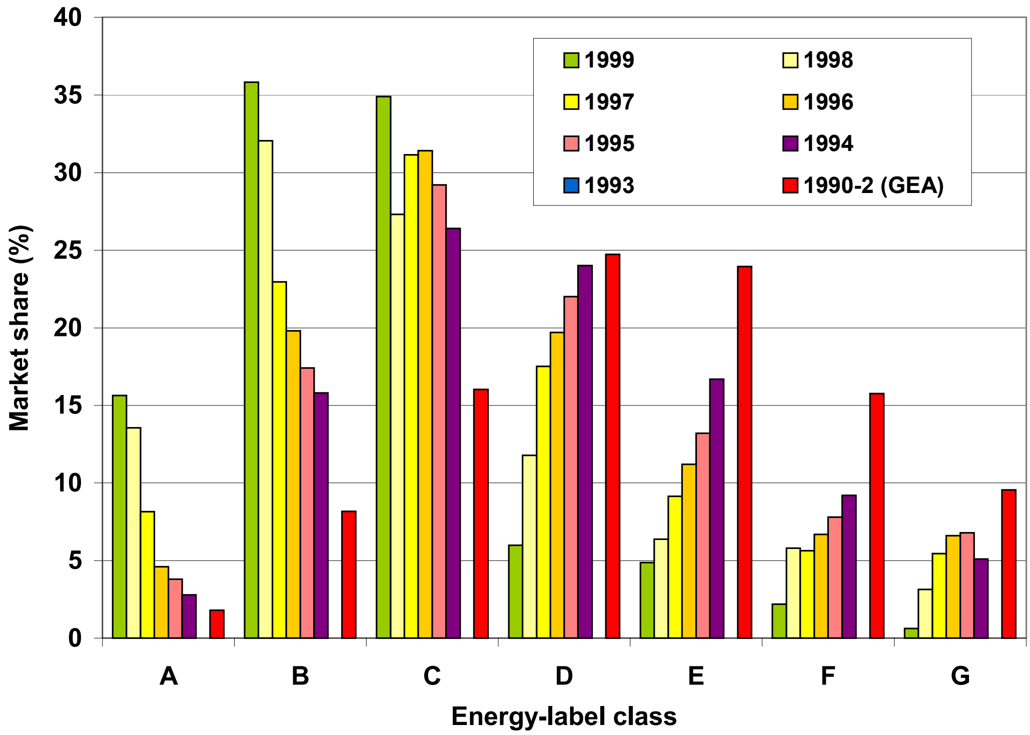
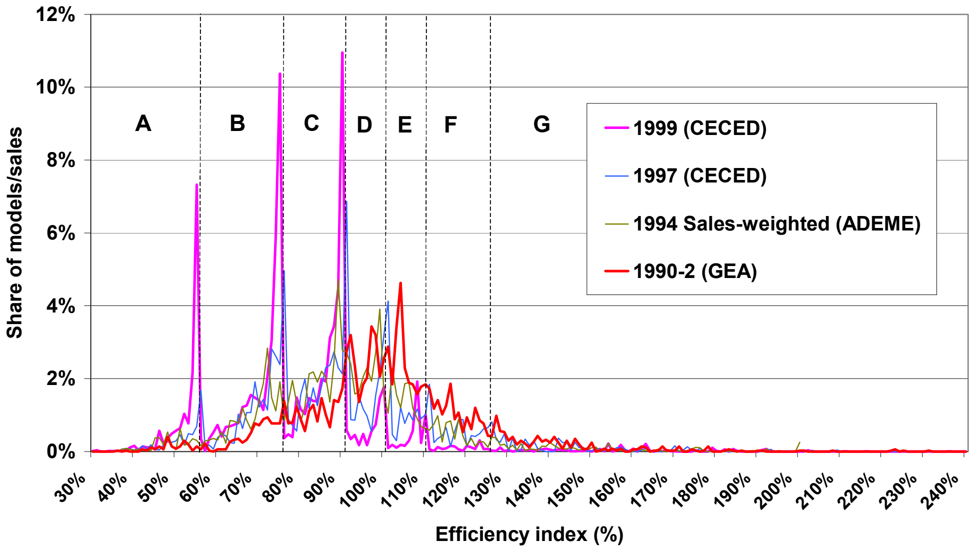


Figure 3. EU cold appliance market shares by labelling class from 1990–92 to 1999 (PW Consulting & ADEME 1998, 2000b). (Neither data for 1999 and 1998 taken from the CECED databases nor the 1990–92 GEA data are sales-weighted; data for 1994–97 are sales-weighted and are taken from the monitoring evaluation studies for the European Commission (PW Consulting & ADEME 1998, 2000a))

[5] The sales-weighted average efficiency is slightly higher than the corresponding model-weighted average efficiency derived from the CECED databases in both 1996 and 1997, albeit that the difference was greater in 1997 than 1996. This may indicate a growing consumer response to the label as its implementation by Member State was extended over this period.

This growing labelling impact is clearly apparent from inspection of the evolution in the distribution of the cold appliance market expressed as a function of the energy efficiency index (Figure 4). It is evident from the statistical analysis of the cold appliance databases that almost all new products now are designed to meet a specific energy-label class threshold, usually to within a margin of just one or two units of EEI, and that by corollary none of the manufacturers are disinterested in the market influence of the label.



Energy consumption trends

Figure 4. Distribution of cold appliances for sale in the EU, by energy-efficiency index (EEI). (PW Consulting & ADEME 2000b)

The average energy consumption of cold appliances declined from ~450 kWh/year in 1990-92 to an estimated 364 kWh/year immediately post MEPS (Table 2).

Table 2 Cold appliance sales-weighted annual average energy consumption for 1994 to 1997 (kWh/year) [1,2]

	EU	Aus	Bel	Den	Fra	GB	Ger	Ita	Nl	Por	Spa	Swe
1999 [2] [3]	364.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999 [1] [4]	378.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	401.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	398.4	323.1	404.8	401.2	430.9	430.5	307.5	458.4	355.3	NA	499.9	428.1
1996	406.1	333.0	427.0	406.7	445.5	441.0	313.5	465.2	368.8	488.9	511.5	422.5
1995	410.9	340.0	433.1	413.5	455.7	443.6	317.5	483.1	380.6	NA	526.8	423.1
1994	409.5	343.1	440.2	NA	458.7	411.6	328.8	485.6	398.1	NA	516.6	NA
1990–92 (GEA)	449.8	NA	NA	415.0	473.4	468.7	403.5	529.1	429.0	642.7	538.1	NA

1 The sales-weighted data for 1994 to 1996 does not include sales of cold appliances with unknown energy consumption data. *Source:* PW Consulting & ADEME 2000a.

2 Neither the 1998 and 1999 data nor the GEA data for 1990–92 are sales-weighted. The 1998 and 1999 data are derived from the CECED cold appliance energy database, which covers at least 90% of the cold appliances on the EU market in the respective years.

3 Derived by considering only those models for sale in 1999 that would pass the minimum energy performance standards (MEPS) requirements implemented in September 1999.

4 Covers all cold appliances for sale in 1999, including those that would not pass the MEPS requirements implemented in September 1999.

The comparatively static sales-weighted annual average energy consumption of cold appliances between 1994 and 1997 is partly explained by a corresponding increase in their sales-weighted average volume. Between 1994 and 1997 the average adjusted volume of the cold appliances sold in the EU increased by 16.1 litres from 284.3 litres to 300.4 litres. Furthermore, there is evidence of some significant changes in market share by cold appliance category from 1994 to 1997. Refrigerator-freezers increased their absolute share of the total cold appliance market by 5.6% to attain 45.3% of the entire market. Most of this increase is accounted for by a decline in sales of refrigerators with a 3-star frozen food compartment which lost 4.4% of total market share or some 44% in relative terms.

The sales-weighted average price of cold appliances decreased by 4.0% from 1996 to 1997 to 413.6 ECU. Prior to this the sales-weighted average price had increased by 5.4% from 408.7 ECU in 1994 to 430.8 ECU in 1996. The price per litre of adjusted volume was 4.2% less in 1997 than in 1994. For the European market as a whole and within most Member States there appears to be a significant positive correlation between average price and average efficiency such that an average A class appliance was 128 ECU (+31%) more expensive than the average of all appliances sold in the EU and the average B class appliance was 29.7 ECU (+7%) more expensive. However, much of this difference is as likely to be due to cross-correlations between brand, country of sale, and efficiency.

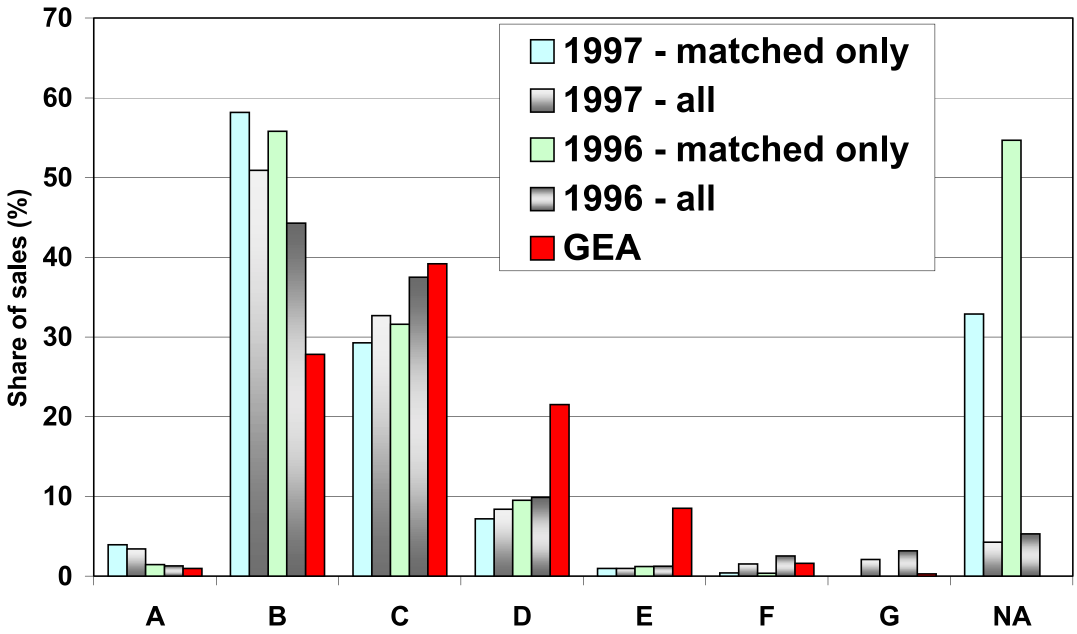
2.3 CLOTHES WASHER MARKET TRENDS

Clothes washer energy efficiency

An analysis of the matched sales and technical database gives the evolution of EU clothes washer sales by energy label class from 1996 to 1997 shown in Figure 5. There was some doubt concerning some of the energy consumption data for clothes washers due to a change in the test procedure in 1995 from a 90 ºC wash temperature to a 60 ºC wash temperature as well as a change in the test load. This complicated the analysis of the energy and efficiency trends as it was not always clear under which version of the test procedure the energy consumption data in the raw sales databases had been measured. Although the CECED data was entirely tested at 60 ºC it seems likely that due to the transition from one test procedure to another that not all models available for sale on the market were included in the 1996 CECED database and to a lesser extent the 1997 database. As a result the share of sales for successfully matched models, for which the energy consumption was certainly tested under the new test procedure, was a comparatively low 45% in 1996 and 67% in 1997. On the other hand the share of sales having potentially correct energy consumption data from all sources was 95% in 1996 and 96% in 1997. For this reason the results are presented separately for the matched-models only and for all models.

Over the two year period, which coincides with the debut of the energy labelling scheme, there was a slight shift to higher efficiency classes such that by 1997 class A appliances accounted for 4% of total sales and class A to D appliances for 98.8% of sales among the matched-only models. For the ‘all model’ sample the share of A to D class appliance sales was 95.4%. These findings suggest that the market in 1997 was on course to satisfy the conditions of the voluntary agreement negotiated between CECED and the European Commission by which most E, F and G class appliances would be removed from the market by 1998.

If the distribution of sales by energy label class is compared with the distribution of models by label class in the GEA database[6] there has been a significant efficiency improvement although the GEA data is not sales-weighted and hence provides a less reliable portrait of the appliance market.



1 The 1997 and 1996 data is does not cover exactly the same EU countries. NA = Not Available. 'GEA' is non-sales-weighted data gathered for the GEA study completed in 1995.

Figure 5 Share of EU annual clothes washer sales by labelling class from 1996 to 1997 – for matched-only and all models[1] (PW Consulting & ADEME 2000a)

The analysis of the combined database indicates that the average specific energy consumption of clothes washers sold in the EU in 1997 for matched-models only was 0.243 kWh/cycle/kg, some 2.8% lower (more efficient) than in 1996 (Table 3) and between 15% and 19.0% more efficient than the none sales-

[6] A database of models offered for sale in most EU countries assembled for the GEA (1995) *Washing machines, driers and dishwashers* the Group for Efficient Appliances working group of the European Energy Network for the Danish Energy Agency and the SAVE programme of DG XVII of the European Commission ISBN 87-7844-016-5, June.

weighted data in the GEA model database depending on the correction applied for the change in test procedure[7].

If the 'all model' data is considered the EU sales-weighted average specific energy consumption is slightly higher at 0.245 kWh/cycle/kg but otherwise the trends are very similar.

Table 3 Clothes washer sales-weighted annual average specific energy consumption for 1996 to 1997 (kWh/cycle/kg): matched models only[1]

	EU	Aus	Bel	Fra	GB	Ger	Ita	Nl	Spa	Swe
1997	0.243	0.240	0.237	0.258	0.239	0.233	0.255	0.232	0.236	0.242
1996	0.250	0.248	-	0.264	0.248	0.244	0.255	0.247	0.235	-
GEA[2,3]	0.286	0.275	0.242	0.308	-	0.275	0.286	0.275	-	0.264

[1]The data does not include sales of clothes washers with unknown specific energy consumption and thus the cited EU average values are the sales-weighted values based on those countries where data is available. The GEA data is not sales-weighted and includes appliances available for sale on the national markets as assembled in the 1995 GEA study.
[2]The GEA data is adjusted from a 90°C wash cycle by multiplying by 0.6 and then corrected for the change in wash load in the new test procedure by multiplying by 1.1
[3]CECED have indicated that the average specific energy consumption of the GEA data when adjusted to conditions under the new test procedure would be 0.3 kWh/cycle/kg

3. Lagging Indicator Programme Evaluations and Impacts

Knowing how the efficiency of products is moving under standard test conditions does not immediately allow the impact of the policy measures to be determined, especially with regard to products for which there is a weak correspondence between energy consumption under standard test conditions and the *in situ* consumption. Thus in addition to tracking the leading market indicators previously discussed the European Commission has also made various enquiries aimed at:

- establishing the degree to which improvement in product efficiency under standard test conditions is translated into actual *in-situ* energy savings
- determining total energy consumption and associated CO_2 emissions by equipment end-use
- applying the results of the estimated energy consumption, CO_2 emissions and life cycle costs of equipment in the residential and tertiary sectors under business as usual and policy measure cases to determine policy impacts.

3.1 END-USE METERING RESULTS

A number of end-use metering campaigns have been conducted in the EU aimed at establishing detailed *in situ* energy and power consumption data in specific locations. Average annual energy-consumption results by end use from some of these campaigns are summarised in Table 4. This data shows the spread in values found between countries and campaigns but also shows some tentative evidence of a temporal decline *in situ* energy consumption for specific products that have been targeted by Community policy measures: notably refrigerators and freezers. Longer time series of such campaigns should show these impacts more clearly.

---

[7] CECED state that the average specific energy consumption of clothes washers in the GEA database would be 0.3 kWh/cycle/kg if the data is adjusted for the change in the test procedure.

The detailed results from these metering campaigns have been extremely helpful in gathering appliance usage data that enables energy test results determined under standard test conditions to be converted into corresponding *in situ* consumption values. User behaviour data e.g. the number of clothes washer wash-cycles at specific wash temperatures per week, can be gathered and used to make estimates of the impact of improvements in standard test condition efficiency levels upon the final energy consumed in use. Furthermore these campaigns can confirm that substituting high efficiency equipment for existing equipment does produce the expected savings. The Ecodrôme campaign conducted in France produced spectacular evidence of this as shown in Figure 6. The Ecodrôme campaign in France monitored major electricity-specific end-uses in 20 households over 1 year and then repeated the exercise after the initial appliance stock had been substituted with more or less identical but energy-efficient appliances (mostly A- and some B-class appliances). The resulting savings were impressive, with an average measured reduction of 1192 kWh/year per household, equivalent to a 37% fall in average total household electricity consumption. Had some of the households not been using electricity for water and space heating, the share of total household electricity consumption savings would have been even greater, but in all cases the householders were very happy with the new appliance stock.

Table 4. Average annual end-use electricity consumption for selected residential appliances measured in 6 end-use metering campaigns.

Appliance	Sweden (Nutek),	Portugal (CCE),	UK (Electricity Association)		France Ciel	France Ecodrôme	France Ecuel
	1992	1996	1995	Up to 1998	1995	1996	1998
Refrigerators	485	274	320	285	370	362	274
Refrigerator-Freezers	763	622	655	717	570	721	592
Freezers	1048	729	615	584	614	619	555
Clothes-washers	315	145	240	213–231	234	262	–
Dishwashers	568	284	360	364–393	280	290	–
Clothes-dryers	372	–	260	220–288	437	373	427
TVs	–	152	–	–	138	201	–
HiFis	–	–	–	–	33	–	–
Vacuum cleaners	–	–	–	–	18	–	–
Lighting	–	–	–	–	–	465	–
Irons	–	–	–	–	42	–	–
Electric ovens	194	–	–	461	–	–	224
Electric hobs	317	–	–	555	–	–	273
Microwave ovens	50	–	–	–	49	–	75
All electric Cooking	570	–	–	–	–	–	568

Abbreviation: CCE = Centro para a Conservação de Energia

Source: Sidler & Waide (1999)

Useful as these campaigns are they have been conducted far too infrequently and often without the use of adequate statistical sampling and data analysis techniques that would have allowed the results to be more generally applicable. Nonetheless the data they have rendered has more than justified their conduct and in some cases has highlighted significant errors in earlier conceptions of energy consumption by end-use.

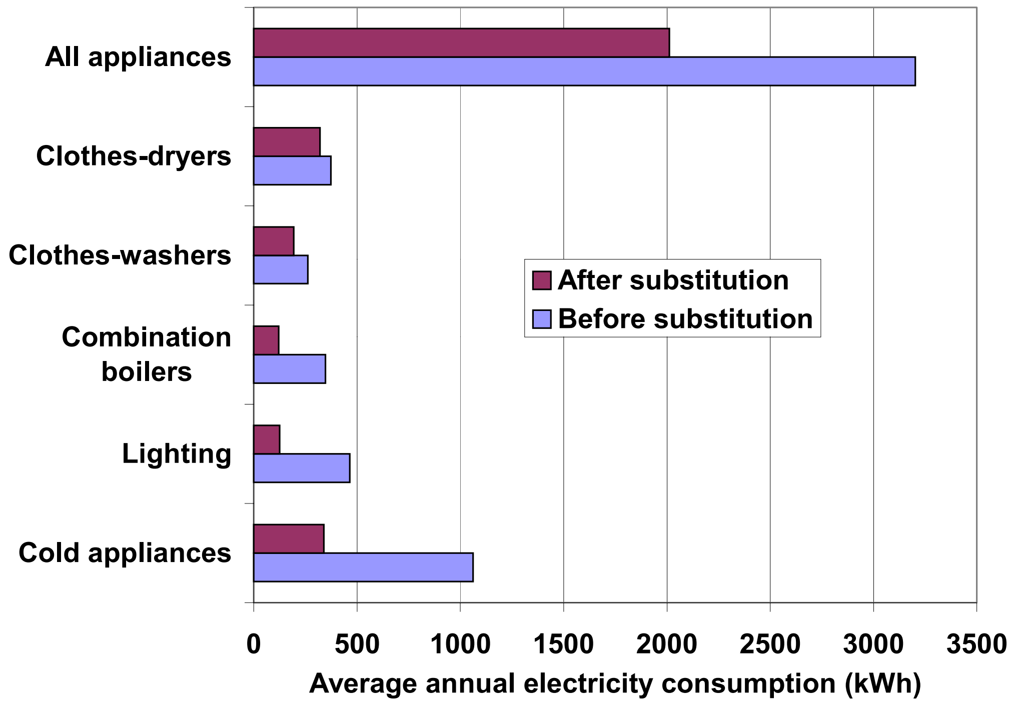


Figure 6. Annual electricity consumption by end-use in French households before and after substitution of existing stock with energy-efficient appliances (Ecodrôme 1998).

3.2 DETERMINATION OF TOTAL ENERGY CONSUMPTION AND ASSOCIATED CO2 EMISSIONS BY EQUIPMENT END-USE

In some instances the data gathered on new product energy and efficiency trends has been combined with sales, ownership and usage data to make estimations of total energy consumption levels by end-use. This information has also been entered into product energy simulation stock models and used to make energy consumption projections. Leading indicator results can be analysed and applied to make estimates of hypothetical historic energy and efficiency levels had no equipment efficiency policy measures been implemented i.e. an historic 'business as usual scenario'. This data can then be entered in the same stock model as the data for the actual energy and efficiency trends in order to produce estimates of the impact of the policy measures up to the present time. The same scenarios can then be projected into the future to try and analyse the likely longer-term consequences of a given set of policy measures. For some products, most notably cold appliances, clothes washers, air conditioners, TVs and ovens this exercise has been done relatively recently using current data. For other products more simplistic projections have been made using less reliable data.

Table 5 shows some recent estimates of the energy consumption by electrical end-use for residential equipment in the EU in 1990 and 1995. The same table shows projections of energy consumption to 2010 under a business as usual scenario (i.e. under a scenario where no new appliance efficiency policy measures are introduced after 2000) and under an enhanced policy scenario where fresh policy measures are implemented in order to meet the Community's Kyoto CO_2 targets. If no new policy measures are introduced after 2000 residential electricity consumption is forecast to rise to 722.5 TWh/year in 2010 across the EU. However, it is also forecast that an additional 156 TWh/year of residential electricity demand can be avoided by 2010 through the implementation of new and additional policies aimed at accelerating the rate at which new products attain average least life cycle cost efficiency levels. Were this to happen residential electricity consumption could be lowered by just over 4% compared to 1990 levels despite a strong underlying growth in the numbers and use of electrical equipment in EU households over the same period. These projections have been made using leading and lagging indicator data gathered in the course of the various programme design, monitoring and evaluation exercises conducted in the EU.

Table 5: Residential electrical equipment energy consumption and savings potential in the EU (ECCP 2000)

	Electricity consumption (TWh/year)				Electricity energy savings in 2010 (TWh/year)	
	1990	1995	2010 (BAU)	2010 (Policy scenario)	Savings 1990 actual vs. 2010 policy scenario	Savings 2010 BAU Vs 2010 policy scenario
Cold appliances	123.6	118.4	96.2	80.7	42.9	15.5
Clothes-washers	40.0	33.4	23.7	17.1	22.9	6.6
Dishwashers	12.8	14.1	17.6	15.6	-2.8	2.0
Dryers	8.2	10.6	14	11.4	-3.2	2.6
Room air-conditioners	1.6	2.5	7.5	6.7	-5.1	0.8
Electric storage water heater	72	68	68	65.2	6.8	2.8
Electric ovens	15.1	16.2	16.5	16.1	-1.0	0.4
Consumer electronics stand-by	15	20	26	4	11	22
Lighting	80	89	112	84	-4.0	27.4
Consumer electronics on mode	15	25	50	40	-25	10
Office equipment	2	10	65	32	-29	33
Heat pump/domestic electric heating	150	150	150	125	25	25
Miscellaneous	26.0	29	39	39	-13	0
Central heating circulation pumps	30	32	37	30	0	7
Total	591.3	618.2	722.5	566.8	24.5	155.7

The same data is converted into estimates of CO_2 emissions using a simple average emission factor approach from which it is calculated that some 70.4 Mt of CO_2/year would be avoided in 2010 through implementation of these measures.

Thus far, the Commission has not conducted a comprehensive appraisal of the quantitative impact of their equipment efficiency policy measures to date although the data needed to do so has mostly been gathered.

4. EVALUATION OF PROGRAMME IMPLEMENTATION

The second main type of evaluation has centred on programme implementation. The *Cool Labels* study conducted in 1997 aimed to evaluate the implementation of the first EU energy labelling Directive for cold appliances (ECU 1998). The evaluation considered the following main areas:

- response of government in each Member State
- compliance of dealers and retailers
- response of consumers
- response of manufacturers
- response of retailers.

The study reported significant delays in the implementation of the EU Directive into national law. Despite being required to implement the Directive from the 1.1.95 only four Member States actually did this. Another seven did so by the end of 1995 but in the worst case, for Italy, the Directive was not implemented until May 1998.

An extensive survey of retailer outlets found that by the summer of 1997 only 56% of cold appliances on display in shops across the EU were fully labelled. Compliance levels per outlet varied from 0 to 100% and not surprisingly there were significant variations between Member States such that in general those states which had not implemented the label legislation had significantly lower compliance levels. In part the relatively low compliance in energy labelling coverage at that time was a function of the label being composed of two pieces due to the existence of 10 major languages in the EU. The label background contains language-specific written information which therefore has to be supplied at the Member State level. The manufacturer only supplies a product information fiche which contains the non-language specific information about the product. This is applied to the label background by the retailer and mounted on the front of the appliance.

This approach was probably unavoidable but necessarily shifts the responsibility of correctly labelling the product from the manufacturer to the retailer and is thus more difficult to implement and enforce. The survey found that all manufacturers were supplying product fiches with their products as required and the problem lay with the retailers who were not always assembling and applying the two elements on the front of the equipment. More recent information suggests that labelling coverage has increased now that there is greater familiarity with the scheme; however, a fresh survey has not yet been conducted across the EU.

Unsurprisingly, there was found to be a strong correlation between the level of fully labelled products and the reported influence of the label on consumer's purchasing decisions. A more recent consumer attitudes survey conducted in five major countries found that of those who saw the label some 24% reported to be strongly influenced by it and some 75% to have been influenced by it to some extent (PW Consulting & ADEME 2000b). These findings are supported by the quantitative investigation of the efficiency sales data which shows that there has been a significantly faster rate of annual cold appliance efficiency improvement in those Member States where the product of the label coverage and the reported interest of the consumer in product energy efficiency is highest.

Accuracy of declared efficiency information

Although manufacturers appear to have fully complied with respect to label supply their compliance with regard to the accuracy of the declared energy and efficiency levels is less impressive. The *Cool Labels* study assembled independent test data from European consumers' associations regarding the accuracy of manufacturer declared energy consumption and efficiency levels. The results found that the measurements of energy and useful volume made by consumers' associations lead to systematically lower energy label ratings than the manufacturers own declared values and often by more than one label class.

These findings have prompted Member States and the Commission to devote significantly more attention to this issue and the European manufacturer's association has since established a formal internal self-policing agreement wherein manufacturers can challenge competitors claims and offending party's will carry the testing costs and relabel any inaccurately labelled products. It is still common for systematic differences to be reported between manufacturer and consumer association test results but of late these seem to be more typically explained by the manufacturer taking advantage of the tolerances permitted within the test procedures than by gross abuses. Despite these concerns the consumer's association data assembled by the Cool Labels study suggested that there was a slight reduction in the average discrepancy between consumer association and manufacturer reported efficiency levels since the introduction of the energy labelling scheme.

6. CONCLUSIONS AND POTENTIAL IMPROVEMENTS

The quantitative and qualitative appliance efficiency evaluations conducted in the EU have identified significant improvements in average efficiency for those products which have been the subject of targeted policy measures and have been useful in identifying weaknesses in programme design and implementation. The quantified analysis of leading market data (sales) indicators has demonstrated a substantial impact from energy labelling and MEPS (and to a lesser extent, voluntary efficiency agreements), that has amply justified these policies. The same analyses have shown what more remains to be achieved before market average product efficiency levels attain consumer least life cycle cost levels and/or the Community's CO_2 emission targets are met.

Despite these achievements much could be done to improve these evaluations. The quantitative evaluations have been conducted in a comparatively piecemeal way with some products and years being excluded. In particular the exclusion of data from earlier years makes it difficult to establish a justifiable trend line from which comparatively reliable business as usual scenarios could be developed for policy impact comparison purposes. It would also have been preferable had more consistent efforts been made to establish comprehensive data at the outset of each new technical and policy product investigation so that a more reliable snapshot of the market in the pre-policy development phase could have been established. Similarly, more might have been done to gather data in the intervals between the initial product technical and policy investigations and the introduction of the policy measures. Another weakness has been a failure to conduct sufficient comparative testing to establish the impact of changes in standard product energy test procedures so that data before and after the change can be properly compared.

Lastly, thus far there is no single combined residential end-use energy consumption model being used in the EU to provide a coherent and consistent analysis of historic and projected policy impacts. Rather, such analyses have been done on a product-by-product basis by different consultants following partially inconsistent approaches. This makes the comparison of policy outcomes across products less transparent

7. REFERENCES AND BRLIOGRAPHY

Energy labelling implementation Directives:

Directive 94/2/EC - Official Journal L 45, 17.02.1994
Commission Directive of 21 January 1994 implementing Council Directive 92/75/EEC with regard to energy labelling of household electric refrigerators, freezers and their combinations.
Directive 95/12/EC - Official Journal L 136, 21.06.1995
Commission Directive of 23 May 1995 implementing Council Directive 92/75/EEC with regard to energy labelling of household washing machines.
Amended by Directive 96/89/EC - Official Journal L 388, 28.12.1996.
Directive 95/13/EC - Official Journal L 136, 21.06.1995
Commission Directive of 23 May 1995 implementing Council Directive 92/75/EEC with regard to energy labelling of household electric tumble dryers.
Directive 96/60/EC - Official Journal L 266, 18.10.1996
Commission Directive of 19 September 1996 implementing Council Directive 92/75/EEC with regard to energy labelling of household combined washer-dryers.
Directive 97/17/EC - Official Journal L 118, 07.05.1997
Commission Directive of 16 April 1997 implementing Council Directive 92/75/EEC with regard to energy labelling of household dishwashers.
Amended by the following measure:
Directive 1999/9/EC - Official Journal L 56, 04.03.1999
Directive 98/11/EC - Official Journal L 71, 10.03.1998
Commission Directive 98/11/EC of 27 January 1998 implementing Council Directive 92/75/EEC with regard to energy labelling of household lamps.

CIEL (1997) An electrical end-use measurement campaign in the French domestic sector: translation into English by PW Consulting from the original French language report by Cabinet Conseil SIDLER for the SAVE programme of DG-XVII of the European Commission, contract no. 4.1031/93.58 and ADEME. June.

ECCP (2000) Estimates generated by Joint-sub working group on Energy consumption in Products and Industrial Processes of the European Climate Change Programme of the European Commission.

Ecodrôme (1998), *Etude expérimentale des appareils electroménagers à haute efficacité énergétique placés en situation ré elle*, Cabinet Olivier Sidler for the SAVE programme of DG-XVII of the European Commission, contract no.4.1031/S/94-093

ECU (1998) *Cool Labels: The first Three Years of the European Energy Label*, Environmental Change Unit, University of Oxford, September.

EERAC (1999) *Energy Efficiency of Room Air Conditioners (EERAC)*, Ecoles des Mines de Paris for DG-TREN.

EVA (1998) *Analysis of Energy Efficiency of Domestic Electric Storage Water Heaters*, EVA for DG-XVII, March.

GEA (1993) *Study on energy efficiency standards for domestic refrigeration appliances*, Group for Efficient Appliances for DG-XVII of the Commission of the European Communities, March.

GEA (1995) *Washing Machines, Dryers and Dishwashers*, the Group for Efficient Appliances for DG-XVII of the Commission of the European Communities, published by the Danish Energy Agency.

Lebot, B., Waide, P. & Newman, J. (2001) 'The European appliance labelling programme' *Lessons Learned in Asia: Regional Symposium on Energy Efficiency Standards and Labelling*, United Nations Conference Centre (UNCC), Bangkok, Thailand, May.

Novem (1996) *Study of Standby Losses and Energy Savings Potential for Television and Video Recorder Sets in Europe*, Novem for DG-XVII of the Commission of the European Communities.

Novem (1998) *Analysis of Energy Consumption and Efficiency Potential for TVs in on-mode*, Contract EC-DGXVII 4.1031/D/97-023, Novem for DG-XVII of the Commission of the European Communities, November.

PW Consulting & ADEME (1998) *Monitoring of energy efficiency trends of European domestic refrigeration appliances: final report*, SAVE contract no. XVII/4.1031/D/97-021, PW Consulting and ADEME for DG TREN of the European Commission, December.

PW Consulting & ADEME (2000a) *Monitoring of energy efficiency trends of refrigerators, freezers, washing machines and washer-dryers sold in the EU* SAVE contract N° XVII/4.1031/Z/98-251 PW Consulting and ADEME for DG TREN of the European Commission, May.

PW Consulting & ADEME (2000b) *Cold II: The revision of energy labelling and minimum energy performance standards for domestic refrigeration appliances*, PW Consulting on behalf of ADEME, with Novem, Ecole des Mines de Paris, VHK, ENEA and TNO and assistance from CECED and AHAM for DG-TREN of the European Commission, SAVE contract No. XVII/4.1031/Z/98-269, December.

Sidler, 0. & Waide. P. (1999) 'Metering matters' *Appliance Efficiency* 4/99, Vol 3.

Sidler, 0., Lenci, O. and Waide. P. (1999) *Electricity Demand Management: an experimental study of cooking appliances, domestic cold appliances and clothes-drying appliances in 100 households: Project ECUEL* Cabinet Olivier Sidler and PW Consulting for the European Commission, Ademe and Electricité de France, SAVE contract No. 4.1031/Z/96-164, June.

Sidler, O., Waide, P. and Lebot, B. (2000) 'An experimental investigation of cooking appliances, domestic cold appliances and clothes dryers in 100 French households' presented at the *ACEEE Summer Study*, Asilomar, California, August.

TTS (2000) *Efficient Domestic Ovens*, TTS Institute for DG-TREN of the Commission of the European Communities.

Vine, E., P. du Pont, and Waide, P. (2000). 'Evaluating the Impact of Appliance Efficiency Labeling Programs and Standards,' in S. Wiel and J. McMahon (eds.), *Energy Efficiency Labels and Standards: A Guidebook for Appliances, Equipment and Lighting*.

Waide, P., Lebot, B and Hinnels, M. (1997) 'Appliance energy standards in Europe', *Energy and Buildings* 26(1).

Waide. P. (1999) '*Market analysis and effect of EU labelling and standards: the example of cold appliances*,' presented at the *SAVE conference for an energy efficient millenium*, Graz, Austria, November.

Waide, P. (2000) *Technical and economic potentials to raise energy efficiency among residential appliances in the EU* for the Joint-sub working group on Energy consumption in Products and Industrial Processes of the European Climate Change Programme, DG-Environment, contract B4-3040/2000/240822/MAR/A2, November.

Waide, P. (2001) 'Major appliance energy efficiency trends in the European Union' presented at the *2nd International Conference on Energy Efficiency in Household Appliances and Lighting*, Naples, Italy, September 27-29, 2000, Ed.s P. Bertoldi, A. Ricci & A. de Almeida, Springer-Verlag, Heidelberg.