Energy label for coffee machines

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Abstract

Espresso machines and other household coffee machines account for a significant proportion of the electricity consumption in more and more European households. The evaluation of a number of measurements reveals that - if not switched off after use – they may consume up to 300 kWh p.a. There are large saving potentials by switching off the heating device automatically and by improving thermal insulation. Therefore an energy label for coffee machines would be appropriate and would give incentives to trade and industry to develop and offer energy-efficient coffee machines. The electricity consumption of electric ovens in the range of 100 kWh p.a. already has to be declared in the EU in the form of an energy label. S.A.F.E. and www.topten.ch are working on measurement methods and usage patterns as a basis for an energy declaration model and a possible energy label (A to G classification). The measurement procedure may be relatively simple as only the stand-by and re-heating modes have to be measured. The usage pattern – e.g. hours of keeping warm per day and year – has to consider all types of machines and properties of the automatic switch-off function. Energy consumption might be integrated into the IEC 60661 standard, "Methods for measuring the performance of electric household coffee makers" (2006-02), where it is mentioned very briefly at present. Clearly defined measuring methods and usage patterns are necessary for comparing the energy efficiency of coffee machines.

Introduction

Sales of espresso machines are growing constantly in Switzerland. A survey in 2002 revealed that 64% of the involved 1130 households had at least one coffee machine in use. Fully automatic espresso machines represented 45% of the sample while filter machines were less important with 17%. Calculation of electricity consumption by typical appliance properties and a standard usage verified the importance of these appliances in household electricity consumption; it exceeds the consumption of electric ovens. Considering the large saving potentials by switching off the heating device automatically and by improving thermal insulation, an energy label as the A to G classification of the European Union would give an incentive to manufacturers to improve energy efficiency of their products. The magnitude of the energy saving potential of an efficient versus a typical espresso machine is about 100 kWh p.a.. For the Swiss situation this represents about 3% of a typical household consumption and some 0.3% of the country electricity consumption.

Espresso machines seem to become more popular in other European countries as well, but we did not investigate on the situation in other countries so far. The mentioned energy saving potentials apply also to other types of coffee machines with keeping hot functions, as the "keeping hot" energy consumption exceeds the consumption for coffee production by far. Therefore we are convinced that an energy label for coffee machines would be of high interest for most European countries.

Other policy opportunities such as a Code of Conduct relating to auto-off functions or to stand-by wattage would yield minor effects. Minimum Efficiency Performance Standards MEPS might be another option, but given the very broad range of products and functions, realisation would be difficult. A large span between best and worst products – larger than many labelled appliances! – supports an A to G label. An important additional advantage is the incentive to manufacturers to reach class A.

This paper suggests a measuring method and a standard usage as a basis for an A to G energy label. Both measuring method and standard usage have been tested by S.A.F.E. and www.topten.ch [1].

Appliance categories and functions

Table 1 Types of coffee machines, price range and energy properties

Type of machine	Price range (Euros)	Approx. mean keeping hot consumption (watts)	Efficiency measures
Filter machines	20…60	40	Automatic switch-off, timer
Manual espresso machines with coffee holders, for households	130…300	20…60	Automatic switch-off, timer, heat insulation
Fully automatic espresso machines, for households	400…1,300	30…60	Automatic switch-off, timer, heat insulation
Espresso machines, capsule systems, for households	130…700	20…60	Automatic switch-off, timer, heat insulation
Hot beverage machines, capsule systems	130…1,500	30…60	Automatic switch-off, timer, heat insulation
Semi-professional, fully automatic espresso machines (high capacity)	1,300…3,000	40…100	Automatic switch-off, timer, heat insulation
Commercial espresso machines (very high capacity)	3,000…15,000	100…	(Not included in study)

The categories listed in table 1 correspond to the Swiss market 2005 and may be different for other countries.

Functions

By means of numerous analyses and measurements that were commenced in 2002/3 within the scope of the “Stand-by consumption of household appliances” research project [2], the functions of the various types of coffee machines were studied from the point of view of energy consumption, and measurements were carried out in order to identify typical consumption characteristics. It was found that all appliances have one thing in common: the need to keep the machine hot in order to permit immediate production of coffee accounts for the greatest proportion of overall energy consumption. This applies even with energy-conscious behaviour (e.g. switching the machine off after coffee breaks) or automatic switch-off function.

A fully automatic espresso machine for coffee beans functions roughly as follows (and the way in which simpler machines function can be derived from this description):

- After the machine has been switched on, the boiler is heated up to between 90° and 94° C, which is the ideal temperature for brewing coffee/espresso. When the heating function initially switches off, this normally indicates that the machine is ready for use, even if heating continues after a pause.

- Many machines carry out an automatic or programmable rinse cycle when they are switched on, i.e. a small quantity of hot water without coffee is pumped out. This clears the spout(s) and removes any residual material that may have been deposited.

- When a product is selected, the coffee is ground (or a portion is removed from the coffee container), and is then fed into the brewing device and pressed. This step is not required in the case of capsule machines. When the capsule holder is closed, small holes are punched into the capsule to allow intake of water and outflow of coffee.

- Hot water is pumped out of the tank – in espresso machines, with approximately 15 bar, – through the coffee powder and into the cup(s). Depending on the quality of the machine, the required quantity of water for the selected product is controlled by a flow meter or timer.

- The coffee grounds are removed from the brewing device and deposited in a container ready for disposal.
- Some machines also carry out another rinse cycle at this stage.
- During the coffee production stage, the machine re-heats as necessary, after which it again indicates that it is ready for use.

In the event of any errors (e.g. no water), the machine's electronic control system has to stop the process by means of sensors and logical circuits, indicate the fault and ensure the safety of the appliance.

Operating modes and energy consumption

Operating modes (for household coffee machines) can be described as follows on the basis of mean power consumption:

Mode, purpose	*Mean power consumption*
Off (display off, but machine still connected to mains)	0 to 4 watts
Stand-by (electronics and display active)	2 to 7 watts
Ready for use (kept hot for immediate production)	20 to 60 watts
Coffee production (water heater switched on)	500 to 1,600 watts

It is not easy to measure the energy consumption per cup of coffee, since the water temperature is controlled and heating up does not necessarily take place at the same time as the coffee is dispensed. Some machines can produce one cup of espresso without switching the heater on (this only occurs afterwards). However, we can calculate the theoretical energy consumption for 1 cup using the quantity of water and temperature difference, while disregarding the consumption by the pump. For 70 K temperature difference and 70% efficiency (assumption), the results are as follows:

Espresso, 35 ml (cf. IEC 60661, 2006-02 [3])	4.1 Wh
Coffee / cappuccino, 125 ml	14.5 Wh

Automatic switch-off

Almost all modern coffee machines are equipped with an electronic device that controls water and brewing temperatures (more accurately than thermostats), offers the selection of different types of coffee (espresso, cappuccino, etc.) and indicates status and function via LEDs or text displays. Electronics can also be used to save energy if the control device includes an automatic switch-off function or a timer (programmable on/off times).

For energy-efficient operation, a practical solution is an automatic switch-off function which can be programmed, e.g. in half-hour intervals, . Unfortunately, factory settings are often 4 or more hours, and thus too long for households, where coffee breaks do not usually last more than 2 hours (the automatic switch-off delay is only intended to keep the ready-state until the next coffee production).

Whether a timer function (i.e. programmable switch-off time) saves energy depends on the behaviour of the user: if coffee breaks are always taken at the same time, programming is easier and saves unnecessary energy consumption in ready mode, but it is of little use if coffee is made at irregular intervals.

It is interesting to note that modern coffee machines have high connection capacities and thus short heat-up times, usually 1 to 1.5 minutes (and even less if the machine is still warm from previous use). This heat-up time is acceptable for every user. And if the machine has a pre-rinse function, the output unit – and if it has been placed under the spout beforehand, the cup too - is also preheated. For household use, such machines do not require a hotplate for preheating cups, which could also be used as an argument against the use of an automatic switch-off function.

Measurement methodology

The measurement methodology encompasses the following operating modes: off, stand-by (without keeping hot) and ready (with heating for immediate coffee production). For measurement in ready mode, one heat-up cycle from cold is also taken into account. Coffee production itself is not measured. A detailed measurement report form is given in table 2.

Measuring equipment

- Power and energy meter for 230 V:
  Energy level response 1 Wh, output 0.1 W, response level approx. 2 VA.
  (Energy level response 0.1 Wh to measure stand-by consumption by Watthours)
  Energy accuracy: 2% (category 2) at least.

- Thermometer, permissible deviation at 20° C: +/- 0.5° C.

- Clock with seconds indicator.

Due to temperature control, consumption in ready mode only depends to a minor extent on the supply voltage. It is therefore not essential to maintain constant voltage, although a tolerance of ± 2% might be required to comply with other energy label measurement standards.

Procedure

Preparations

The required ambient temperature is 22° to 24° C, which also applies to the water in the tank (max. fill-up quantity). This is in accordance with other household appliances testing standards.

Coffee does not have to be used for measurement purposes, but with manual appliances the coffee holder has to be used.

Automatic switch-off: programmable delay times should be noted. Identify and note factory setting in programme mode. For measurement purposes, minimum setting should be 2.25 hours.

Fig. 1 Measuring campaign S.A.F.E. 2003

Measuring consumption in off and stand-by modes

If figures are difficult to read due to fluctuations, the difference on the energy display can be converted into watts during a period of at least 1 hour (with response = 0.1 Wh).

Measuring energy consumption in ready mode

The machine must remain in stand-by mode for at least 6 hours in order to ensure that it has cooled sufficiently.

For measurement purposes, the machine has to be activated, e.g. by pressing a key, so that it switches to ready mode. No coffee (water) output! If the machine has a switchable rinse function, this may be switched off for measurement purposes. Consumption in ready mode is measured for at least 2 hours, during which time the machine must not be allowed to return to stand-by mode (automatic switch-off setting). If necessary, deviations (e.g. with electromechanical thermostats) of up to 5 minutes may be adjusted linearly. This is also necessary if it is only possible to set automatic switch-off times shorter than 2 hours. In this case, precise times in seconds must be recorded.

For machines without an automatic switch-off function, the energy consumption after 1 and 2 hours should be recorded (indicating exact times) in order to measure the mean consumption in ready mode when the machine is in heated status (i.e. without heating-up energy).

For coffee machines with a switchable hot plate (operating instructions!), the energy consumption may also be declared using this option.

Table 2 Report form for measurements

Measurement report, coffee machine:		
	Location	
	Date	
	Name of person carrying out measurement	
	Measuring device used (brand, type)	
1	Rating plate / specifications: Make, model, year of manufacture Capacity as per rating plate Automatic switch-off: Programmable parameters from / to Programmable intervals Factory settings	W or kW
2a	Consumption in off mode Minimum / maximum	W
b	Consumption in stand-by mode Minimum / maximum	W
3a	Ambient temperature 0.5 metres laterally from appliance	° C
3b,	Energy reading at start Precise time (hh:mm:ss)	Wh
c	Energy reading in ready mode (after 1 hr) Precise time (hh:mm:ss)	Wh
d	Energy reading after 2 hrs Precise time (hh:mm:ss)	Wh
	Ambient temperature after 2 hrs	° C

Figures for W and ° C to be shown to 1 decimal place

Table 3 Results from the measurement report

2a	Consumption in off mode	P_{off}	W
2b	Consumption in stand-by mode	P_{stb}	W
3d *	Energy in ready mode, 2 hours, including heat-up	$E_{2h\text{-}ready}$	Wh
3(d – c) *	Energy for re-heating device, 1 hour, excluding heat-up	$E_{1h\text{-}Wh}$	Wh

* linearised if necessary and (d – c) calculated

Energy consumption per annum

In the same way as for all devices and appliances with different modes and usages, the annual energy consumption has to be determined for uniform – i.e. standard – usage. To date, no standard usage has been defined for coffee machines. However, we do possess information about the use of coffee machines in Switzerland. In 2002, within the scope of a research project “Stand-by consumption of household appliances” [2], S.A.F.E. conducted a representative survey in the German-speaking and French-speaking areas of the country concerning ownership and usage of coffee machines [2, 4]. The following three important findings were obtained with respect to energy consumption and the definition of standard usage:

- The number of cups of coffee consumed per day resulted in a weighted average of 6.3, which (taking holidays into account) translates into approximately 2,000 cups p.a.
- The participants in the survey stated that they were highly energy-conscious within their household: a majority of them said they switch off their coffee machine after each use, while 15% switch it off after their coffee break and 15% at night.
- There is a surprisingly high frequency of household coffee machines in offices: almost two-thirds of gainfully-employed participants stated they have a (household) coffee machine at their disposal at work. Slightly less than half of these are switched off in the evening, and this indicates a very high savings potential for automatic switch-off function.

Standard usage

The electricity consumption of household coffee machines is calculated on the basis of the following criteria, which represent typical user behaviour in Switzerland. These criteria are also used for calculating consumption levels for inclusion in the tables published by topten.ch (www.topten.ch).

Criteria for ready mode with economically configured automatic switch-off function:

Length of period of use (coffee break)	1 hour
Setting for switch-off delay	1 hour
= *2 hours ready mode per period of use*	
Periods of use: 2 per day, 52 full (7-day) weeks a year	730 p.a.
Total usage in ready mode = 730 * 2 =	1,460 hrs p.a.

If the machine is never completely switched off, total stand-by time is 8,760 – 1,460 = 7,300 hrs p.a.

If the machine does not have an automatic switch-off or timer function, a less economical user behaviour is assumed, with 12 hours daily use in ready mode (switched off at night, 1 heat-up process per day):

Total hours in ready mode without automatic switch-off = 365 * 12 =	4,380 hrs p.a.
Corresponding off time = 8,760 - 4,380 =	4,380 hrs p.a.

For coffee production, a theoretical figure is applied and no measurement is carried out since the related consumption is of secondary importance:

Theoretical consumption at 70% efficiency (see above):	
Espresso, 35 ml	4.1 Wh
Coffee / cappuccino, 125 ml	14.5 Wh
For standard usage:	
Mean energy per cup of coffee (*energy_cup*)	10.0 Wh
Annual coffee production energy for 2,000 cups	20 kWh

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Resulting standard energy consumption for 1 year

A. With automatic switch-off function

730 * energy for ready mode-2hrs + 7,300 * stand-by consumption + 2,000 * energy_cup

$$E_{tot\ Ao} = (730 * E_{2h\text{-}ready} + 7300 * P_{stb})/\ 1000 + 20 \quad \text{in kWh}$$

B. Without automatic switch-off function

365 * (energy for ready mode_2hrs + 10 * energy for re-heating device_1hr)
+ 4,380 * off consumption + 2,000 * energy_cup

$$E_{tot\ 0} = (365 * (E_{2h\text{-}ready} + 10 * E_{1h\text{-}Wh}) + 4{,}380 * P_{off})/\ 1{,}000 + 20 \quad \text{in kWh}$$

Examples with typical measurement readings

With automatic switch-off: $E_{tot\ Ao} = (730 * 90 + 7300 * 4)/\ 1{,}000 + 20 = 114.9$ kWh

Without autom. switch-off: $E_{tot\ 0} = (365 * (90 + 10 * 35) + 4{,}380 * 1.5)/\ 1{,}000 + 20 = 187.2$ kWh

Criteria for an energy label

To judge whether an energy label is reasonable, the energy consumption of coffee machines is compared with that of other appliances that have already to be declared using an energy label:

- Oven class A
  Annual electricity consumption in household, 150 baking/roasting cycles 100 kWh
- Refrigerator/freezer, 225 litres, no freezer compartment, class A+ 131 kWh

The energy consumption of coffee machines is thus comparable. In contrast to many "white" appliances – e.g. ovens, dishwashers, washing machines etc. – there is a large span between best and worst coffee machines (cf. table 2, fig. 4), what speaks in favour of an A to G label. This type of label gives incentive to manufacturers to reach class A.

Guidelines for ratings for an energy label can be deduced from the findings of earlier measurements for household coffee machines, as listed in table 4.

Table 4 Examples of electricity consumption of coffee machines; extremes for classification purposes

	Ready mode, 2 hrs, incl. heat-up, Wh	Ready mode, mean con-sumption, W	Standby, W	Off, W	2,000 cups, Wh	Total, kWh
Minimum	50	20	2	0		
Maximum	140	60	5	3		
		Wh	**Wh**	**Wh**		
With automatic switch-off, standard usage, minimum	36,500		14,600		20,000	71.1
Maximum	102,200		36,500		20,000	158.7
Without automatic switch-off, standard usage (re-heating 12 hrs p. day, minimum	18,250	73,000		0	20,000	111.3
Maximum	51,100	219,000		13,140	20,000	303.2

S.A.F.E. measurements 2002…2005

Based on the stated assumptions, the most efficient coffee machine consumes 71 kWh p.a. This level could be brought down further if stand-by consumption were to be reduced: with 0.5 instead of 2 W, the consumption level would be 60 kWh p.a. Insulation of the boiler represents another efficiency potential.

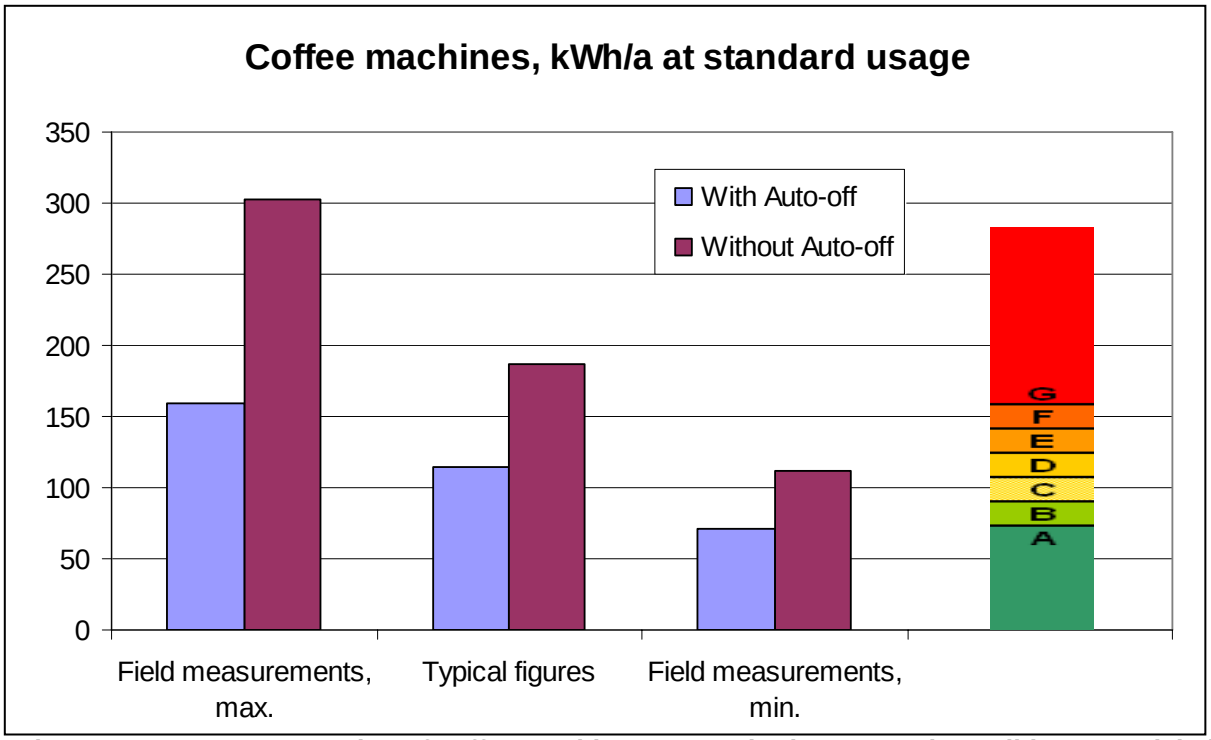

Fig. 2 Energy consumption of coffee machines at standard usage and possible energy label scheme

The threshold level for category A could therefore be defined as 60 kWh p.a., or 70...80 kWh p.a. if category A appliances should already be available on the market (Fig. 2). The upper threshold between categories F and G can, for example, be defined as double the threshold for category A (120

or 140...160 kWh p.a.). Machines without automatic switch-off do not necessarily have to be classified in categories F/G, if they have low mean "ready" power consumption. It appears less useful to specify a mean level on the market as D, as originally foreseen for household appliances in EU directive 92/75/EWG. The resulting mean level would be too high because of the large share of appliances without auto-off function. An A to G energy label might of course comprise further information as annual consumption and stand-by wattage.

Conclusions

In most households, coffee machines account for more electricity consumption than an energy-label class A oven or a class A+ refrigerator. Regarding the great differences between products and the high saving potentials by known simple technologies as an auto-off switching function, an energy-label for coffee machines would be a very effective measure to arise efficiency of coffee machines. A measurement methodology and a standard usage pattern are suggested and might be incorporated into the IEC 60661 standard and a labelling directive, respectively.

References

[1] www.topten.ch – Buyers' guide to energy efficient appliances (in German, French, Italian)

[2] Nipkow, J., Bush, E.: *Stand-by consumption of household appliances*, Swiss Federal Office of Energy SFOE, Berne 2003. Download from: www.electricity-research.ch (search: appliances)

[3] *Methods for measuring the performance of electric household coffee makers*, international standard IEC 60661, Ed. 2.2, 2006-02

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