EcoFamilies: evaluating and promoting energy savings

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Abstract

In 2007 Quercus, a Portuguese environmental non-governmental organization, selected 225 out of 500 volunteer Portuguese families to analyse their energy saving potential. The main objective was to evaluate how changing families' consumption habits could have a significant impact on reducing electricity consumption. The project's main areas of action were lighting, standby and off-mode. Electricity saving potential was also calculated for washing and refrigeration equipment.

The 'use of energy' evaluation consisted of a questionnaire on the usage of electrical equipment. The installation of Energy monitors in all households, with remote monitors (telemetry) being installed in 50 of the households.

The energy saving potential identified in reducing standby and off-mode usage represents 5.3% of the EcoFamilies electricity consumption. In the lighting sector, replacement of incandescent and halogen bulbs would result in an energy saving of 3.2%. Substituting refrigeration equipment (fridge/freezer), considering a 6-year return period, was viable only for 15 EcoFamilies, representing 1.9% of the EcoFamilies electricity consumption. No potential saving was identified with regard to dishwashers and washing machines as the return on investment period was more than 6 years.

Overall, by altering behaviour and substituting equipment each family had a potential saving of 348 kWh/year; 10.4% of total electricity consumption.

In this project a multiple adapter plug with power switch was given to each family to help reduce the energy consumption of standby and off-mode. With this measure it was possible to reduce this consumption by 80%.

This paper aims to describe the tools used to measure the energy consumption of various electrical equipment, the potential saving associated with the elimination of standby and off-mode use and the actual savings achieved by the EcoFamilies after the adoption of these measures.

Introduction

Final electricity consumption grew across the EU-25 at an average annual rate of 1.8% between 1990 and 2004 (overall increase: 22.6 %). This rate of increase was only slightly less than the average GDP (gross domestic product) growth rate over the same period, showing an apparent strong correlation between electricity consumption and economic growth. However, the increases in electricity consumption resulted not only from a growing economy, but also from an increasing share of electricity in final energy consumption, rising from 17.4% in 1990 to 20.0% in 2004. The attractiveness of electricity is due to its flexibility of use and the importance placed by consumers on the variety of energy services it provides (EEA, 2007). In Portugal electricity consumption represented 20.2% of final energy consumption in 2004 (DGEG, 2008).

In Portugal, between 2002 and 2005, electricity consumption grew at a mean rate of 5.7% per year. In 2006 the increase was only 2.6%, in 2007 and 2008 the increase was slower, respectively 1.8% and 1%, respectively (REN, 2008).

Total electricity consumption in the residential sector for the EU-25 grew by 10.8% in the period 1999-2004, from 690 TWh in 1999 to 765 TWh in 2004, representing 29% of total elec-

tricity consumption (JRC, 2007). This figure was mirrored in Portugal (DGEG, 2008).

The rate of electricity consumption growth in Portugal has been higher than in Europe, and in particular, we have been unable to decouple energy use from economic growth. Therefore, both conservation and efficiency measures in the area of energy use are extremely relevant.

Electricity use has grown at almost the same rate as the economy (GDP). Increasing electricity demand, within EU-25, is due to many different factors, including (JRC, 2007):

- More penetration of "traditional" appliances (e.g. dishwashers, tumble driers, air conditioners, personal computers, which are all still far away from saturation levels);
- Introduction of new appliances and devices, mainly consumer electronics and information and communication technology (ICT) equipment (Set Top boxes, DVD players, broadband equipment, cordless telephones, etc.) many with standby features.
- Increased use of 'traditional' equipment: more hours of TV watching, more hours of use of personal computer (driven by some tele-working and increased use of internet), more washing and use of hot water.
- Increased number of double or triple appliances, mainly TVs and fridge freezers.
- More single family houses, each with some basic appliances, and larger houses and apartments. This results in more lighting, more heating and cooling, and last but not least, an older population demanding higher indoor temperatures and all-day heating in winter and cooling in summer, and spending more time at home.

To be able to decrease the electricity consumption significantly we need more knowledge not only about how, when and why households use energy, but also about how the household members in the same household use the various appliances (Green and Ellegård, 2007).

Energy consumption can be reduced by providing the consumer with a more informed choice about their energy-using practices. In general, changing energy-using behaviour has a promising potential for energy conservation (Wood and Newborrough, 2002).

A study made by REN (Energy National Networks) indicated that in Portugal one kWh saved is ten times cheaper than one earned by investing in renewable energy sources (Verdelho, 2005).

EURECO project allowed the measurement, for one month, the electricity consumption of the main end-uses in 400 households of four European countries (Denmark, Greece, Italy and Portugal). An average saving of 1200 kWh/year per household was then measured, representing 40% of the total initial consumption (Sidler, 2003).

A total annual saving of 733 kWh/household was identified in the EURECO project as being possible for Portugal, using the following measures (ADENE, 2002):

- Replacement of all refrigeration equipment with the most energy efficient models available on the European market (« A » in the European Energy Label) (37% of total saving);
- Replacement of all incandescent and halogen lamps with compact fluorescent lamps (14%);
- Reduction or elimination of standby power waste whenever possible through simple means such as a multiple plug with an on-off switch (42%);
- Replacement of clothes washers with a class A model, or connecting the clothes washer to the hot water outlet, or encouraging cold temperature washing (7%).

A similar project, aimed at reducing the consumption of electricity in the domestic sector by reducing standby usage, was carried out in Denmark (Gudbjerg and Gram-Hanssen, 2006). Characteristics similar to that of EcoFamilies include the stimulation of behavioural change by offering an adapter plug with power switch among other measures. Measurements were taken at the end of the project to ascertain the savings made by this change of behavior. In this project it was possible to cut standby usage by 64%.

By making energy consumption transparent, the EcoFamilies project aimed at raising citizens' awareness about the questions associated with the consumption of electricity in the domestic sector. This project is a way to get closer to Portuguese families, acting directly in their homes, with the goal of reducing their energy consumption through the change of behaviour, but without interfering in their quality of life. EcoFamilies 225 covered families through all the country (Figure 1).

The project also had the goal of publishing the results achieved, to maximise and enlarge the range of the project to all Portuguese families.

The project had the following goals:

- Characterization of the energy consumption habits of Portuguese families;
- Define demand side management plans for each family and promote its implementation;
- Promote efficiency energy consumption in the domestic sector, through personalized and direct advice.

The objective of this paper is to describe the methodology used in the measurement of potential and actual energy savings of the participating families. It also aims to discuss how the savings were and could be made; by changes in either equipment/appliances or behaviour.

METHODOLOGY

The evaluation of the EcoFamilies energy behaviour was made in two ways:

- Analysis of appliance usage habits, obtained from the questionnaire;
- Measurement of the consumption of appliances and other equipment, using local measurement devices (energy checks) and remote monitoring instruments.

Local measurement equipment (Figure 2) allows for the reading of electricity consumption in each plug, for one or more devices. Around 300 devices were installed in homes.

Figure 1 – EcoFamilies geographic distribution

Figure 2 – Local measurement instrument

Figure 3 – Remote counting instrument

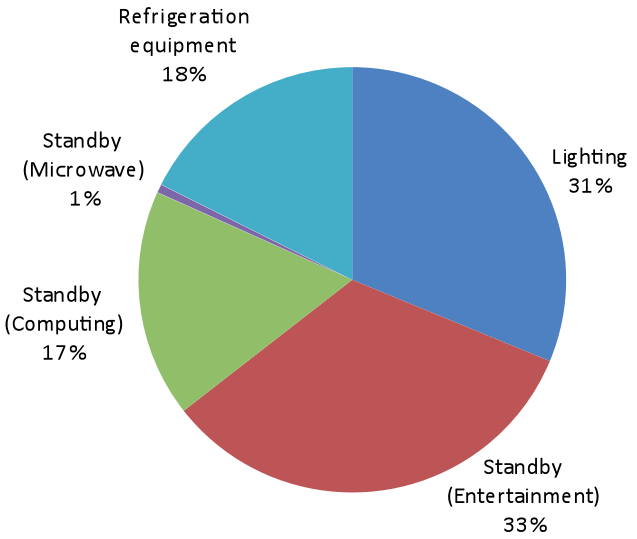

Figure 4 –Potential savings distribution in the different categories

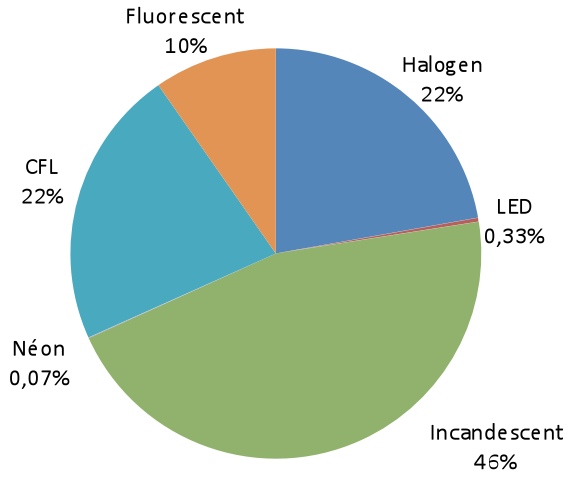

Figure 5– Bulbs used in households

Remote measurement instrument (Figure 3) allows for the remote measurement of electricity consumption in each circuit breaker, sending the data by GPRS to a central database. This solution allows the monitoring of equipment connected directly to the electricity network of the house, such as the ceiling lighting, electric ovens and hobs. There were 50 measurement devices installed in the EcoFamilies homes.

DIFFICULTIES

Due to the geographic dispersion and some faulty measuring devices used in the project some difficulties occurred. These were mainly due to schedule incompatibility between the families and the technicians, measurement equipment bugs or problems accessing the electricity connection of some home appliances.

Furthermore some families left the project for personal reasons, and therefore the total number of families engaged in the project fell from 225 to 206.

RESULTS

Energy saving potential was calculated based on the consumption of:

- Standby,
- off-mode,
- lighting,
- refrigeration equipment,
- washing machines and dishwashers.

With regard to standby and off-mode consumption, the saving potential was calculated using multiple adapter plugs with off power button.

For the evaluation of lighting saving potential, several characteristics such as type and time of use were considered. Electricity saving potential was obtained by replacing the bulbs with more efficient alternatives, considering the power of the bulb, time of consumption and the investment in the new bulbs. It was concluded that the replacement of the lighting was only justified for a pay-back period of 5-years at the most.

In the analysis of the consumption of refrigeration equipment, washing machines and dishwashers the possibility of replacing the equipment by more efficient alternatives was evaluated, too. Here a maximum of 6-year pay-back period was considered.

Analysing by category, the most significant reductions possible, were identified as being the elimination of standby and off-mode in entertainment equipment (33%), followed by the replacement of existing lighting appliances (31%) and refrigeration equipment (18%) with more efficient models (Figure 4). Avoiding standby and off-mode in computing equipment represents 17%, whereas avoiding microwave standby contributes to just 1% of the identified saving potential.

Using more efficient bulbs represents a saving potential of 107 kWh/year per family, around 3.2% of total electricity consumption. Incandescent bulbs are still the main lighting method used by the families (46%). There is also a significant potential in the replacement of halogen bulbs for more efficient ones (Figure 5).

Regarding appliance replacement, only in 8 cases was it reasonable to replace the existing refrigeration appliance with a more energy efficient model, achieving an energy reduction potential of between 585 and 1594 kWh/year (982 kWh/year on average). These replacements represent a global saving of 7852 kWh/year, i.e. 1.1% of the EcoFamilies total electricity consumption.

When analysing freezer energy consumption we found that it was viable to replace 7 appliances, achieving an energy reduction potential of between 712 and 809 kWh/year (766 kWh/year on average). These replacements represent a saving potential of 5360 kWh/year (0.8% of the total electricity consumption of the families).

Cutting standby and off-mode losses of entertainment and computing equipment is the category with the highest saving potential. The presence of this type of equipment in the households is very significant. Thus, in over a third of the assessed

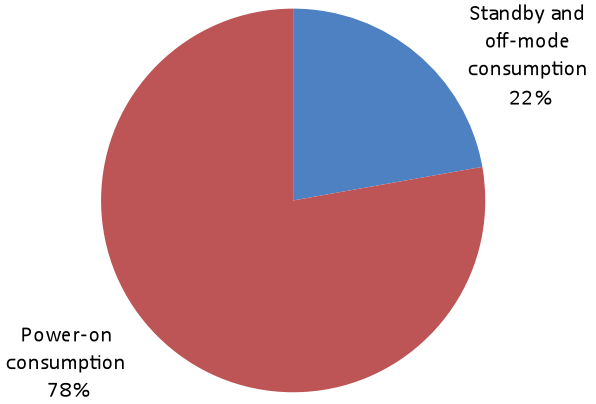

Figure 6 – Potential savings in appliances with a standby or off-mode

Table 1 – EcoFamilies 255 saving potential

		Standby and Off-mode	Lighting	Refrigeration equipments	Total
Total	kWh/year	36283	22140	13212	71634
	€/year	4103	2504	1494	8101
	kg CO2/year	17452	10649	6355	34456
Per family	kWh/year	176	107	64	348
	€/year	20	12	7	39
	kg CO2/year	85	52	31	167
% of saving from consumption		5,3%	3,2%	1,9%	10,4%

households the standby and off-mode represented at least 40% of the consumption in this category. The saving potential was lower in some cases where good practices already existed.

Standby and off-mode elimination in entertainment and computing equipment represent an annual saving per family of 176 kWh/year. This elimination represents a saving of 22% in entertainment and computing categories (Figure 6), and 5.3% of the EcoFamilies total electricity consumption.

All 225 families were provided with multiple adapter plugs with power switch. Of these, measurements were taken in 30 households in order to ascertain the reductions achieved by this simple measure. These final measurements showed the reduction to be 80% of the potential savings previously identified relating to standby consumption. This possibly highlights the fact that we have a lower starting point in Portugal, with many families using old/ineficient appliances. However this factor was not controlled by the study.

Finally, it would be interesting to follow up and evaluate the long-term effectiveness of this project, particularly with regard to the continued 'good' behaviour of the families involved in the project.

Globally, with the change of behaviour and the replacement of equipment, the families that participated in the project had a potential energy saving of 348 kWh/year per family (10.4% of total electricity consumption) (Table 1).

CONCLUSION

In EcoFamilies a potential energy saving of 10.4% of the total electricity consumption was identified.

In this project the largest potential saving was identified as being the elimination of standby and off-mode in certain appliances. This was largely achieved with the offer of a multiple adapter plug with power switch and education of the families as to the importance of their usage. The actual saving achieved in this area was 80%.

With regard to lighting, there was also a large potential saving, which corresponded to 3.2% of the total electricity consumption of EcoFamilies. This potential saving exists due to the continued high level use of incandescent and halogen bulbs. Due to a lack of finance it was not possible to provide new energy efficient light bulbs to the families, however, some families took that initiative upon themselves.

The substitution of domestic appliances in these families presented a potential saving of 1.9%. This figure is lower than in other studies maybe due to the fact that domestic appliances in these families are relatively recent and for this reason already quite efficient.

This saving potential can still be improved by increasing the use of renewable energy and improvements in the construction refurbishments.

This paper affirms that a saving potential in the domestic sector is very significant. Although habits are shifting fundamentally towards more efficient energy consumption, it must be recognised that further education of the population at large as to the benefits, both environmental and financial, is necessary if we are to maximise the potential savings discussed in this study.

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