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Standby consumption of household appliances

prepared by

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Contents

Summary

The electricity consumption of large household appliances is well documented for conventional operating cycles, and their classification from A to G for energy label purposes is based on the available data. However, the power consumption of these appliances in standby mode is becoming an increasingly significant (though still little known) problem. Many smaller household appliances such as coffee machines and microwave ovens also yield standby losses, and given the trend towards comfort functions such as status display, timer switching, programme selection, etc., the level of stand-by consumption in the area of household appliances is constantly increasing. And an increase in the networking of household appliances would intensify the problem of standby losses still further.

In the first stage of this project we examined the present status of scientific knowledge by carrying out international research. We followed this up by conducting a representative market survey concerning the ownership and use of coffee machines and steamers – appliances about which very little data were previously available. Our survey encompassed 1,129 households, 225 of which were in the French-speaking part of Switzerland. We then proceeded to carry out detailed standby measurements on more than 60 household appliances. Standby measurements are very demanding in that they often involve very low power, idle currents, harmonics and three-phase connections. Finally, we evaluated our findings and formulated recommendations and strategies for reducing standby losses.

Our representative **market survey** revealed that 64% of households in Switzerland use one or more coffee machines. We were surprised to find that household coffee machines are also very widely used in offices and business premises: almost two-thirds (64%) of the participants in the survey stated that they have a household coffee machine at their disposal at the office! On average, 6.3 cups of coffee are prepared per day and appliance, or 2,000 per annum (projection based on 48 weeks, or 336 days of use). The answers to the question regarding switching off the appliance after use indicate highly energy-conscious behaviour: 70% of the participants in the survey stated that they switch their coffee machine off after use or when their coffee break is over, while 9% use an automatic switch-off function. This indicates that only approximately 20% of coffee machines in households are only switched off at night or not switched off at all. Not surprisingly, the situation in offices is very different: here, 47% of these coffee machines (household appliances, not professional models!) are only switched off at night, 29% are not switched off at all, and switch-off times are unclear for the remaining 24%. There is therefore enormous efficiency potential here. We also determined that Swiss households use an oven 2.5 times per week on average.

Our measurements and evaluations show that the **total standby losses for household appliances in Switzerland amount to approximately 400 GWh**, and the associated electricity costs are around 80 million Swiss francs per annum. The greatest proportion – approximately 60 million – is attributable to heating requirements for coffee machines. The proportion of standby losses to overall electricity consumption for a given appliance is also of interest, since this is of relevance in terms of energy efficiency. Here the respective figures are 84% for coffee machines in offices, 60% for coffee machines in private households, and 48% for induction cooker tops, followed by appliances with lower standby losses such as microwave ovens (29%), ovens (18%) and dishwashers (3%).

The main technical criteria for **enhancing the energy efficiency** of coffee machines are an automatic switch-off function and improved insulation of boilers. According to the latest manufacturers' specifications, it is apparently possible to significantly reduce the surprisingly high losses associated with control devices. Generally speaking, power supply units still possess efficiency potential, and in this connection measures to bring about improvements have already been initiated by the industry within the scope of the EU Code of Conduct on Efficiency of External Power Supplies. However, a further increase in the number of appliances with standby

functions and in the networking of household appliances means we have to anticipate still higher standby losses over the next few years.

Since it appears that significant efficiency potentials can be utilised with the aid of relatively simple measures, we recommend that steps should be taken to enhance efficiency levels. Here it is essential to formulate detailed **guidelines** and define **testing standards** for declaring standby losses. The European Commission is currently working on the formulation of guidelines for measuring standby consumption. However, the current draft does not incorporate losses associated with heating requirements for coffee machines, and this means there is a danger that the largest category of appliances responsible for standby losses may not be included in the standard at all.

Based on the findings obtained from our measurements in the course of this project, we have drawn up a proposal for an **energy declaration for coffee machines**. This means that testing centres now have a tool at their disposal for measuring and comparing standby losses. We also recommend that the relevant EU authorities should consider paving the way for the introduction of an energy label for coffee machines. The main arguments in favour of this move are the high power consumption of coffee machines and utilisation of significant efficiency potential with the aid of technical measures, plus the fact that measuring procedures are relatively easy to define. Manufacturers should also be notified about the technical potentials and encouraged to declare standby losses. And with a variety of stock categories, the retail trade has the option of offering more energy-efficient models and including energy efficiency requirements in their lists of specifications.

Abstract (English)

While the electricity consumption of household appliances is well documented for conventional operating cycles, there are still many gaps in our knowledge regarding consumption in standby status. The aim of this project was to obtain new findings by carrying out market surveys, measurements and evaluations. The total standby losses for household appliances in Switzerland amount to approximately 400 GWh. The resulting electricity costs amount to around 80 million Swiss francs. The greatest proportion – approximately 80 percent – is attributable to heating requirements of coffee machines. In some appliance categories the proportion of standby losses to overall electricity consumption is extremely high. The figure for coffee machines in offices is 84 percent, for coffee machines in private households it is 60 percent, and for induction cookers it is 48 percent. The main technical criteria for enhancing the energy efficiency of coffee machines are an automatic switch-off function and improved insulation of boilers. According to the latest manufacturers‘ specifications, it is apparently possible to significantly reduce the surprisingly high losses associated with control devices. Generally speaking, power supply units still possess efficiency potential. It is now possible to reduce consumption levels from 4 W to below 0.5 W. Since it appears that significant efficiency potentials can be utilised with the aid of relatively simple measures, it is recommended that steps should be taken to enhance efficiency levels. Here it is essential to formulate detailed guidelines and define testing standards for declaring standby losses. The proposal put forward here for an energy declaration for coffee machines is intended to help test centres, EU authorities and manufacturers carry out uniform measurements and evaluations. Given the high power consumption of coffee machines, their significant efficiency potentials and relatively simple measuring procedures, we recommend the relevant EU commission to pave the way for the introduction of an energy label for coffee machines.

Abstract (German)

Der Elektrizitätsverbrauch von Haushaltgeräten ist für die klassischen Betriebszyklen recht gut bekannt, hingegen bestehen zum Standby-Zustand noch wesentliche Wissenslücken. In diesem Projekt wurden mit Marktbefragungen, Messungen und Analysen neue Kenntnisse hinzu gewonnen. Die Standby-Verluste der Haushaltgeräte in der Schweiz summieren sich gesamthaft auf rund 400 GWh. Dies führt zu Stromkosten von rund 80 Millionen Franken pro Jahr. Der grösste Anteil – rund 80 Prozent – ist der Warmhaltung von Kaffeemaschinen anzulasten. Bei einigen Gerätekategorien ist der Anteil des Standby-Verbrauchs am gesamten Elektrizitätsverbrauch der Geräte extrem hoch. Bei Kaffeemaschinen am Arbeitsplatz beträgt der Anteil der Standby-Verluste 84%, bei Kaffeemaschinen im Haushalt 60% und bei Induktions-Kochfeldern 48%. Technische Ansatzpunkte zur Effizienzsteigerung sind bei den Kaffeemaschinen insbesondere Auto-off-Funktionen und bessere Wärmedämmung der Boiler. Bei den Induktionskochfeldern lassen sich die überraschend hohen Verluste für die Steuerungen offenbar massiv reduzieren, wie neuste Herstellerangaben dokumentieren. Generell liegen bei den Netzteilen noch Potenziale; die früher üblichen Leistungsaufnahmen von 4 W und mehr lassen sich bis unter 0.5 W vermindern. Da offenbar grosse Sparpotenziale mit einfachen technischen Mitteln zu erschliessen sind, wird empfohlen, Massnahmen zur Effizienzsteigerung zu ergreifen. Die entscheidende Voraussetzung für alle Massnahmen sind praxisgerechte Richtlinien und Messnormen zur Deklaration der Standby-Verluste. Der hier erarbeitete Vorschlag zur Energie-Deklaration von Kaffeemaschinen soll Testinstitute, EU-Stellen und die Hersteller unterstützen, einheitlich messen und bewerten zu können. Aufgrund des hohen Energieverbrauchs der Kaffeemaschinen, der grossen Einspar-Potenziale sowie relativ einfach definierbarer Messverfahren wird der EU-Kommission empfohlen, die Einführung einer Energieetikettierung für Kaffeemaschinen einzuleiten.

Résumé (French)

La consommation d’électricité des appareils ménagers est assez bien connue pour les cycles de fonctionnement conventionnels. En revanche, les connaissances sont encore très lacunaires en ce qui concerne le mode "veille" (stand-by). A travers des enquêtes, des mesures et des analyses, ce projet a permis d’acquérir des connaissances nouvelles à cet égard. Les pertes en mode "veille" des appareils ménagers en Suisse représentent environ 400 GWh au total, soit un coût de quelque 80 millions de francs par année. La plus grande partie – à peu près 80 pour cent – est imputable au maintien de la température de fonctionnement des machines à café. Dans certaines catégories d’appareils, la part de la consommation en mode "veille" à la consommation globale d’électricité des appareils est extrêmement élevée. Elle s’élève à 84% pour les machines à café sur les lieux de travail, à 60% pour les machines à café dans les ménages et à 48% pour les plaques de cuisson à induction. Les possibilités techniques à disposition pour accroître l’efficacité énergétique sont notamment, pour les machines à café, les fonctions "auto-off" et une meilleure isolation thermique des chauffe-eau. S’agissant des plaques de cuisson à induction, les pertes étonnamment élevées liées aux commandes peuvent être massivement abaissées, si l’on en juge d’après les plus récentes indications des fabricants. Globalement, un potentiel d’économie d’énergie subsiste du côté des blocs d’alimentation: la puissance absorbée, qui était jusqu’ici de 4 W et plus, peut être ramenée à moins de 0,5 W. Etant donné que, en tout état de cause, des moyens techniques simples permettent de diminuer fortement la consommation d’électricité, la mise en œuvre de mesures destinées à accroître l’efficacité énergétique s’impose. Cela présuppose des directives axées sur la pratique et des normes de mesure pour la déclaration des pertes en mode "veille". La proposition élaborée ici en vue d’une déclaration énergétique des machines à café doit aider les instituts d’essais, les instances de l’UE et les fabricants à adopter un dispositif de mesure et d’évaluation uniforme. Compte tenu de la forte consommation d’énergie des machines à café, des potentiels d’économies subsistants et de la relative simplicité des procédés de mesure à définir, il est recommandé à la commission de l’UE de s’engager vers l’introduction d’un étiquetage énergétique pour les machines à café.

1. Methodology and procedure

The electricity consumption of household appliances is well documented for conventional operating cycles. However, the power consumption of these appliances in standby mode is becoming an increasingly significant (though still little known) problem. Even small kitchen appliances such as coffee machines, etc., often indicate high standby losses, and given the trend towards comfort functions such as status display, timer switching, programme selection, etc., the level of stand-by consumption in the area of household appliances is constantly increasing.

We therefore measured the power consumption of a variety of household appliance categories on a random sample basis and projected the findings to the whole country, taking account of distribution, market perspectives, usage, technological progress and other factors. We then outlined the main criteria for reducing or eliminating standby losses. Our project also supplements others in the area of electricity consumption that have since been completed: project [1] examined the feasibility of collecting data on electrical appliances, while project [2] studied the impacts of instruments and measures on the energy efficiency of electrical appliances.

For the following appliance categories, the **main findings** were based on information concerning standby functions, power consumption levels and, where appropriate, user behaviour:

- Ovens, steamers
- Induction and standard glass-ceramic cooker tops
- Refrigerators and freezers
- Dishwashers
- Washing machines and dryers
- Microwave ovens
- Coffee machines

We conducted a special study on the distribution and usage of household coffee machines and steamers, which was based on a representative survey in households.

The aim here was to use the findings to assess and present the perspectives concerning standby losses in household appliances, their proportion to overall electricity consumption, the outlook with respect to technological developments, and ways in which they can be reduced.

Procedure

In the first stage of this project we examined the present status of scientific knowledge by carrying out international research, while taking account of the situation with respect to existing international standards (*CECED, EU*) through an evaluation of the findings of the CEPE research project, “Energy declaration of electrical appliances” ([3], Dec. 2001).

We then followed this up by conducting a representative market survey concerning the distribution and usage of coffee machines and steamers. Our survey encompassed 1,129 households, 225 of which were in the French-speaking part of the country.

The next step was to carry out detailed standby measurements on more than 60 household appliances. For this purpose we put together a special set of measuring instruments. The measurements themselves were carried out at specialised retail outlets and major distributors, and in private households.

Finally, we evaluated our findings and formulated recommendations and strategies for reducing standby losses.

2. Standards, definition of standby

The term “standby” has not yet been definitively defined in the area of household appliances. In *IEC 62301* (Household Electrical Appliances – Measurement of Standby Power, [4]), which has not yet been officially approved, standby is defined as the lowest level of consumption that cannot be switched off.
This definition becomes problematic if a given appliance has two standby modes, and the higher level is on additional standby to receive a signal or command or for other functions. In the area of household appliances, examples include coffee machines, which are able to produce coffee immediately when they are in higher standby mode, i.e. are keeping the water-heating element hot, as well as dishwashers, washing machines and tumble dryers, which continue to consume power in higher standby mode after completion of the respective process and when the door is still closed.

With dishwashers and washing machines, measurements have shown that the difference between the two standby modes is very minor, and is thus of little significance here. However, given a limited definition of “standby” (“lowest level of consumption that cannot be switched off”), the very significant power consumption required by coffee machines for keeping the heating element warm clearly cannot be regarded as standby consumption. From the point of view of efficiency, it is not the definition that counts, but rather finding ways to minimise or optimise consumption.

3. Measurement methodology

3.1 Requirements

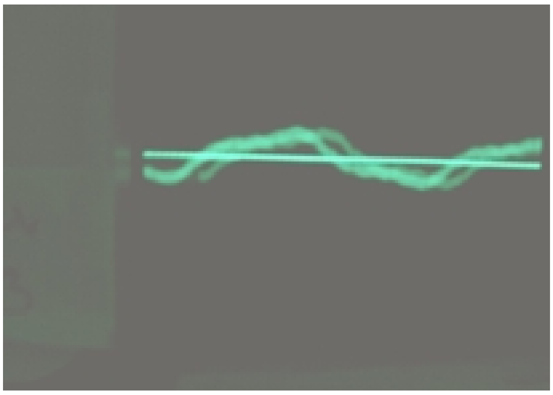
The measurement of standby consumption of household appliances differs from other measurement procedures in the following ways:

1. In most household appliances, the maximum power consumption is in the kilowatt range, since they contain heaters and/or motors. But in standby mode, the level is normally only a few watts. Measuring devices therefore have to be able to withstand (though not necessarily measure) high power levels yet measure low consumption levels with high accuracy.
2. Power supply units for standby functions usually indicate a low phi cosine (transformers, capacitors), and this calls for real power (active power) measurement. Furthermore, the rectifier load often gives rise to a distorted current flow, and this calls for at least a true RMS measurement up to approximately 1 kHz.
3. In addition to a power supply unit, some appliances have a high-capacity standby function (e.g. for keeping the heating element warm in a coffee machine) that is regulated by short pulse packages or high-power activation intervals. In such cases it is not sufficient to record an on-the-spot reading – instead, the power consumption has to be measured over a suitably lengthy period.
4. In the case of appliances connected to a two-phase or three-phase circuit, unless the electrical structure is known, it is often not clear how the power supply units are connected. In some cases, measurements show that at least 2 phase conductors and the neutral wire carry current. It is possible that some control devices are designed so that they function without neutral in both single-phase and multiple-phase connections. It is also possible that such power supply units produce differing outputs, depending on the type of connection. But it is likely that there are also screening units that give rise to the indication of active power for given phases.

In order to ensure the most flexible use of measurement devices, all equipment should be fitted with standard plugs (T13, T15, possibly 16 A).

IEC 62301 places extremely high demands on acuracy, and these are reflected in high costs for measuring devices (power analysing device, costs between 20,000 and 30,000 Swiss francs and is also difficult to transport). For the purposes of this project we therefore had to accept a lower level of accuracy, though this was more than sufficient for assessing the standby consumption of the various appliances, since we did not have to make comparisons between appliances, nor carry out or verify energy declarations.

A series of tests with different measuring devices and recordings of current flows using an oscilloscope indicated widely varying power supply technologies (Fig. 3.1). In the case of high frequencies such as with the mobile phone in Fig. 3.1b, basic electronic measuring devices quickly prove to be insufficiently accurate. However, many appliances indicate flatter current flows. The air-flow clothes dryer in Fig. 3.1a indicates a standby consumption of 0.4 W, which is almost too low to record, even for the smaller of the EMU devices, whereas a moving-coil wattmeter is still capable of producing an acceptable level of accuracy.



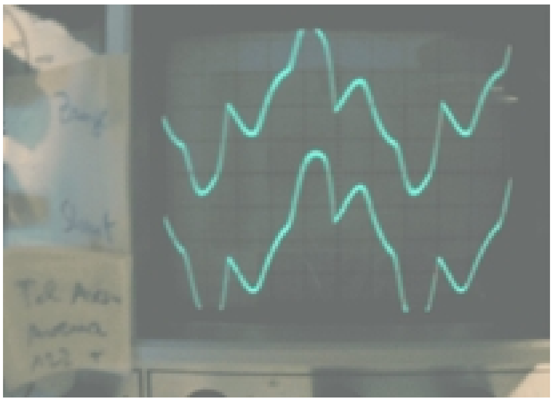


Fig. 3.1 Oscillograph showing current flows:
a) air-flow clothes dryer, approx. 0.4 W (left)
b) mobile phone, 4.5 W (right – upper curve = fork sensor, lower curve = shunt)

Following additional consultations with specialists we were able to conclude that with a moving-coil wattmeter it is also possible to reliably measure single-phase standby consumption levels that indicate a strongly distorted current flow. With two-phase or three-phase connection and an unknown internal structure, there is still one uncertainty factor, namely that, due to the impedance of screening components it is usually not possible to clearly determine whether the power supply unit is connected in single-phase or between two phases (400 V).

3.2 Measuring equipment

The measuring equipment described below was chosen on the basis of the requirements cited above and installed in a special case (see Fig. 3.2.)

Fig. 3.2 Equipment for measuring standby consumption (EMU 32 3-phase, adaptable inputs/outputs, moving-coil wattmeter, sensor, multiple measurement device)

Single-phase measurements (230 V AC)

The following devices were used here:

- "EMU 1.24" power and energy meter (EMU Elektronik AG, 6314 Unterägeri):
  Up to 10 A, T13 adapter, precision category 2
  Active power response 0.1 W, recording to 7th harmonic
  Energy level response 0.1 Wh
  Current 0.01...10 A, voltage range 176...264 V
  Responds even with very low currents > 5 mA, so no power supply units were encountered that it was not able to measure (including mobile phone power supply devices with 0.3 W).
- "Wattavi k" moving-coil wattmeter
  Meter, response approx. 0.2 W
  Range up to 500 V, i.e. able to measure two-phase appliances without neutral.
- Multiple measuring device (current. voltage, etc.), true RMS.
- Oscilloscope, fork sensors (for measuring special types of current curves)

Three-phase measurements (400 V AC), including with neutral

A special case was constructed for these measurements, containing the following devices (Fig. 3.2):

- "EMU 32x4" power and energy meter:
  Direct connection 10 (63) A, precision category 2 IEC 1036
  Active power response 0.1 W (specially configured)
  Recording up to 7th harmonic
  Energy response 0.1 kWh (100 Wh)
  Optical pulse output 10 p./Wh
  Current 0.01...10 (63) A
  Only responds to currents greater than approx. 15 mA, so does not measure extremely low consumption levels. Response can be forced by connecting power resistors for 5 W at 400 V or 5 W at 230 V (line connector, see below), though precision is limited due to potential phase shifts.
- Pulse counter with optical coupling of EMU 32x4 pulse output, reversible. Installed in casing with digital clock, allowing simple recording of pulse rate. Pulse counting makes it possible to accurately measure devices with short activation intervals.
- By incorporating a line connector into the measuring kit, it is possible to allocate the measurement paths to the connected plugs (T15 and industrial 16 A). In this way, appliances can simply be connected to the corresponding socket. It is also possible to connect permanently installed appliances using an additional T15 connection device with open wires or clamps (may only be carried out by specialists).
  It is also simple to loop the moving-coil wattmeter, fork sensor and ammeter via the line connector (see Fig. 3.2).

Degree of precision

The “Wattavi” moving-coil wattmeter, which is classified 1.5 (VDE 0410) and is manually set to zero (mirrored scale) with high precision (< 0.05 W), serves to control the *EMU 1.24,* for which an error rate of ≤ 5% ± 0.05 W may be anticipated in the range up to approx. 10 W. This means that very precise readings of standby levels can be obtained with the *EMU 1.24*.

The *EMU 32* three-phase energy and power measuring device is not accurate enough for measuring standby consumption below 5 W. This means that supplementary measurements always have to be carried out, preferably with the moving-coil device. For this purpose, the current-bearing leads have to be found with the aid of the fork sensor, and the moving-coil device has to be plugged in accordingly. With appliances connected three-phase + neutral, unless we are familiar with the internal circuitry, it is uncertain in some cases whether the power supply unit is single or two-phase (or perhaps a combination of the two), cf. Requirements, Part 4.

The degree of precision attained with the limited equipment available may be described as sufficient for the purpose of the study. The main aims of the measuring campaign carried out within the scope of this project were to assess the current situation and classify standby consumption levels.

4. Representative survey concerning coffee machines and steamers

4.1 Method, sampling

A survey was carried out concerning the distribution and usage of coffee machines and steamers because no data were available regarding these appliances and it was assumed that their electricity consumption is significant, especially in the case of coffee machines, which have a high heating requirement. We were interested in assessing the distribution of steamers because, as an auxiliary cooking appliance (in addition to an oven), they usually require grey energy and consume electricity in standby mode.

A representative survey was conducted by telephone in October 2002 (*Matthias Peters*, social research and consulting, *DemoSCOPE,* [5]). In the case of coffee machines, we were interested in the distribution of the various types, user behaviour, and the proportion of appliances with an "OFF" power consumption. We also set out to obtain additional information about the use of coffee machines in offices. With respect to steamers for use in private households, we were primarily interested in assessing their current distribution. We also asked questions concerning the use of ovens.

A copy of the questionnaire is reproduced in Appendix A1.

The survey encompassed 1,129 households, 225 of which were in the French-speaking part of the country. For evaluation purposes, we took account of the real proportions of two regions by weighting the random sample (slight surplus in the German-speaking region). Specially trained personnel (*DemoSCOPE*) were used for conducting the survey, and they all worked in their own mother tongue.

The population comprised people over the age of 15 living in private households in the German-speaking and French-speaking regions of Switzerland, and speaking German or French. The random sample procedure consisted of two stages: random selection from the telephone directory of the region concerned, then combined age/gender distribution within the household (age groups: 15-24, 25-34, 35-54, 55+). In those households in which we were able to establish contact, a total of 30% of eligible subjects refused to be interviewed (19% due to lack of interest, 7% due to lack of time, 4% against surveys). This result may be regarded as good.

For the projection of the findings from the random sample to the overall population, the statistical circumstances resulted in a bandwidth of ± 2.9% with a statistical accuracy of 95%.

4.2 Findings concerning coffee machines

- 64% of households use at least one coffee machine (excluding Italian espresso makers for use on hotplates). 26% of these have an electronic display, 13% of which (i.e. only 3.4% of all machines) continue to display data when the machine has been switched off. Please refer to Fig. 4.1 for details concerning types of coffee machines.
- We were surprised to find that household coffee machines are also very widely used in offices and business premises: 47% answered yes, 27% answered no, 25% do not work, 1% said they do not know. This means that almost two-thirds (63.5%) of the participants who are gainfully employed stated that they have a household coffee machine at their disposal at the office! However, this figure cannot be projected using the proportion of people surveyed to the total of all households (47% of 3.15 million households would result in 1.5 million coffee machines). Due to the likelihood of multiple counts of the same coffee machines, a figure below 1 million is probably more realistic (with 3.8 million jobs).

- The figures for the whole of Switzerland (3.15 million households in 2000) are as follows:

In households (64% of 3.15 million, ignoring multiple counts):	2.02 million
In the office (cautious estimate):	0.75 million
Total no. of household coffee machines in use:	**2.77 million**

This figure is backed up by the sales data compiled by the FEA [6]:

1998	1999	2000	2001	2002
326,600	365,400	383,200	377,400	435,700

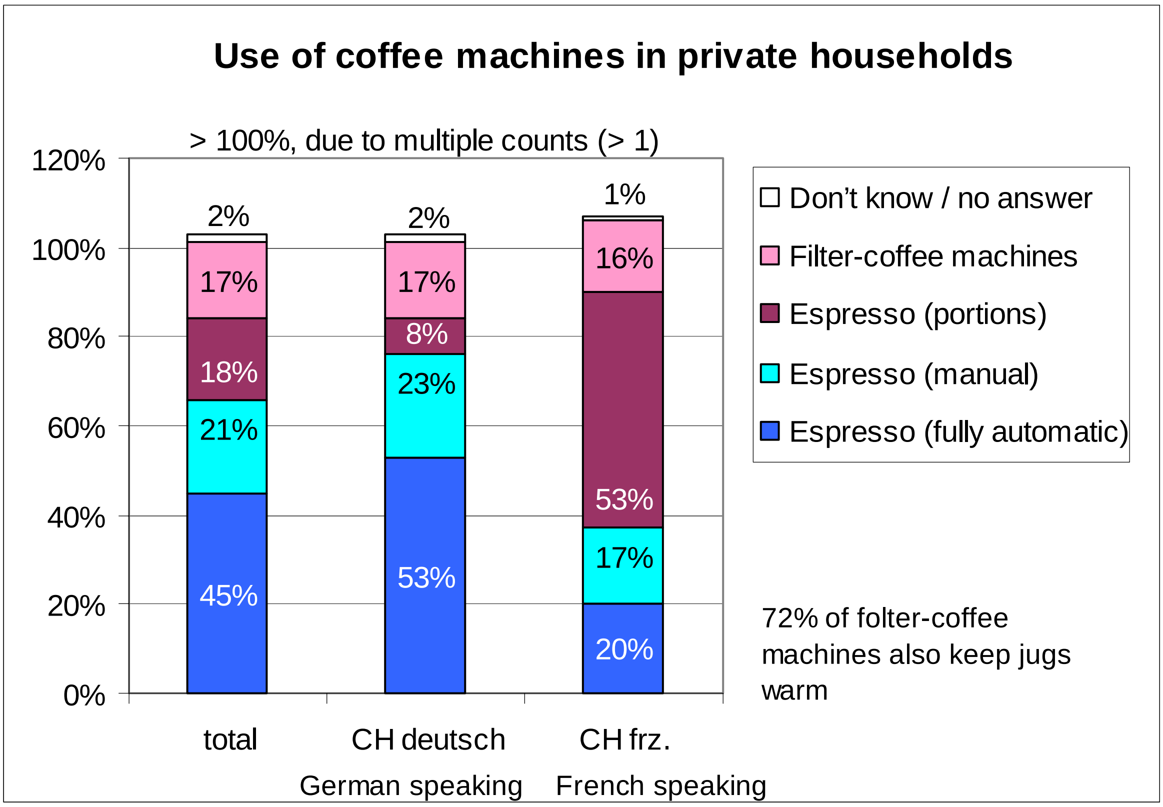


Fig. 4.1 Distribution of coffee machines by type and region (representative survey, October 2002)

- The answers to the question regarding switching off the appliance after use indicate highly energy-conscious behaviour: 70% of the participants in the survey stated that they switch their coffee machine off after use or when their coffee break is over, while 9% use an automatic switch-off function ("turns itself off"). The corresponding figures for fully automatic machines are 59% and 15% respectively (Fig. 4.2). This indicates that only approximately 20% of coffee machines in households are only switched off during the evening or not switched off at all (fully automatic machines: 23%). Not surprisingly, the situation in offices is very different: here, 47% of these coffee machines (household appliances, not professional models!) are only switched off in the evening, 29% are not switched off at all, and switch-off times are unclear for the remaining 24% (Fig. 4.3). There is therefore enormous efficiency potential here, despite the smaller number of appliances.

- The answers with respect to number of cups per day resulted in a weighted average of 6.3 (Fig. 4.4). The number is considerably lower in the French-speaking area than in the German-speaking region (4.9 versus 6.7). If we take 48 weeks (336 usage days) a year as the basis, this results in approximately 2,000 cups as an assumption for our projection.

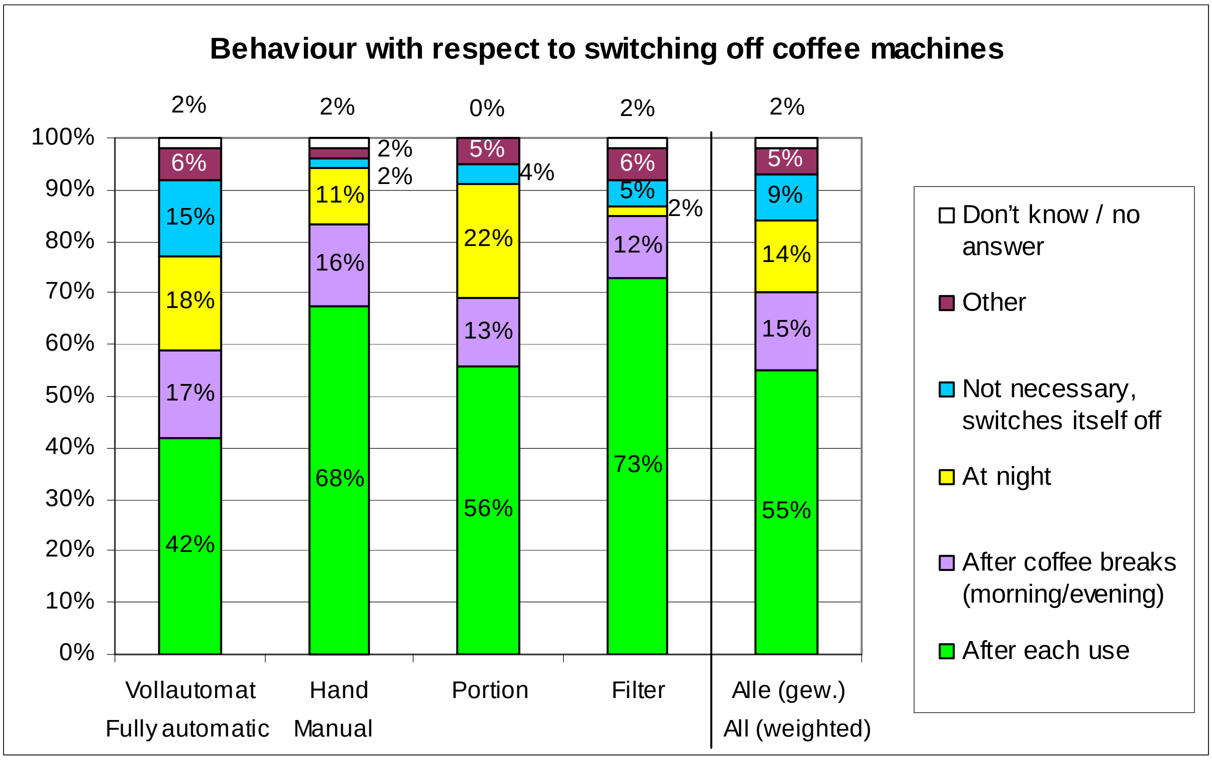


Fig. 4.2 Switching off of coffee machines by type (representative survey, October 2002)

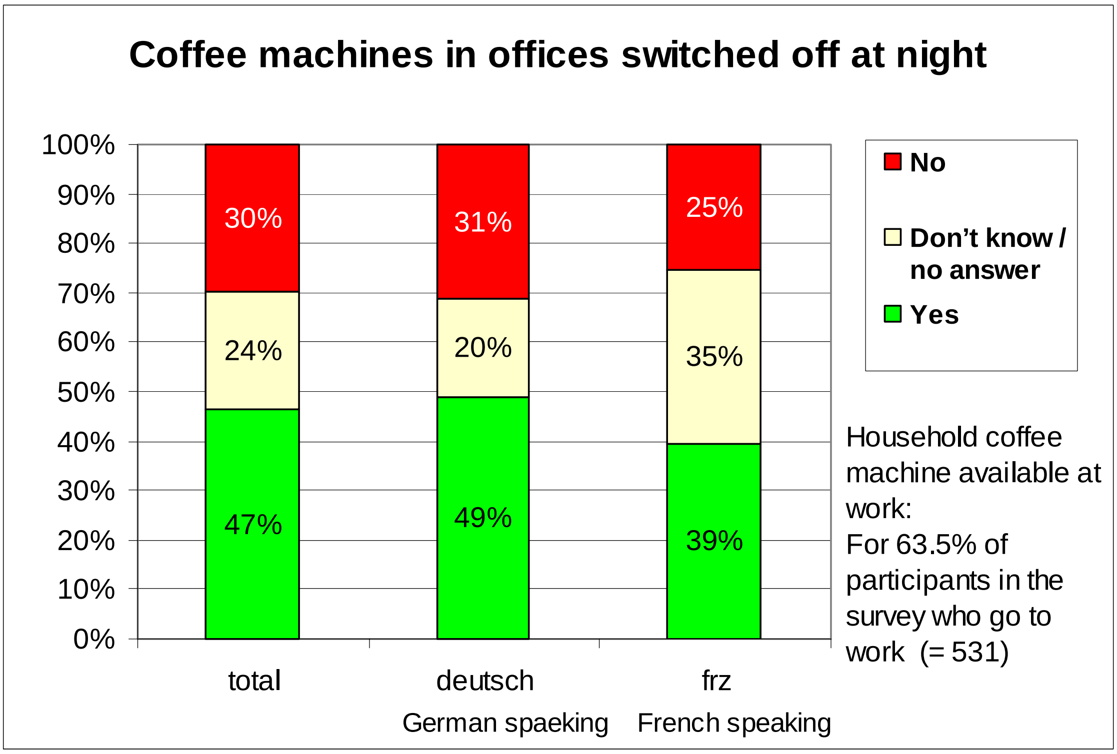


Fig. 4.3 Switching off of coffee machines in offices (representative survey, October 2002)

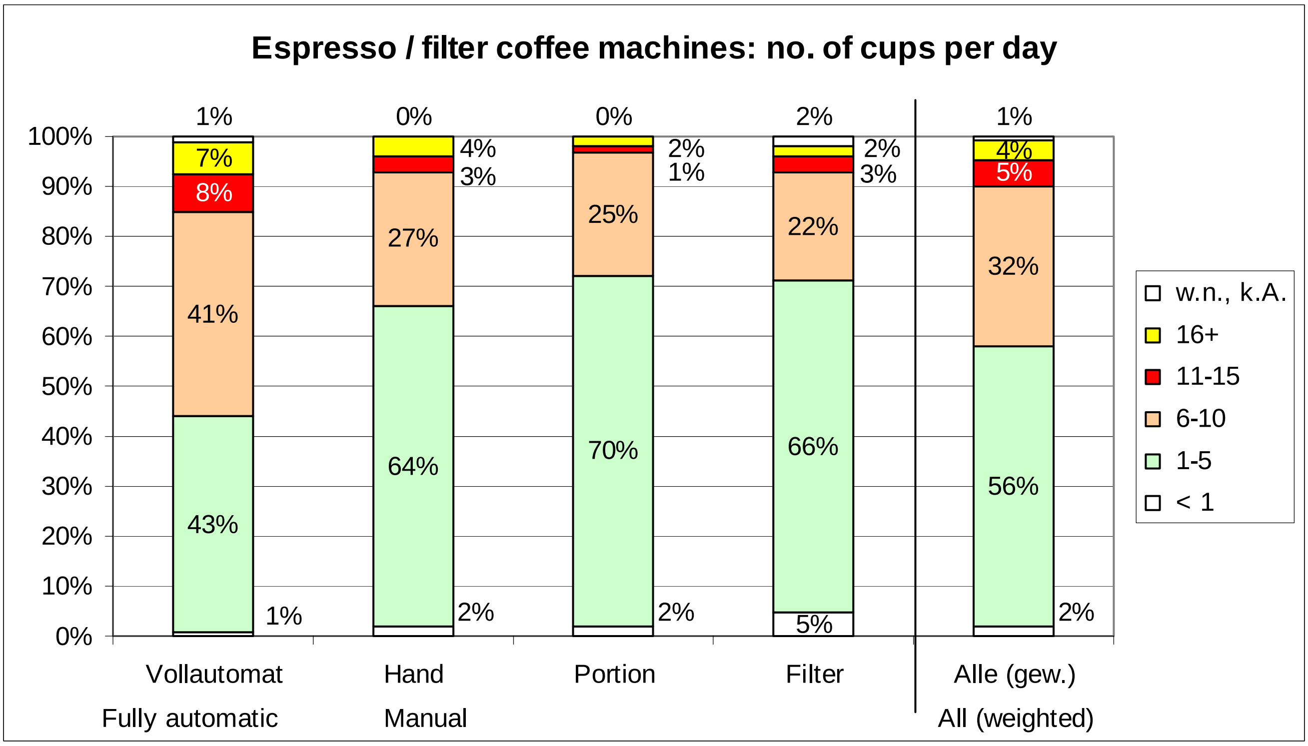


Fig. 4.4 Use of coffee machines by type (representative survey, October 2002)

4.3 Main findings for steamers and ovens

9% of the households in our survey stated they have a steamer, while the majority (85%) stated they also have an oven. A further 4% have an oven that may be used as a steamer by adding water. 5% either did not know whether their oven is also usable as a steamer, or did not reply to this question. The projection based on these answers results in a quantity of steamers that is far higher than the sales figure released by the Association of Electrical Appliances. It is possible that this discrepancy is attributable to products such as those presented in Fig. 4.5: compact plug-in units that are also designated as "steamers" and are probably widely used throughout the country. It is therefore not possible to reliably deduce a figure for large household steamers from the findings of the survey.

Fig. 4.5 900-watt plug-in steamer

Usage of ovens is a particularly relevant factor for determining the specific electricity consumption for the various methods of preparing hot food and drinks. No statistical data were previously available here. The survey indicated that ovens are used 2.5 times a week on average (see Fig. 4.6 and Table 4.1).

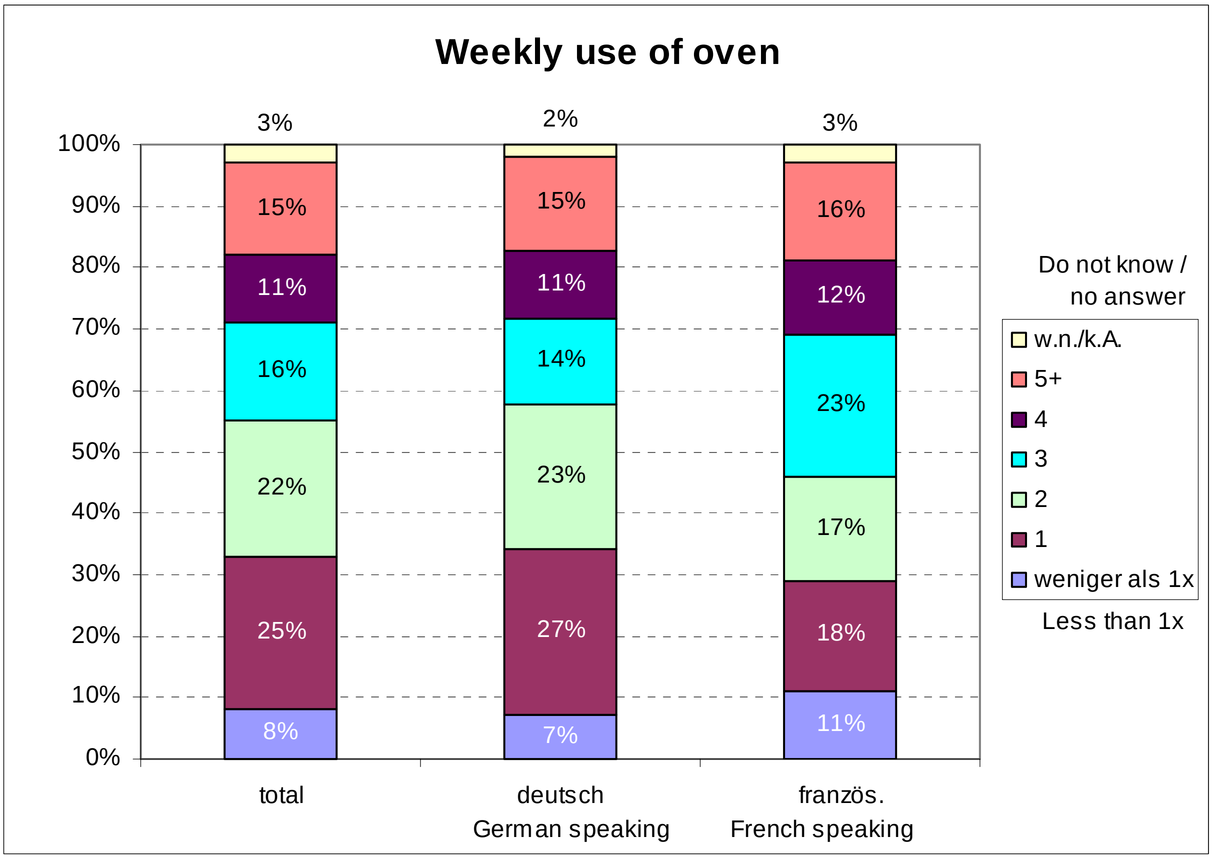


Fig. 4.6 Weekly use of ovens (representative survey, October 2002)

Weekly use of oven	Index	Proportion	Product
less than 1x	0.4	8%	0.032
1	1	25%	0.25
2	2	22%	0.44
3	3	16%	0.48
4	4	11%	0.44
5+	6	15%	0.9
Don't know/no answer		3%	
		Weekly use	**2.54**

Table 4.1 Frequency of use of ovens

5. Findings

5.1 Measurement results

Table 5.1 presents an overview of the measured appliances. A total of 60 different appliances were tested in the period from October 2002 to February 2003. The majority of appliances and models were less than 5 years old – very few were between 5 and 12 years old. We were unable to provide details regarding market shares and popularity of brands, but set out to achieve a certain degree of representation by excluding luxury models as far as possible.

We did not encounter any networked appliances, i.e. linked via a wireless or powerline interface. According to [7], an additional power consumption of approximately 4 W would be required for such appliances.

In the categories of ovens, dishwashers, refrigerators and freezers, washing machines and microwave ovens, a high proportion of appliances in use (and to some extent, still on the market – e.g. microwave ovens) are still fitted with electromechanical controls, and thus do not have a standby mode. However, it is not always possible to verify this with any degree of certainty unless the appliance is opened or a detailed description is available. In some cases a signal lamp can give rise to standby consumption of between 0.3 and 1 W, and this uncertainty factor needs to be taken into account for projection purposes by using estimates (see Chapter 6).

Appliance	Comments	No. measured	No. OFF ≠ 0	Stby ∅ W (incl. OFF)	Stby min. W*	Stby max. W*
Ovens	Standby function for oven (timer, program)	5	5	2.2	1	2.6
Steamers		2	2	2.5	1.9	3.1
Induction cooker tops	3 of which are probably of identical construction (8 W)	4	4	7.1	4.5	8
Dishwashers	Standby after completion of program (if device is not switched off)	4	1	1.3	0	2.4
Refrigerators/ freezers	Standby hardly of relevance, since these appliances are always in operation	1		1.7		
Washing machines	1 without electronic controls	10	3	2.7	0	6
Tumble dryers		6	3	1.4	0.6	2.2
Air-flow clothes dryers	2 series with OFF/standby ≠ 0 Room drying function not as standby	9	5	0.9	0	2
Microwave ovens	3 without electronic controls	6	3	1.1	0	3
					Element heating (min.-max. W **)	
Coffee machines	Espresso and portions	9	2	1.3	18	57
Coffee machines	Filter coffee (3 with option of “auto off” after 2 hours)	4	3	1.2	(54)	60

* M ** Average power consumption over > 1 hr, min./max., within appliance category

Table 5.1 Overview of results of standby measurement campaign (October 2002 to February 2003

5.2 Ovens, cooker tops, steamers

Both fixed and free-standing ovens dating from the past 10 to 15 years have been equipped with timers (with the exception of very basic models), and many more recent models (5 to 10 years) also have electronic controls. Earlier timers are electromechanical (synchronous motor, approx. 1 W), while more recent ones are electronic (some with keys, LEDs, display units) and thus consume power in standby mode.

The standby consumption of cooker tops (hotplates) is attributable to use of the oven, since hotplates usually do not have a standby mode (residual heat is displayed via electromechanical thermostats). However, electronic control of cooker tops will increase with the use of keypads, though no such devices were encountered in the course of our measurement campaign. (Induction cooker tops, see below).

Other features of modern ovens that consume electricity but do not enhance the baking/roasting process (interior lighting contributes to the cooking process):

- Hot-air fans (only during baking/roasting time), 10...30 W
- Extractor fans (baking/roasting time + cool-down period, e.g. 15 minutes), approx. 10 W
- Rotisserie (usually short operating time)

None of the above are standby functions, nor do they give rise to a relevant increase in electricity consumption, as the following example shows:
Assumption, 100 kWh/a baking/roasting, ∅ power consumption, 1.5 kW ⇒ 67 hrs p.a. baking/roasting.
Additional 40 W = 2.5 kWh/a or 2.5% of consumption for baking/roasting.

The measured consumption of steamers (large, fixed installations) in standby mode was 1.9 W to 3.1 W, which is similar to that for ovens; it is likely that the same power supply units are used for both appliances.

Since there are no existing methods for measuring the power consumption of steamers, it is not possible to assess the impacts of the use of these appliances on overall electricity consumption.

For projection purposes, the electricity consumption for normal baking/roasting was assumed to be **0.8 kWh**. This figure was calculated as follows:

- Threshold levels for efficiency categories in accordance with Directive 2002/40/EG issued by the European Commission on 8 May 2002 for medium-sized ovens (35...65 litres):
  A ≤ 0.8 kWh
  B $0.8 \leq E \leq 1.0$ kWh
  C $1.0 \leq E \leq 1.2$ kWh
  Numerous products on the Swiss market belong to efficiency category A, with levels below 0.8 kWh. The typical volume of baking/roasting ovens is 46…50 litres.
- Typical level for warm-up + 1 hr operation in accordance with the former FEA goods declaration: 0.9 kWh (best reading, 2002: < 0.7).
- The standard energy consumption of older ovens is usually slightly higher than 0.8 kWh. However, average baking/roasting times are probably shorter than 1 hour (as assumed for the former goods declaration), or contain a lower quantity of food than cited in the standard load in accordance with the energy label ("brick test").
  0.8 kWh may therefore be safely assumed to be a typical consumption level.

The average usage rate as identified from the survey (2.5 times per week over 48 weeks) at an assumed consumption level of 0.8 kWh per usage results in an

average electricity consumption of 100 kWh per annum for baking/roasting

The readings obtained from the representative survey and measurement campaign (coffee machines) concerning electricity consumption for cooking purposes can now be compared with other figures. In order to assess efficiency potentials (e.g. of induction cooker tops), it would be useful to carry out additional studies on the electricity consumption of kitchen appliances.

Electricity consumption of kitchen appliances in households (per household)

- Coffee machines, S.A.F.E. 2003 (cf. Table 5.4) 100 kWh/a
- Ovens, S.A.F.E. 2003 100 kWh/a
- "Cooking/baking", S.A.F.E. appliance statistics, 2003 [8], ("lower threshold") 380 kWh/a
- "Cooking/baking", VSE statistics for house appliances, Mutzner 1996 650 kWh/a
- "Cooking/baking", figures indicated by VSE prior to 1990 1,000 kWh/a

5.3 Induction cooker tops

Thanks to the fact that energy is transferred directly to the base of the pan, cooking with induction technology is faster than with conventional methods based on heat conduction (and to some extent, radiation), and also reduces dispersion losses. Induction cookers available on the market today are equipped with touch-pad controls that function electronically and therefore have to be supplied with power. Models are available that are equipped with 2 induction plates and 2 conventional glass ceramic fields, though the standard configuration appears to be 4 induction plates with 2 generators, with 1 generator per 2 fields, which means that it is not possible for them to yield maximum output simultaneously. One advanced model is equipped with 4 generators, yet to our surprise it indicates a lower standby consumption. All models currently available on the market appear to contain 230-volt generators, divided into two phases in order to avoid the need for more than 16-amp fuse protection.

The measured standby consumption readings are well below the sometimes cited levels of 20 to 50 W. However, the levels of 8 W obtained for 3 models give rise to an annual electricity consumption of around 70 kWh. In a small household, or in a household in which meals are only prepared once a day (i.e. the electricity consumption for cooking purposes – excluding oven – is below 200 kWh per annum), the additional standby consumption is more than 30%, and thus well exceeds the savings that should be possible with induction technology. This means that it will only be possible to market induction cooker tops as “energy efficient” if the standby consumption is brought down to below approx. 2 W – and this is apparently already the case with some new models. With very intensive use (e.g. in large families, commercial operation, etc. when consumption exceeds the level of around 600 kWh per annum), the savings attained during the cooking process are outweighed by the higher standby consumption.

From a technical point of view, there is no apparent reason why a consumption of 4 W per generator should be required for control purposes. If manufacturers want to market induction technology as energy efficient, they will need to reduce standby consumption to the more usual levels of 1 W or less. Another option would be to install a main switch for separation from the power supply, but the effectiveness of this solution would of course depend on energy-conscious behaviour on the part of the user.

According to the latest manufacturers' specifications, there are now appliances on the market that indicate standby losses below 2 W.

5.4 Refrigerators and freezers

Many new refrigerators and freezers are equipped with an LCD or LED, and thus require a power supply unit. We were only able to measure one such appliance: result, 1.7 W. With refrigerators and freezers, standby consumption is included in the declaration for the energy label, since permanent operation is measured over a number of switching cycles. There is therefore no call for special clarifications or incentives with respect to reduction of power consumption.

With older models we had observed various practices that are intended to simplify control procedures but are also associated with energy losses, e.g. heating of the plus cool zone by using interior lighting, and use of evaporation heating (3 W) for the purpose of removing liquid resulting from defrosting. However, such methods are likely to be a thing of the past thanks to the incentives provided by the energy label.

5.5 Dishwashers

The new generation of dishwashers is equipped with electronic controls that offer benefits with respect to programming, and some also have sensors for detecting the degree of soiling.

This trend is not necessarily associated with standby losses: in 3 out of 4 measured appliances, the door is linked to a main switch that cuts off power entirely when the machine is opened. In this case the standby consumption is restricted to the level with the door closed. Most users probably open the door after the program has been completed, or by the following morning at the latest (it may be useful to verify behaviour here by carrying out a separate survey). This would mean that standby consumption would be limited to 1/2 to 1/3 of the annual hours.

Up to approximately 2000, most dishwashers were connected two-phase (440 V), but in the meantime connection is now usually single-phase (230 V), and this means it is possible to carry out measurements with EMUs.

5.6 Washing machines

For some time now it has been standard practice to equip washing machines with electronic controls, usually in the form of keypads and display devices. Some control units switch the display off after several minutes of inactivity, but this has very little effect on power consumption. Some washing machines are connected via an external main switch (for example, located behind the appliance), but such switches are seldom turned off in practice.

We found that washing machines indicate the broadest range of standby consumption levels, namely from 0 (operation of main switch) to 6 W (small 3-kilogram model).

5.7 Tumble dryers

In most cases, tumble dryers are equipped with the same control modules as washing machines, or at least with the same power supply units. Here, too, some models are equipped with a main switch, so that there is no standby consumption once the door has been opened. The use of electronic humidity sensors does not lead to higher (permanent) standby consumption since these controls only need to be active while the dryer is in operation.

For all these appliances fitted with doors (dishwashers, washing machines, tumble dryers), a permanent standby mode would not be necessary for any **timer function** (e.g. for switching the appliance on at the start of the off-peak period), since the door would in any case have to be closed and the main switch would have to be ON. Permanent standby would only be necessary if the option of programming while the door is open were to be required.

5.8 Air-flow clothes dryers *

Most models are either already equipped with electronic controls, or will be in the foreseeable future. The range of measured standby consumption levels was between < 0.3 (accuracy of measurement!) and 2 W. In addition to the primary functions (drying process, defrosting, heating), the behaviour of the appliance is controlled in a differentiated manner: as a rule, a ventilator continues to operate for approximately 30 minutes, during which period the humidity of the room is monitored and, if the programmed level is exceeded, the compressor is automatically switched on again. These processes have to be regarded as part of normal operation. The appliance only switches into standby mode after the ventilator has finally been switched off.

Controls with auxiliary functions enable permanent monitoring of the humidity of the room. For this purpose, a ventilator may be switched on periodically in order to determine the mean humidity of the room. If this exceeds a given level, the compressor is switched on. The power consumption between the active stages counts as standby losses, but the room-drying mode is not part of standby operation.

* Clothes drying system with heat pumps. In the drying room, air is circulated by a fan and dehumidified by the heat pump. Wash has to be hung up; specific energy consumption is about 50% compared to tumble dryers. See also: www.topten.ch, > Haushalt > Wäschetrockner
> Raumluft-Wäschetrockner. Webpage also in French and Italian.

5.9 Microwave ovens

Basic and/or older models are controlled using a clockwork timer, and therefore do not require standby mode. However, electronic control devices make it possible to freely program a broad range of cooking procedures. The model with 3 W standby consumption dated from around 1996.

Microwave ovens also have doors, and thus door contacts, so once the appliance has been separated from the power supply, there is no standby consumption. However, microwave ovens can only be programmed when the door is closed.

5.10 Coffee machines

As far as coffee machines are concerned, we first have to make a distinction between commercial and household models; commercial coffee machines have a permanent water supply and cost significantly more than household models (i.e. more than 2,000 Swiss francs). However, a large number of household coffee machines are also used in offices and commercial premises, and this was incorporated into the survey (Chapter 4.2).

With coffee machines, in addition to the actual production of coffee there are at least three other operating modes that are of relevance with respect to electricity consumption (see also Table 5.2):

- Off: the appliance is plugged in but not switched on (or not activated, if it does not have a main switch).
- Standby (with element heating): the appliance is ready for operation, the boiler/flow heater (approx. 1 dl) is kept at a temperature of between 80 and 90°C, so that coffee can be produced immediately at the press of a button. With most machines, a flat surface is also kept warm so that cups can be preheated. Basic or older models use a thermostat control, whereas with new machines the heating output is controlled via electronic pulse package switches (cycle < 1 minute, very little temperature fluctuation). The mean heating output needs to be measured over a period of at least 1 hour (and in some cases, over the full thermostat cycle). Typical average readings are between 25 and 50 W (minimum, 18 W, maximum, 60 W).

  Standby (with element heating and active hotplate): Some machines also use a separate heater for the cup-warming hotplate, and these give rise to an average overall power input of up to 60 W (it should be noted here that two filter-coffee machines indicated similar heating requirements).
- Standby (without element heating): the appliance is switched on, but the heater is switched off. This mode is only possible in machines in which the heater can be switched off manually or electronically, or which are equipped with an auto-off function. The latter automatically switch the heater off after a fixed or programmable period of inactivity. Here, the standard period we noted was 2 hours. With some models it is also possible to programme the time after which the heater is switched on again.

Cups per annum	6 per day, approx. 48 weeks	Cups p.a.	2000
Heating requirement per cup	0.1 l, c = 0.86 kWh/kg K	kWh/c	0.01
Preparation of 2,000 cups p.a.	η = 50%	kWh/a	40
Standby electronics	2 W, 8,760 h	kWh/a	18
Average heating requirement (cf. Table 4.1)	Range: 18...60 W	W	35
Heating, 35 W – questions regarding switch-off behaviour:			
"Switch off after every use"	1 hour per day, 48 weeks	100 kWh/a	12
"Switch off after morning/evening coffee breaks"	3 hours per day, 48 weeks		35
"Switches itself off"	6 hours per day, 48 weeks		70
"Switch off at night"	15 hours per day, 48 weeks		176

Table 5.2 Calculation assumptions for coffee machines (7-day weeks)

Measurements – including coffee output – and examples of projections (Tables 5.3 and 5.4) show that most coffee machines consume the greatest amount of electricity for heating purposes (keeping temperature, i.e. without coffee output). If a coffee machine is not switched off at night, then the electricity requirement for heating would be as much as 6 times higher than the level required for making coffee.

	Electricity consumption in kWh/a			
Switch-off behaviour	"negligent" (24 hrs)	"normal" or "auto-off"	"economical"	
				Machine without standby mode
2,000 cups per annum (6 per day, 48 weeks)	40	40	40	40
Heating, 35 W, 2 hours per day, 48 weeks			24	24
Heating, 35 W, 6 hours per day, 48 weeks		71		
Heating, 35 W, 24 hours per day, 48 weeks	282			
Standby electronics, 2 W, 8,760 hrs per annum	18	18	18	0
Total for 2,000 cups per annum	**340**	**129**	**82**	**64**

Table 5.3 Typical electricity consumption of coffee machines

The findings with respect to mean consumption levels obtained from the representative survey were as follows: 100 kWh/a for coffee machines in households – i.e. between "economical" and "normal" – and 260 kWh/a for coffee machines in offices – i.e. between "normal" and "negligent" (cf. Table 5.4).

Projection for coffee machines

The overall electricity consumption of household coffee machines can be projected with the aid of assumptions based on the results of measurements and the findings obtained from the representative survey (Table 5.2). Due to various sources of potential error, the calculations inevitably contain some uncertainties, but they nonetheless provide us with an approximate picture of the situation (tolerance margin, ± 25%). The conclusion to be drawn is that coffee machines are a significant appliance category in terms of electricity consumption. Their efficiency potential is enormous, and can be realised through both technical measures and improvements in behaviour.

Coffee machines in private households				kWh/a
2,000 cups per annum (from survey)				40
Heating requirement (48 weeks per annum):	35	W		
User behaviour (as per survey):	valued as h/d	kWh/a weighted	Proportion	
Switch off after every use	1	11.8	55%	6.5
Switch off after morning/evening coffee breaks	3	35.3	15%	5.3
Switch off at night	15	176.4	14%	24.7
Not necessary, switches itself off	6	70.6	9%	6.4
Other behaviour	12	141.1	5%	7.1
Standby 2 W	Assumption, 50% with standby	18	50%	9
per appliance				98.9
Coffee machines in private households		million	2.02	
Consumption with user behaviour as per survey *of which standby incl. heating*		**GWh/a**	**200** *119*	
Coffee machines in offices				kWh/a
2,000 cups per annum (assumption)				40
Heating requirement (50 weeks per annum):	35	W		
User behaviour (as per survey):	valued as h/d	kWh/a	Proportion	
Switch off at night	12	147	47.0%	69
Never switched off	24	294	30.0%	88
Don’t know	18	221	23.0%	51
Standby 2 W	Assumption, 50% with standby	18	50%	9
per appliance				257
Household coffee machines in offices	(see text)	million	0.75	
Consumption with user behaviour as per survey *of which standby incl. heating*		**GWh/a**	**193** *163*	
Total electricity consumption of household coffee machines *of which standby incl. heating*		**GWh/a**	**393** *282*	

Table 5.4 Projected electricity consumption of coffee machines in Switzerland

Summary, comments on findings:

- At approximately 400 GWh/a, the estimated electricity consumption of household coffee machines is surprisingly high. This figure is equivalent to more than 0.7% of end-user electricity consumption in Switzerland, which is more than all TV sets.
- Of this figure, 65% is attributable to heating requirements, and 6.4% to standby consumption of electronic components.
- In a given household, the electricity consumption of a coffee machine is roughly the same as that of an oven, and slightly less than that of a cooker top (hotplates) – cf. Chapter 5.2, Ovens.
- The significant proportion of electricity consumption for heating purposes is user-dependent, but can be reduced through the use of efficient electronic controls (auto-off, 1 hour), which would be especially effective in offices.

Proposal for an energy declaration for coffee machines

The basis for subsequent description and reduction of standby losses is an energy declaration for coffee machines. Below is a first draft:

Delimitation, objectives

Household coffee machines (even if they are in use in offices);
criterion: no fixed connection to water supply.

No previously published energy declaration.

In IEC 60661 "Methods for measuring the performance of electric household coffee makers" (1999 + A1 2003, [9]) measuring the standby or heating consumption is very briefly mentioned: "In addition the energy consumption for a standby operation for 1 h shall be indicated", whereas the energy consumption for coffee making is defined in detail. On that background we explain heating (keeping temperature) and its measurement.

The power required for heating is a major factor with respect to energy consumption; the main influencing factor is the operating time in heating mode. This can be automatically limited through the use of a control unit (auto-off function: machine is automatically switched off after, for example, 2 hours of non-use).

Objectives: - Definition of a measuring procedure
- Declaration to be included in sales material
- Introduction of an energy label (throughout the EU).

Heating mode

- Machine switched on, any initialisation procedure has been completed, ready to produce coffee
- Several switching cycles prior to measurement
- Defined ambient temperature: 23°C (IEC 60661: 20 ± 5°C)
- Defined temperature of produced coffee
- Measurement period, at least 3 hours or 20 cycles (electromechanical thermostat)

The electricity consumption of control devices (standby in the strictest sense of the term) is generally much lower.
"Heating" requirement includes standby consumption during the heating period.

Points to be noted for measurement purposes:

- Thermal equilibrium is normally attained after 1 to 2 hours
- Once thermal equilibrium has been attained, measurement must encompass the full range of switching cycles
- Any actively heated hotplates have to be measured at the same time – it is not possible to carry out separate measurements. The measurement period can be extended to at least 6 hours in order to minimise any errors caused by separate switching cycles.

Procedure for measuring power consumption for heating

1. Ambient temperature, 23°C ± 1 K, mean temperature throughout measurement period.
   23°C corresponds to the ambient temperature for oven testing as prescribed by EN 50304.
   A tolerance of ± 2 K is permissible if the temperature is monitored and recorded, and any deviation from the defined temperature is mathematically adjusted (formula, see below).
2. Remove appliance from packaging and prepare it for operation in accordance with the manufacturer's instructions. Connect to power supply via power and energy measurement device.
3. Make 1 cup of coffee, then wait > 30 minutes (refilling and replacing the coffee holder, if applicable).
4. Make coffee for temperature measurement (adjustment formula, see below):
   - Product = "Espresso" (approx. 0.5 dl; no reheating cycle should commence while coffee is being produced).
   - Start immediately after heat-up cycle (observe measuring device)
   - Pour into light plastic or paper cup (do not allow coffee to cool)
   - Measure temperature immediately with thermometer, stirring gently.
5. Measuring time starts immediately after the end of a heating cycle (watch measuring device), at least 2 cycles or 10 minutes after production of coffee. Duration of measurement, at least 3 hours (with active hotplate, 6 hours), and for appliances with an electromechanical thermostat, at least 20 cycles. Measuring time to finish immediately after the end of a heating cycle.
6. Measuring time, ± 5 seconds tolerance.
7. Measurement of electricity consumption: ± 1.5% max. measurement error.
   Example: 3 hrs, 35 W > 105 Wh, 1.5% = 1.5 Wh, i.e. required accuracy = 1 Wh or better.
8. Reporting: findings should be converted to average power consumption [W] and rounded up/down to 1 decimal place. For scaling for labelling purposes, an annual electricity consumption may be calculated (see below) by means of standard utilisation.

Adjustment of ambient temperature alone:	$E =$	$E_{mes} * (T_{ref} - 23) / (T_{ref} - T_{Umes})$
Adjustment of ambient temperature <u>and</u> output temperature:	$E =$	$E_{mes} * (T_{ref} - 23) / (T_{Ames} - T_{Umes})$
	E	electricity consumption to be declared
	E_{mes}	measured electricity consumption
	T_{ref}	reference output temperature, e.g. 80°C
	T_{Umes}	recorded mean ambient temperature
	T_{Ames}	measured temperature of produced coffee

Whether or not it is necessary to **adjust** the electricity consumption **with respect to output temperature** is still not clear (if it is possible to obtain good coffee at 70°C, so much the better!) For adjustment of the ambient temperature, an upper reference temperature (in practice, the boiler temperature) is required for heat loss. For the purpose of adjusting the ambient temperature alone, a temperature of (e.g.) 80°C may be assumed. Careful measurement of output temperature is essential.

A similar procedure is possible for **filter-coffee machines**, with slight modifications.

Measuring standby power consumption of control device

According to IEC 62103 (when approved), or by means of power and energy meter resolving 0.1 W.

Testing the auto-off function

The auto-off function should be tested in order to verify that the declared and/or configured switch-off time is not exceeded. A data logger may be used for determining when the appliance was last heated up.

If no default value is programmed for switch-off time, proceed according to the operating instructions and use any setting that may have been recommended by the manufacturer. If there is neither a recommended nor a default setting, calculations for standard utilisation have to be made without auto-off.

Standard utilisation

A standard utilisation (Table 5.5) is used for projecting electricity consumption. This is defined as follows (see also Tables 5.3 and 5.4):

Cups per annum	6 per day, approx. 48 weeks	(Cups per annum	2,000)
Preparation of 2,000 cups per annum	η = 50%	**kWh/a**	**40**
Heating time without auto-off (= standby time)	12 hours per day, 48 weeks	**h/a**	**4,032**
Heating time with auto-off:			
Coffee-making times	2 x 1 hr per day, approx. 48 weeks		(672 hrs)
Heating time =		**h/a**	**672 x (auto-off h + 1)**
"Auto-off h" is the programmed or default setting for auto-off delay, see above (Testing the auto-off function). For standby consumption of control device, the assumed figures are 4,032 (without auto-off) and 8,760 h/a (with auto-off).			

Table 5.5 Standard utilisation of coffee machines (7-day week)

Energy label

Coffee (espresso) machines should be labelled in the same way as other household appliances for the following reasons:

- Their energy consumption is within a similar range (100 to 300 kWh/a)
- They have major efficiency potential that can be realised through technical measures
- Consumption measurement procedures are fairly easy to define
- An energy label would be effective on the sales floor, since most users buy appliances from retail outlets and the label can be displayed on or near the appliance.

These arguments can be quantitatively supported by the findings presented in this report.

A draft proposal for a procedure for measuring the mean power consumption for heating has been outlined above. A standard utilisation can be defined for calculating annual electricity consumption based on measurement results.

Filter-coffee machines can also be measured using the same procedures, with minor modifications.

Scaling guidelines for an energy label can be drawn from the measurement results (Table 5.1) and standard utilisation data:

	Heating, minimum	Heating, maximum	Typical standby of control	2,000 cups	total kWh/a
Power consumption (W)*	18	60	1.2		
kWh/a with 12 hrs/day heating (4,032 h/a)	72.6		4.8	40	117.4
(maximum)		241.9	4.8	40	286.7
kWh/a with auto-off 1 h (2 x 672 = 1,244 hrs)	24.2		10.5	40	74.7
(maximum)		80.6	10.5	40	131.1
Standby with auto-off, 8,760 h/a, otherwise 4,032 h/a.					

* Average power consumption, min./max., within appliance category

Table 5.6 Examples of electricity consumption of coffee machines (extremes for classification purposes)

Based on the stated assumptions, the most efficient coffee machine consumes 75 kWh/a. This level could be brought down further if the power consumption of the electronic components were to be reduced; with 0.5 instead of 1.2 W, the consumption level would be 69 kWh/a. The threshold level for category A could therefore be defined as 70 kWh/a (or 80 kWh/a if category A appliances should already be available on the market). The upper threshold between categories F and G should not be set at the “maximum” level in Table 5.6, since the “maximum” appliance is in any case category G. Instead, it should be (e.g.) 160 kWh/a, so that appliances without an auto-off function do not automatically have to be classified in category G.

6. Status of standby losses in household appliances

Table 6.1 contains the latest figures for 2000 as released by the Swiss Federal Office of Energy in Dec 2002 ("Prognos" report) [10]. Figures for appliances that are not listed separately there have been estimated on the basis of FEA sales data [6]. Figures in the "with electronics" column are estimates, since no specific data were available. For coffee machines we have shown the level obtained from the survey. With respect to standby consumption, household steamers have been treated as ovens, and are therefore not shown separately (some are combination appliances).

According to research findings, conventional glass-ceramic cooker tops (hotplates) do not usually have a standby mode, and have therefore not been included in the table.

	Status, 2000 [million]	With electronics (million)	Mean standby consumption [W]	h/a of relevance for standby	Standby consump-tion (GWh/a)
Ovens (including steamers)	2.8	1.4	2.2	8,760	27.0
Induction cooker tops	0.01	0.01	7.1	8,760	0.6
Refrigerators and freezers	4.9	0.5	1.7	8,760	7.4
Dishwashers	1.6	1.2	1.3	6,000	9.4
Washing machines	3	2	2.7	8,760	47.3
Clothes dryers	0.95	0.8	1.4	8,760	9.8
Microwave ovens	0.8	0.2	2	8,760	3.5
Total, excluding coffee machines					105
Coffee machines (household models only), incl. in use in offices	2.75	1.5	(cf. evaluation)		282
Total					**387**
As percentage of end-user electricity consumption in Switzerland for 2002 (54 TWh/a)					0.72%

Table 6.1 Overview of standby consumption of household appliances

With a precise definition of standby mode as per the draft IEC standard, the electricity used by coffee machines for keeping the heating components hot would no longer be classified as standby consumption. However, the term "standby" means "ready for use", and would therefore appear to apply to the process of keeping heating components hot. If this factor is eliminated from the equation, this results in a significantly lower overall standby consumption (cf. Fig. 6.1).

Our calculations of annual standby losses resulted in an overall figure of approximately 400 GWh. The associated electricity costs are around 80 million Swiss francs per annum, and with a share of approx. 60 million, a major proportion of these losses is attributable to the heating requirements of coffee machines.

The proportion of standby losses to overall electricity consumption for a given appliance is also of interest, since this is of relevance in terms of energy efficiency. For the overview presented in Table 6.2 we used consumption levels of new, relatively efficient appliances (energy label categories A+/A/B).

The pie-chart in Fig. 6.2 clearly depicts the most critical appliances with respect to proportion of standby consumption: coffee machines in offices, coffee machines in private households, induction cooker tops, followed by appliances with lower power consumption in standby mode, namely microwave ovens, ovens, washing machines. Information concerning use of appliances is to a large extent based on selection criteria and hints published on the "topten" web site (www.topten.ch) [11].

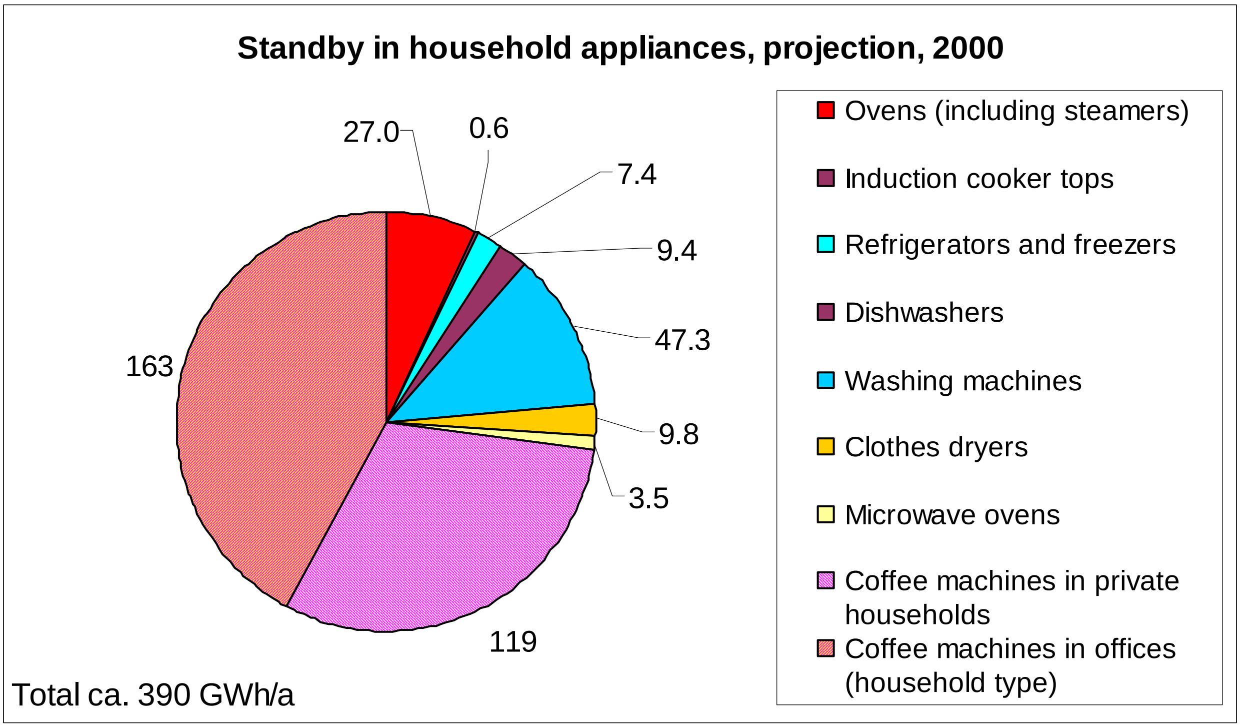


Fig. 6.1 Standby consumption of household appliances, including heating requirements of coffee machines

	Mean standby consump-tion [W]	h/a of relevance for standby	Standby consump-tion (kWh/a)	Power consump-tion of appliance (kWh/a)	Standby in % of power consumption of appliance	Source for power consumption data:
Ovens (including steamers)	2.2	8,760	19.3	100	19.3%	Own projection
Induction cooker tops	7.1	8,760	62.2	130	47.8%	S.A.F.E. internal calculations (kitchen appliances)
Refrigerators and freezers	1.7	8,760	14.9	250	6.0%	Topten
Dishwashers	1.3	6,000	7.8	300	2.6%	Topten
Washing machines	2.7	8,760	23.7	300	7.9%	Topten, usage in single-family dwellings
Clothes dryers	1.4	8,760	12.3	500	2.5%	Topten, usage in single-family dwellings
Microwave ovens	2	8,760	17.5	60	29.2%	S.A.F.E. internal calculations (kitchen appliances)
Coffee machines in private households	cf. Table 5.4		59	99	59.6%	(Useful energy for coffee output, 40 kWh/a)
Household coffee machines in offices	cf. Table 5.4		217	257	84.4%	(Useful energy for coffee output, 40 kWh/a)

Table 6.2 Standby consumption of household appliances, proportion of overall consumption of electrical appliances

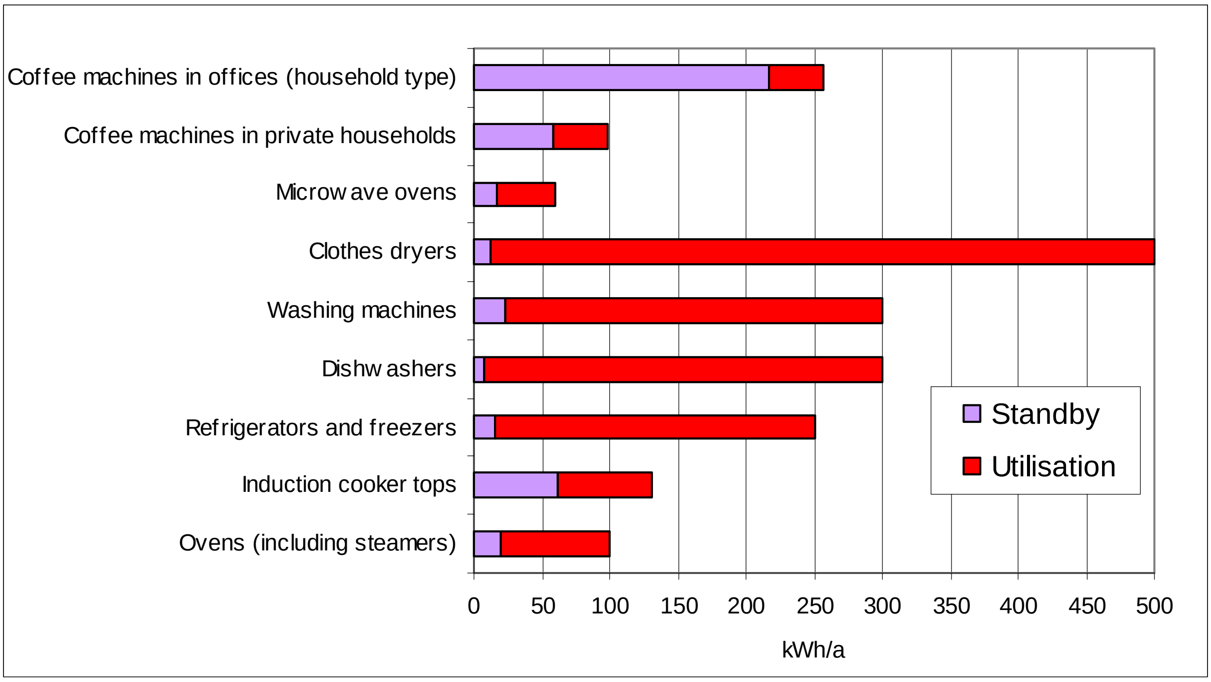


Fig. 6.2 Standby consumption per appliance compared with consumption when in use (representative survey, October 2002)

7. Efficiency potentials, outlook

7.1 Technical potentials

Power supply to control units and display devices

The latest control units and timer functions are fully electronic and are equipped with a transformer or electronic power supply unit (which in its simplest form is an external potential divider capacitor). The power consumption of such devices ranges from 1 to 5 W, and in some cases may be around 0.5 W. Higher consumption levels are primarily attributable to transformers with a high iron loss (poor quality products). However, brightly lit displays (time, status, etc.) also have a relatively high energy requirement, and in some cases this is due to an inappropriate power supply to the LED (e.g. 12 V with resistance to 2 V LED feed: η 17%).

Technical means of reducing standby consumption include:

- Use of efficient transformers (options include toroidal core transformers with 0.1 W idle loss, as well as small standard models with < 0.4 W)
- Use of efficient power supply units or electronic versions (e.g. new types of chargers as used in mobile phones, "Mainy" plug-in devices available on the market). It is possible that high losses could be caused by conflicting voltage levels (e.g. power supply unit supplies 12 V, but device only consumes 5 V or 2.5 V [LEDs], potential dividers, etc.).
- Dual standby levels: here, an appliance can be switched into higher standby mode (activation of displays, sensors, etc.) by pressing a button or even by simply approaching it (movement sensors, consumption levels around < 0.5 W). If the appliance is not switched on, or if no further activity takes place, it is switched back into economy standby mode after a period of (for example) 5 minutes.
- Use of more efficient standby devices: with LED and background illumination of LCDs with adjustable brightness (in some cases dependent on ambient lighting), and electronic power switches instead of relays (and if relays are to be used, they should always have zero consumption in standby), it is possible to increase the efficiency of power supply units.
- Appliances with a main switch (consumer electronics, but also coffee machines, microwave ovens) often continue to consume electricity even when switched off: here the main switch is off, but the power supply unit is still connected to the mains! There are various reasons for this practice, but its purpose is often confusing for users. If it cannot be avoided for some reason, then the power consumption should at least be lowered to < 0.5 W.

Induction cooker tops

Although this technology is very new, the associated standby consumption levels are surprisingly high. From a technical point of view it is difficult to understand why this should be the case, especially since energy efficiency is one of the main sales arguments for this technology. Measurements and evaluations have revealed that the energy savings attained during the cooking process are cancelled out by high standby consumption (glass-ceramic cooker tops normally did not have a standby mode). Apparently the industry has already reacted to the findings obtained during 2002, and is now offering more efficient solutions (cf. comments at the end of Chapter 5.3).

Coffee machines

The above statements also apply to control devices for coffee machines. There are various ways in which it would be possible to reduce the high level of consumption for **heating** purposes:

- Auto-off function with default setting 1 hour: the appliance is automatically switched to low standby mode (i.e. the heating function is switched off) after a specified (programmable) period. This function is already available in some appliances, but the default setting is usually 2 hours. It would be especially important for an auto-off function to be available or configured for coffee machines in offices, since economical user behaviour cannot be anticipated here. A delay of 2 hours would be more appropriate in an office environment in order to avoid frustration.
- Appliances could be designed to ensure that heating processes consume less electricity (e.g. insulation of boiler, smaller cup-warming zone). With electronic controls it would be relatively simple to achieve a lower heating temperature of, for example, 70°C; heating to 85...90°C would take place while the coffee is being ground.
- Appeals can of course be made to users to behave economically (e.g. by switching off appliances after use), but these are not particularly welcome. In view of this, we have to focus on finding and implementing technical solutions.
- If an energy label should be introduced for coffee machines, the classification criteria should be defined to ensure that only those appliances with an effective auto-off function can be considered for classification in category A (cf. energy label, Chapter 5.10).

7.2 Networking

We repeatedly hear predictions concerning a boom in the networking of household appliances, but very little has actually taken place to date in practical terms. The objective here is to network appliances and users, and appliances to one another, both for information and for operating purposes, e.g. via remote control, timers, etc. Whether consumers really want to use such functions is something that still needs to be fully established.

For networking purposes, a transmitter/receiver or communication device needs to be installed in the appliance. Technically speaking, the power consumption of such a device could be below 1 W (including with wireless and similar solutions). The allocated logic component does not require more power than the equivalent component in a mobile phone, i.e. well below 1 W. But in view of findings obtained from studies on other appliance categories, we have to anticipate the likelihood that the first series of products to come onto the market will be equipped with control devices and/or power supply units that give rise to high energy losses.

The findings of a Swiss Federal Office of Energy research project, "Networking in private households – impacts on electricity consumption" [7], indicate that the future development of networking will probably give rise to increased electricity consumption. And the first prototypes do in fact indicate very high energy consumption, cf. www.futurelife.ch ("vernetztes Haus"). While this may be deemed tolerable for prototypes, any product that is brought onto the market must be able to meet modern-day requirements with respect to energy efficiency.

7.3 Perspectives

As noted in Chapter 7.1 above, from a technical point of view it would be possible to achieve significant reductions in standby consumption versus the levels shown in Table 6.1 and Figure 6.1. The fact that the industry does not question this is illustrated by the existence of such appliances (cf. low-consumption models included in Table 5.1). Furthermore, the European Commission's "Code of Conduct on Efficiency of External Power Supplies" [12] lists corresponding consumption levels for external power supply units that would also be realisable today for internal units (Table 7.1).

	Maximum no-load power consumption		
	Phase 1	Phase 2	Phase 3
Rated input power	01.01.2001	01.01.2003	01.01.2005
> 0.3 W and < 15 W	1.0 W	0.75 W	0.30 W
> 15 W and < 50 W	1.0 W	0.75 W	0.30 W
> 50 W and < 75 W	1.0 W	0.75 W	0.75 W

Table 7.1 Timetable for the EU "Code of Conduct on Efficiency of External Power Supplies"

There appears to have been progress with the implementation of the EU "Code of Conduct" or corresponding measures, in that a variety of devices are now available that have standby levels below 1 W. This trend looks set to continue. But there are also contrary trends, e.g. in the direction of total penetration of the household appliances market by electronic control devices without improvements in efficiency, and the possibility of networking of household appliances (with high standby consumption).

Table 7.2 presents a summary of the main factors concerning **positive and negative trend scenarios for energy efficiency** for the period up to 2010. These forecasts are based on the widely shared assumption that the number of households will increase to around 3.3 million (+ 5%), as predicted in the "Prognos" report [10]. In the positive scenario it is assumed that the readily realisable technical measures will be implemented, but will not begin to fully take effect until 2010 since many of the appliances that are new on the market today will still be in operation. In the negative scenario it is assumed that present-day standby levels will undergo very little improvement.

In the positive scenario, overall standby consumption remains more or less at the present-day level, whereas in the negative scenario it is conceivable that it will increase by around 1,000 GWh/a. This is equivalent to almost 2% of Switzerland's end-use electricity consumption.

Positive trend	Δ GWh/a	**Negative trend**	Δ GWh/a
Household appliances in general			
Reduction of standby consumption of new appliances to 0.2 W (cf. Table 7.1). Average level in 2010, 0.4 W. Low number of new household appliances with standby (on average, 3 per household): Total, 25 million at 0.4 W, 8,760 hrs: 88 GWh/a versus present-day 105 GWh/a	- 17	Same standard of power supply units as today (average, 2 W) More appliances with standby consumption (5 on average): 3.3 million at 5*2 W, 8,760 hrs	300
Induction cooker tops			
Successive reduction of standby consumption of new appliances to 0.2 W by 2010. Increased distribution, 1 million by 2010. 1 million at ∅ 1 W, 8,760 hrs	9	Increased market share of induction cooker tops, some with relatively high standby consumption: 2 million at ∅ 4 W, 8,760 h/a	70
Coffee machines (increase from 2.75 to 3.5 million = + 27%)			
Auto-off now standard, delay = 1 hr. Users continue to behave economically. Approx. 2/3 of reduction attributable to coffee machines in offices.	- 75	No improvements through technical measures, more negligent user behaviour → 127*120% = 150% (+ 50%)	150
Networking			
Gradual increase in distribution, (additional) power consumption decreasing to 0.4 W by 2010. As of 2010, average of 2 appliances per household at ∅ 1 W: 3.3 million at 2*1 W, 8,760 hrs	60	Rapid increase in distribution, average of 4 appliances, (additional) power consumption constant at 4 W by 2010: 3.3 million at 4*4 W, 8,760 hrs	460
Total	- 23		980

Table 7.2 Standby consumption of household appliances: scenarios for positive/negative trends up to 2010

8. Implementation

The standby losses associated with household appliances in Switzerland add up to almost 400 GWh per annum, giving rise to electricity costs amounting to approximately 80 million Swiss francs. Almost 80% of these losses can be attributed to heating requirements for coffee machines. Since it appears that significant efficiency potentials can be utilised with the aid of relatively simple measures, we recommend that steps should be taken to enhance efficiency levels.

Here it is essential to formulate detailed guidelines and define testing standards for declaring standby losses. The European Commission is currently working on the formulation of guidelines for measuring standby consumption, and this means that an important instrument will be available for describing standby losses in many categories of household appliances, and for taking measures to reduce them. Future updates of European energy labels should incorporate standby losses into their annual energy consumption figures. This especially applies to washing machines, clothes dryers, dishwashers and ovens. For refrigerators and freezers, standby losses are (automatically) integrated into measurement and testing standards.

However, the current draft does not incorporate losses associated with heating requirements for coffee machines, and this means there is a danger that the largest category of appliances responsible for standby losses may not be included in the standard at all. Based on the findings obtained from our measurements in the course of this project, we have drawn up a proposal for an **energy declaration for coffee machines**. This proposal could lead to the implementation of the following measures:

- Recommendation to **consumer organisations**, publications and related Internet sites to include standby losses in measurement and testing procedures, and to base the associated measurements on the procedure outlined in the proposal. In this way it would be possible for consumers to obtain the necessary information concerning standby losses, and they would also be able to include energy-relevant criteria in their purchasing decisions.

- We recommend that the relevant **EU authorities and national energy agencies** should consider paving the way for the introduction of an energy label for coffee machines. The following arguments can be put forward here:
  - Their energy consumption is within a similar range to that of other labelled appliances (100 to 300 kWh/a)
  - They have major efficiency potential that can be realised through technical measures
  - Consumption measurement procedures are fairly easy to define
  - An energy label would be effective on the sales floor, since most users buy appliances from retail outlets and the label can be displayed on or near the appliance.

- **European initiatives** such as the "Code of Conduct on Efficiency of External Power Supplies" should be contacted and provided with up-to-date information.

- **Trade journals** should publish articles on the topic of standby losses.

- **Articles** should be published in the general media in order to draw attention to behavioural measures to optimise the energy consumption of coffee machines. The emphasis here should be on manually switching off the machine after use, providing an overview of the most energy-efficient models, and configuring short activation times for automatic switch-off functions (especially for appliances used in offices).

- **Manufacturers** should also be notified about the technical potentials and encouraged to declare standby losses. The most important factors here are auto-off functions and insulation of boilers.

- And by providing the purchasing departments of **major distributors** with expert advice, the trade will be able to offer more energy-efficient models and include energy efficiency requirements in its lists of specifications.

9. References

[1] Feasibility study on data collection in the “Electricity” programme: household appliances, etc. (A. Huser et al), household technology and special applications (J. Nipkow et al), final reports of the SFOE “Electricity” research programmes, Dec. 2000/Jan. 2001

[2] Conrad U. Brunner et al. *Energieeffizienz bei Elektrogeräten – Wirkung der Instrumente und Massnahmen* (*Energy efficiency of electrical appliances – impacts of instruments and measures*). SFOE, 2001

[3] Aebischer, B. & Huser, A. *Energiedeklaration von Elektrogeräten* (*Energy declaration for electrical appliances*). Final report of the SFOE “Electricity” research programme, Dec. 2001

[4] *Measurement of Standby Power, IEC 62103 Ed. 1*, Committee Draft 59/297, 7/2002

[5] *Benutzerverhalten bei Haushalt-Kaffeemaschinen und Haushalt-Steamern* (*User behaviour relating to household coffee machines and household steamers*). Survey, 2002, Matthias Peters, Frauenfeld. Evaluation report. Documentation held by S.A.F.E., J. Nipkow, Schaffhauserstrasse 34, 8006 Zurich

[6] FEA 2002 market statistics. Fachverband Elektro-Apparate (Association of Electrical Appliances), Zurich

[7] Aebischer, B. and Huser , A..*Vernetzung im Haushalt – Auswirkungen auf den Stromverbrauch* (*Networking in private households – impacts on electricity consumption*). Final report of the SFOE “Electricity” research programme, November 2000
Cf. www.futurelife.ch ("Vernetztes Haus")

[8] S.A.F.E. internal statistics concerning electrical appliances. (Status 2003, constantly updated)

[9] *Methods for measuring the performance of electric household coffee makers*, IEC 60661 (1999 + A1 2003)

[10] *Die Entwicklung des Elektrizitätsverbrauchs serienmässig hergestellter Elektrogeräte in der Schweiz unter Status-quo-Bedingungen und bei Nutzung der sparsamsten Elektrogeräte bis 2010 mit Ausblick auf das Jahr 2020* (*Development of the power consumption of mass-produced electrical appliances in Switzerland by 2010, given a status quo and use of the most efficient appliances, and outlook up to 2020*). Peter Hofer et al, Prognos, Basel, Dec. 2002

[11] www.topten.ch. Toptest GmbH. June 2003

[12] *Code of Conduct on Efficiency of External Power Supplies,* EUROPEAN COMMISSION, DIRECTORATE-GENERAL ENERGY AND TRANSPORT, Promotion of Renewable Energy Sources & Demand Management, Brussels, 15 June 2000

- Internal documentation relating to measurement campaign (test reports, Excel worksheets).

Other selected sources of information (though these mainly concern consumer electronics and electronic office equipment):

- *Standby Power Use*: How Big is the Problem? What Policies and Technical Solutions Can Address It?
  Paper presented at ACEEE 2002 Summer Study on Energy Efficiency in Buildings, August 18-23, 2002 at the Asilomar Conference Center in Pacific Grove, California, by Paolo Bertoldi et al.
- *Guidelines for Measurement of Standby Power Use*,
  In Response to Executive Order 13221, Version June 6, 2002
  (Annex to Code of Conduct on Efficiency of External Power Supplies)

10. Appendix

Questionnaire for representative survey on coffee machines and steamers

Sex	Age
1 Male	15-34
2 Female	35-54
3	55+

1. Do you use any coffee machines in your household?

1 Yes
2 No → Proceed to question 8

2. What type of machine do you use?
   1 Fully automatic espresso machine (with grinder and powder disposal)
   2 Manually operated espresso machine
   3 Espresso machine with ready-to-use coffee portions (e.g. Nespresso)
   4 Filter-coffee machine

(Italian espresso makers for use on hotplates are not regarded as coffee machines)

3. Does your (filter) coffee machine automatically heat up cups?

1 Yes
2 No

4. Does your coffee machine have an electronic display with numbers or text?

1 Yes
2 No

5. When the machine is switched off, is any information still visible on the display?

1 Yes
2 No

6. When do you switch your coffee machine off?
   1 Not necessary, machine switches off automatically
   2 At night
   3 After coffee breaks (morning/afternoon/evening)
   4 After each use
   5 Other

7. How many cups of coffee do you make each day on average (incl. Saturdays and Sundays)?

PLEASE INDICATE APPROXIMATE NUMBER OF CUPS

8. Is there a coffee machine in your office that is operated by the employees themselves? (question refers to household coffee machines, not commercial beverage dispensers or coin-operated appliances)

1 Yes
2 No → Proceed to question 10
3 Question not applicable – proceed to question 10

9. Is the coffee machine in your office switched off at night?
1 Yes
2 No
3 Don't know

10. Do you have a steamer?
1 Yes → Proceed to question 14
2 No

11. Can you use your oven as a steamer by adding water?
1 Yes
2 No → Proceed to question 13

12. How frequently do you use the steamer function?
1 Frequently
2 Fairly frequently
3 Not very often
4 (Almost) never

13. Are you thinking of buying a steamer within the next 2 years?
1 Yes
2 No

PLEASE PROCEED TO QUESTION 15

14. Do you have an oven as well as a steamer?
1 Yes
2 No

DEPENDING ON THE SITUATION, PLEASE ASK EITHER OF THESE QUESTIONS, OR BOTH (BASED ON ANSWERS TO QUESTIONS 10 AND 14):

15. How many times a week do you use your oven on average?
PLEASE NOTE NUMBER OF TIMES PER WEEK

16. And how many times a week do you use your steamer on average?
PLEASE NOTE NUMBER OF TIMES PER WEEK

Thank participant and sign off