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Standby consumption of new appliances on Hungarian market: trends and energy savings potential

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ABSTRACT OF THESIS submitted by
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The present study examined the energy savings potential through comparing standby power consumption of best available technology on the Hungarian market to the consumption of current household stock. The total number of appliances measured in stores and households was 692. It was found that it was found that current household stock consumes more power than new appliances of the same type available on the Hungarian market. The least consuming products in the stores were appliances with LCD technology (0.7 W per hour in standby both for monitors and TVs), while CRT TVs turned out to be the most consuming ones with an average power consumption of 4.5 W per hour. In contrast, the best performers in the household stock were washing machines, and the worst ones – CRT computer monitors.

Furthermore, it was estimated that standby consumption of major household equipment is responsible for 4.1 percent of energy consumption from electric appliances and lighting in Hungary. Replacement of current household appliance stock with the best available technology is expected to save 367 GWh per year, which translates into 3.4 % of energy consumption by household electric appliances and lighting in Hungary. The energy savings potential resulting from the implementation of 1 and 0.5 W limit by 2013 is estimated to be 338 GWh per year, or 3.1% of energy consumption by household electric appliances and lighting. In order to realize these potentials several recommendations for the government were presented.

Keywords: energy, standby consumption, energy savings potential

Table of Contents

List of tables

List of Figures

1 Introduction

1.1 Standby Power Consumption on the International Agenda

Concern for growing energy consumption and rising energy prices, together with the increasing environmental awareness in developed countries put standby consumption of household and office equipment into the spotlight more than a decade ago. To date, a variety of approaches exists to tackle the problem, from voluntary schemes to regulations and information campaigns. However, it is noted that a universal approach to regulate standby power is needed, as the number of appliances with standby functions is expected to increase and thus affect the overall energy consumption and CO_2 emissions (Meier 2008; Pellegrino 2008).

According to Ellis (2007), estimated energy savings potential from reducing standby power consumption worldwide is 300 TWh per year, which equals the total annual electricity consumption of Italy. The achievement of this potential is however subject to joint efforts of the government, manufacturers and consumers of each and every country. The European Union (EU) has recently set a good example to follow by endorsing the limit on standby consumption of major office and household energy-using products, which is expected to result in the savings of 50 TWh of electricity and 14 Mt of CO_2 per year (Europa 2008).

Despite the fact that an extensive research of the phenomenon has been undertaken in some countries, such as Australia, the United States and Korea, there are still no comprehensive data on standby power consumption by major household and office appliances and even less data on the same issue with regard to new appliances and their functions appearing on the market in the rest of the countries. The availability of such data would allow monitoring standby consumption trends over time and in various parts of the world, making comparison by type and brand of appliances, analyzing user and product behavior, and shaping future policies (Pellegrino 2008; EnergyConsult 2007b).

The present research intends to contribute to filling in this gap by assessing the energy saving potential in standby consumption in Hungary. The previous research in Hungary encompassed standby power consumption in households, conducted through whole-house measurements (Valentova 2007, Strukanska 2001). However, to date, to the knowledge of the author, there has been no attempt to estimate the savings potentials through the *best available technology* on the Hungarian market of household appliances. This focus of the study is especially important, given the rapid technological development that brings new features to residential appliances from year to year, thus affecting the overall standby consumption. Drawing on the previous research in Hungarian households, this thesis will provide a comparative analysis between the standby power consumption of the current residential appliance stock and new products available on the market. As a result, the energy savings potential for Hungary from the perspective of the best available technology will be estimated.

1.2 Aim and objectives of the study

The aim of the research is to assess the energy savings potential in standby power consumption of major household appliances in Hungary.

The following objectives will facilitate the fulfillment of the aim:

- compare the standby power of appliance on display in Hungarian electronics stores to the previous in-situ data in households;
- draw trends in total national standby power consumption by product type over time;
- quantify the rate of improvement/deterioration by product type over time;
- calculate the energy savings potential with a hypothesis that: a) existing household stock will be exchanged for the best available technology (as of 2008) by 2013; b) all new household appliances will consume 1 or 0.5 W in standby mode from 2013, depending on the type of appliance;
- estimate reduction potential in CO_2 emissions;
- provide recommendations for achieving estimated savings potential in Hungary.

The present study is valuable in providing baseline information about the standby power of new appliances as of 2008, which might be further used for comparative analysis of the trends in the standby consumption over time and for tracking market transformation progress as a result of future policies scenarios in Hungary.

1.3 Thesis Outline

Chapter two consists of three parts focused on the standby consumption issues. It starts with an overview of major developments in the standby concept since its appearance in the late 1980s. In the second part of the chapter a variety of existing definitions of standby consumption is discussed and related debates are disclosed. The third part of the chapter examines current standby regulations implemented worldwide and points out the major advantages and disadvantages of possible approaches to the standby regulation.

Chapter three presents data collection and data analysis format, and introduces the calculation methods used in the study. The limitation of the research are also pointed out and explained at the end of the chapter.

The results of the study are presented and analyzed in chapter four. The core elements of this chapter are first of all the comparative analysis of standby consumption of best available technology on the Hungarian market and the current household stock. Secondly, trends in new appliances on the market, such as presence of electronic displays, labels, off switches are thoroughly examined. Finally, the energy savings potentials from replacement of existing stock in households with new appliances on sale are calculated and analyzed. The estimations are then compared to the previous data from similar research in Hungary.

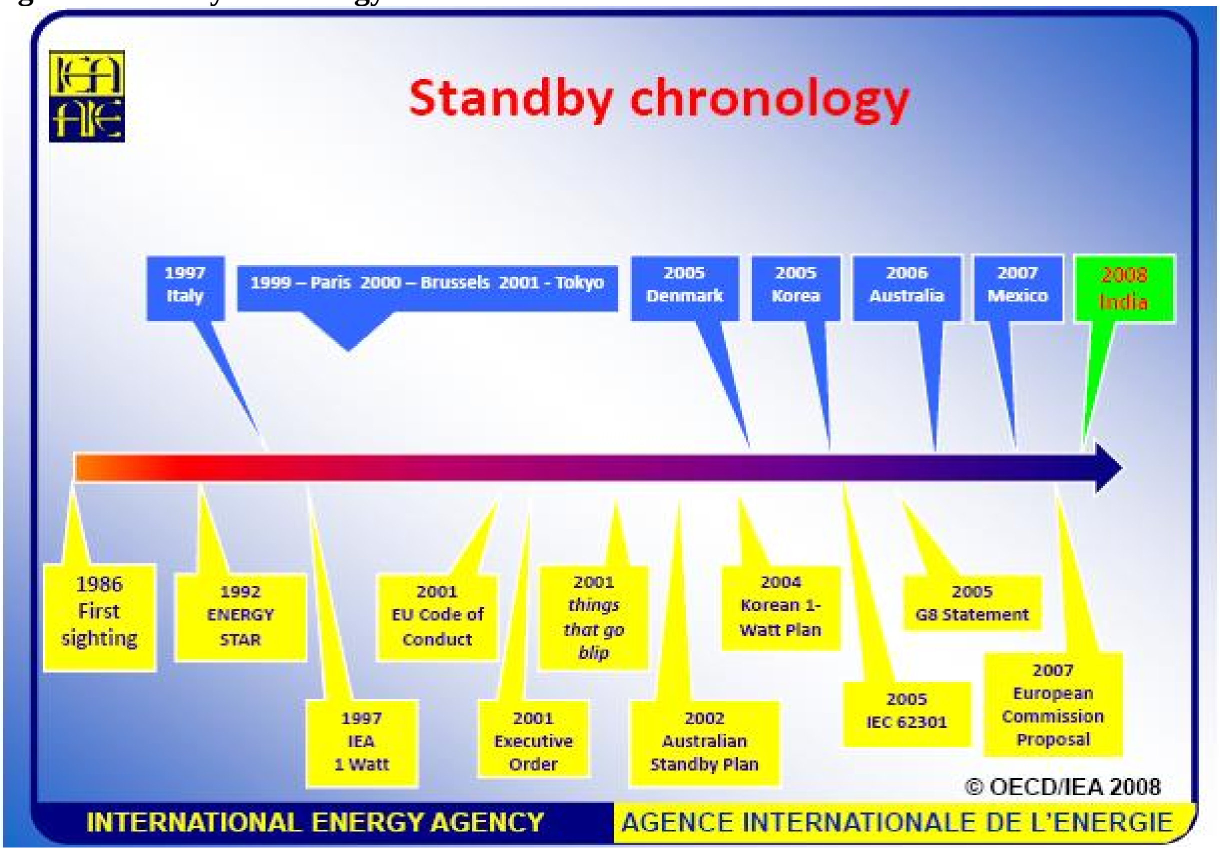
Lastly, recommendations that are meant to support and enhance the estimated energy savings potential from the adoption of best available technology in Hungary are discussed in chapter five.

2 Literature Review

2.1 Evolution of standby concept

Since the standby power consumption was first brought to the attention of the public in 1986 (Ellis 2008) as an attempt to ensure energy conservation, triggered by the world energy crisis of the 1970s, the concept of standby power consumption has gained a global understanding and mobilized policy actions in many countries worldwide. Figure 1 highlights the most important dates and events in the development of the standby concept.

Figure 1 Standby chronology



Source: Ellis 2008

As it is shown in Figure 1, the first milestone in the evolution of the concept is the introduction of the Energy Star Program by the US Environmental Protection Agency in 1992 aiming to enhance energy efficiency and reduce greenhouse gas emissions (U.S. Environmental Protection Agency and U.S. Department of Energy). The voluntary Energy Star label now covers a wide range of home and office appliances indicating energy efficiency features and low standby power consumption of the products.

The One Watt Plan, initially proposed by Alan Meier at the International Appliance Energy Efficiency Conference in 1997, was a major contributor to the subsequent policy developments, increased attention of the public to the standby issue and a drive for some manufactures to use the idea for marketing purposes (Energy globe 2002). The Plan called for the adoption of the One Watt target for all appliances by 2010 with an interim target of 50% of appliances covered by 2005, which would be possible if the producers of electronic equipment managed to reduce standby losses to the identified level. Other important features of the Plan included the call for the development of unified test procedures by the international certification bodies and selection of country-specific policies to achieve the compliance with the target (Meier and Lebot 1999).

The first action of the European Union to tackle the standby issue dates back to 1999 when the Commission issued a communication to the EU Council and Parliament on Policy Instruments to Reduce Stand-by Losses of Consumer Electronic Equipment, resulting in the adoption of Codes of Conducts for External Power Supplies and Digital TV services (European Commission 1999). The prominent features of both Codes of Conduct are that they are voluntary and involve the producers.

The EU initiative on the Code of Conduct and growing international attention to the standby issue was not unnoticed by the United States, as in July 2001 George W. Bush signed the Executive Order on Energy Efficient Standby Power Devices. According to the Order, executive agencies are obliged to purchase appliances "that use no more than one watt in their standby power consuming mode" or have the lowest possible standby consumption, in case of unavailability of the former ones (Bush 2001).

Earlier the same year the IEA published *Things that Go Blip in the Night: Standby Power and How to Limit it* that gave a comprehensive overview of the developments in the standby concept and described the main technological and policy-level solutions to deal with the problem.

Further progress in the field of standby power consumption was marked by the adoption of national strategies. Concerned by the highest rates in the standby consumption in the world, Australia was one of the first countries to commit to the IEA's One Watt initiative through adopting the Standby Strategy 2002-2010 entitled *Money isn't All You're Saving*. In short, the Strategy draws on the identification of problematic products in terms of standby consumption and developing a profile for such products. Furthermore, the industries are given the opportunity to engage into voluntary agreements and improve standby levels of their products, otherwise, should there be a failure to meet the set targets, mandatory measures (Minimum Efficiency Performance Standards (MEPS) and warning labels) are introduced (Ministerial Council on Energy 2002).

Following Australia's example, The Republic of South Korea introduced the One Watt policy which started off at a voluntary stage (years 2005-2007), succeeded by the preparation to the mandatory stage (years 2008-2009) and resulting in the mandatory measure from the year 2010 onwards. It is also based on the mix of policy tools, such as warning labels, MEPS and Energy Efficiency 1st Grade label (Kim 2008).

Another milestone in the evolution of the standby problem was the development of measurement standards IEC 62301 by International Electrotechnical Commission in 2005. A number of amendments were agreed to be included into the standard in 2006, among which are guidance for choosing the metering equipment, metering procedures specifications, integration of modes and others (Harrington 2008).

The endorsement of the IEA's One Watt initiative by G8 leaders in 2005 was an important step towards the implementation of the target in the countries involved and putting forward the idea for other countries. The statement also entitled the IEA "to review existing global appliance standards and codes, building on its existing capacity on energy efficiency in appliances" (Americ.gov 2005). It should be noted, however, that the initial proposal back in 1999 was amended by the IEA in the way that it recommended to adopt a regulatory approach rather than a voluntary one to reach the target. Also, the approach was called 'horizontal' as it aims at achieving the One Watt target in all appliances, regardless of the type and modes present (Meier and Siderius 2006).

The recent development in the relevant policies on the EU level is related to the EcoDesign Framework Directive 2005/32/EC, according to the requirements of which in 2007 the EU Commission proposed a working document for standby/off mode design requirements for household and office appliances. The new regulations set the One Watt and Two Watt targets, depending on the mode, which should be achieved one or three years after entry into force (Kolb 2008).

Finally, building on the EU work in the field, in 2007 the IEA came up with a new Implementing Agreement on Efficient Electrical End-Use Equipment, one of the annexes of which deals specifically with standby power. Being a 'soft'-type agreement, the document is meant to promote cooperation of the participating governments, facilitate the dialogue between the stakeholders and enhance research in the area of energy efficiency. As for the Standby Annex, the main actions envisioned should be related to the development of horizontal approaches for decreasing standby power consumption (IEA 2007).

2.2 Scope and definition of standby modes

Several researchers (Schlomann *et al* 2005; Payne and Meier 2004; Harrington 2008; Siderius *et al* 2006) have noted a difficulty in determining the scope and definition of standby power mode which would be more or less universal. The challenge lies in the rapid development of electronic appliances and the abundance of all kinds of modes in them that often have different names, such as "sleep", "standby" or even "hibernation". Lack of a single definition and a clear scope create policy development and implementation problems. To date, there are several definitions of standby mode, but none can be considered exhaustive.

Figure 2 illustrates some of the most commonly used definitions of standby modes. The ones proposed by the IEC and IEA are somewhat similar, as they emphasize the amount of power (lowest) used as compared to other modes. In contrast, Nordman and Sanchez (2006) do not address the power aspect but point to the "principal function" which is not performed by the appliance at the moment. Meier and Lebot (1999) argue that the proliferation of different modes and the complexity of appliances make it extremely difficult sometimes to figure out which function is the principle or primary one. Instead of collecting all the existing modes under the 'standby umbrella', Payne and Meier (2004) propose to define these numerous modes as low power modes, or 'lopomos', since the main characteristic of the standby is that power is still drawn although they device is not in operation. The definition of standby modes used for the Ecodesign directive (Fraunhofer IZM 2007) is based on the functional approach and distinguishes seven modes an appliance can have, from disconnected to transitional to active modes (see Figure 2). In the framework of the EcoDesign Directive, standby as such relates to networked standby and passive standby. The two types of standby mode are defined as "… condition, in which EuP[1] is connected to a power source, draws energy and offers a selection of the following reactivation and continuity functions" (Fraunhofer IZM 2007). The examples of such functions are the reactivation by hard or soft switch or remote control (reactivation functions), information and status display, sensor-based safety functions (continuity function) and others[2] .

According to Harrington (2008), the IEC is currently working on differentiation of standby and off modes for the framework of definitions of IEC602301. These definitions are said to be close to the ones proposed by Fraunhofer IZM (2007), in the way that the functional approach is used: 'off mode' will imply that the appliance does not perform any function, while standby will refer to some "user-oriented" function. However, products like dishwashers or washing machines still do not fit into the proposed definition (Harrington 2008).

[1] EuP – energy using product (Fraunhofer IZM 2007)
[2] Reactivation and continuity functions are described in greater detail in Fraunhofer IZM (2007)

Furthermore, Siderius *et al*. (2006) define standby modes from a product perspective, distinguishing between on/off product, standby product[3] and networked products[4]. Defining the standby product very close to the functional definition by Fraunhofer IZM (2007), the authors put forward an interesting idea that the networked products (i.e. networked modes) have a great potential to become even more important in terms of regulating their energy consumption in the future than the standby modes. The reason is that a rapidly increasing number of household and office appliances that have the networked functions, appears on the market. The examples include not only classical networked equipment such as computers, but also cold appliances and set-top boxes. So it might turn out that such appliances are in on mode all the time, rather than in standby which means a new regulatory approach might be needed.

Summing it up, although the standby concept was discovered decades ago, there is still no unambiguous definition that would cover all the aspect of the phenomenon. In a way, the existing definitions simply cannot keep up with the technological advances which bring new modes and functions in the appliances. Nevertheless, the uniform definition is still needed for developing relevant policies and as a prerequisite for measurement procedures, which in turn, are the basis for technological changes in the appliances.

[3] According to Siderius *et al* (2006), the standby product may be defined as “the product performing some function(s) not being one of the main functions of the product, e.g. enabling (remote) control, waiting for a user command, internal timer/clock, clock display or other indicator”

[4] Networked products are those that can be controlled external sources and not only by the user and can communicate with the external sources (network providers or service centers). More examples are given by Siderius *et al* (2006)

Figure 2 Standby mode definitions

IEC (2003)

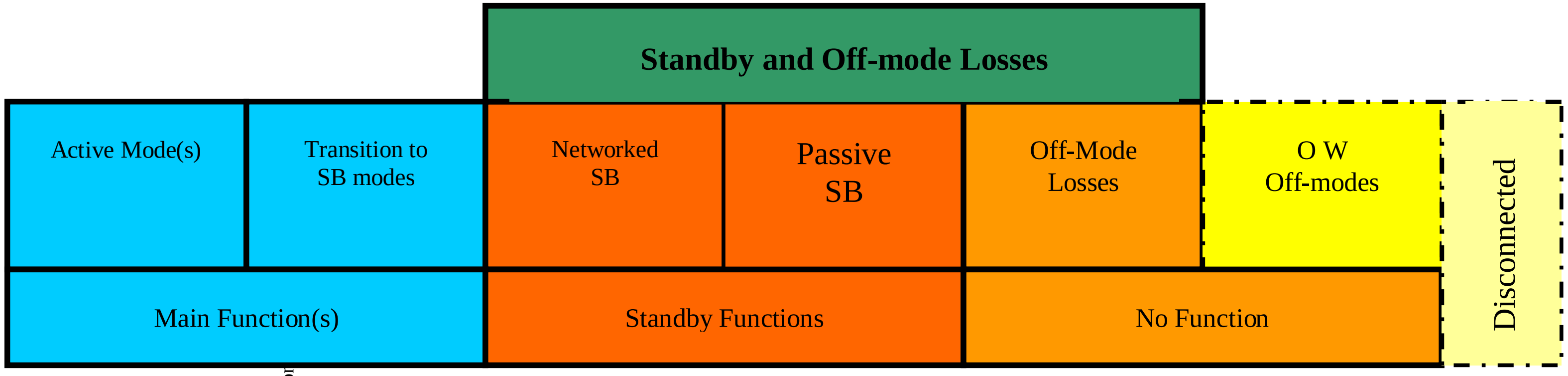
SB mode – lowest power consumption mode which cannot be switched off (influenced by the user) and that may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions.

IEA (2001)

SB power includes power used while the product is performing no function. For many it is the lowest power used while performing at least one function.

Nordman and Sanchez (2006)

SB mode is any mode in which a product is not performing any of its principal functions.
Type of modes:
On Sleep Off



Source: Fraunhofer IZM (2007)

2.3 Current State of Standby Regulations Worldwide

After the standby power consumption has gained international recognition in many countries of the world, governments started to develop and implement policies to tackle the problem. The existing policies have a wide scope and include voluntary targets and agreements, economic, regulatory measures and informative ones, as shown in Figure 3. The choice of policies is of course country-specific and so is the success of their implementation.

Starting from the voluntary instruments, these were the initial tools used in the European Union. The voluntary approach was employed for selected products, like external power supplies and digital TV services to reduce the power consumption of these appliances in standby and off mode through following the Codes of Conduct[5]. This approach was believed to be the most appropriate due to its low cost and flexibility (Siderius *et al* 2006). Another example of a voluntary approach is the Energy Star program which used labeling to inform the consumers and benefit the producers through better marketing and was adopted in such countries, as Australia, Japan, New Zealand, Taiwan and others. Voluntary negotiated agreements between government and manufacturers can also be effective if the targets set are achievable in a pre-defined timeframe and cost-effective for the industries (IEA 2001). The EU Commission (1999) points to the following advantages from producers' perspective from the negotiated agreements:

> According to manufacturers, negotiated agreements give them more freedom in reaching the target, by selling more high

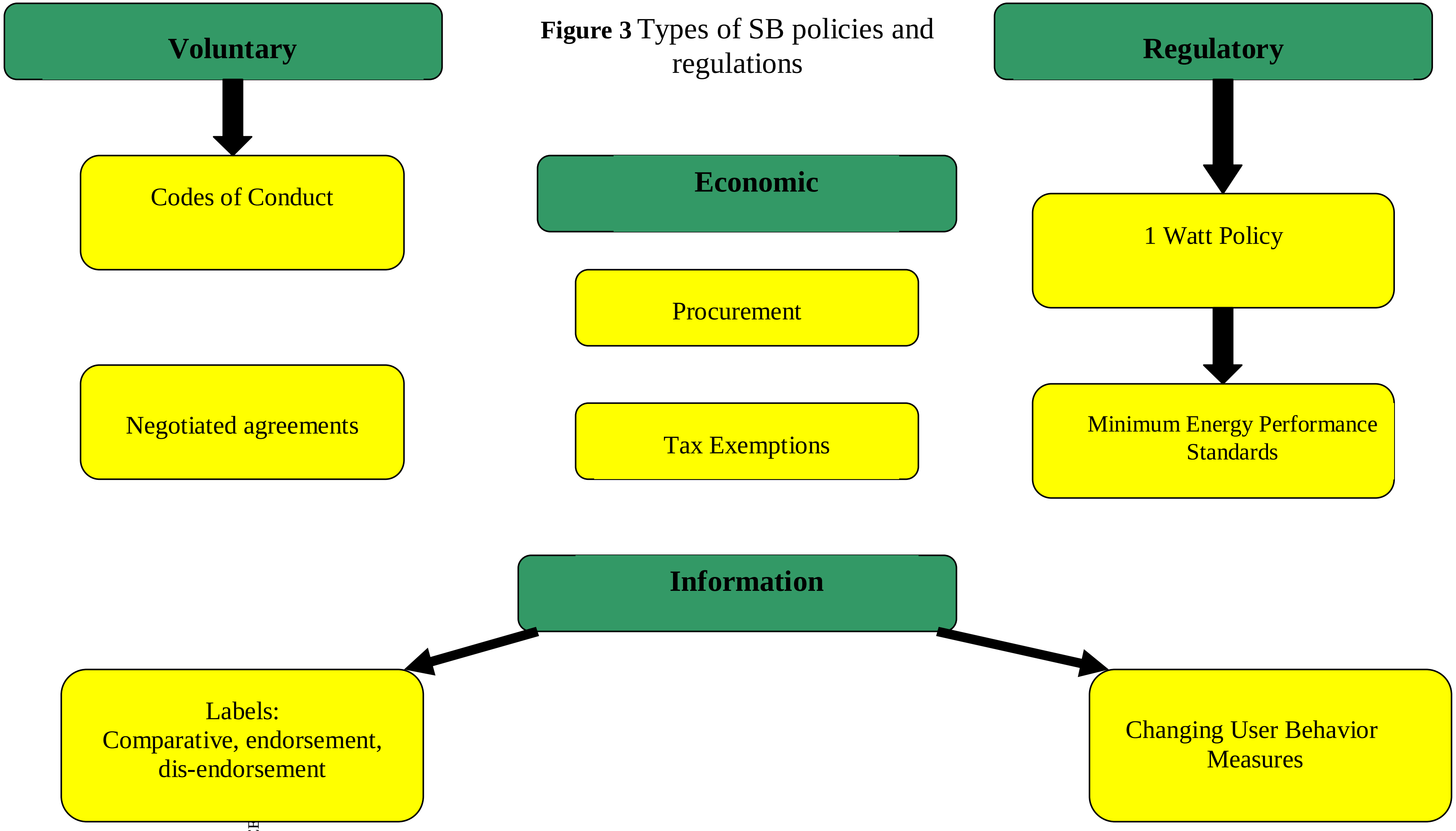
[5] The first Codes of Conduct (for External Power Supplies and Digital TV Services) were adopted in the EU in 1999 as a result of the EU Communication on Policy Instruments to Reduce Standby Losses of Consumer Electronic Equipment.

> efficiency products, by having flexibility when to phase out low efficiency units and therefore maximize their profits, while achieving energy efficiency improvements. In addition, manufacturers have highlighted the advantages of having a demand driven process, which would favour cost effective solutions and which would allow manufacturers to have a pro-active role in setting quantified criteria, in implementing the measures and achieving the results.

However, voluntary instruments also have a number of disadvantages which finally led to considering other measures. Siderius *et al* (2006) note that one of the disadvantages is the impossibility to attain 100% coverage of all products in the market simply because the electronic equipment is often produced elsewhere and it is hard to motivate the overseas manufacturers to comply with the voluntary Code of Conduct. Moreover, the author points out the re-active character of the voluntary agreements, which basically means that it is a bit too late to introduce the measures when a product is already on the market.

So far the economic instruments aimed at reducing standby power consumption have been the least common of all types. They are not usually directed specifically to standby but to the promotion of energy efficient appliances and reduction of energy consumption as a whole. This type of instruments can be applied in the form of energy taxes, rebates, tax exemption or green procurement mechanisms. An example of a tax exemption program is the Maryland Clean Energy Incentives Act which offers a sale tax waiver on some Energy Star appliances resulting in a 5% saving for consumers (IEA 2001).

Figure 3 Types of SB policies and regulations



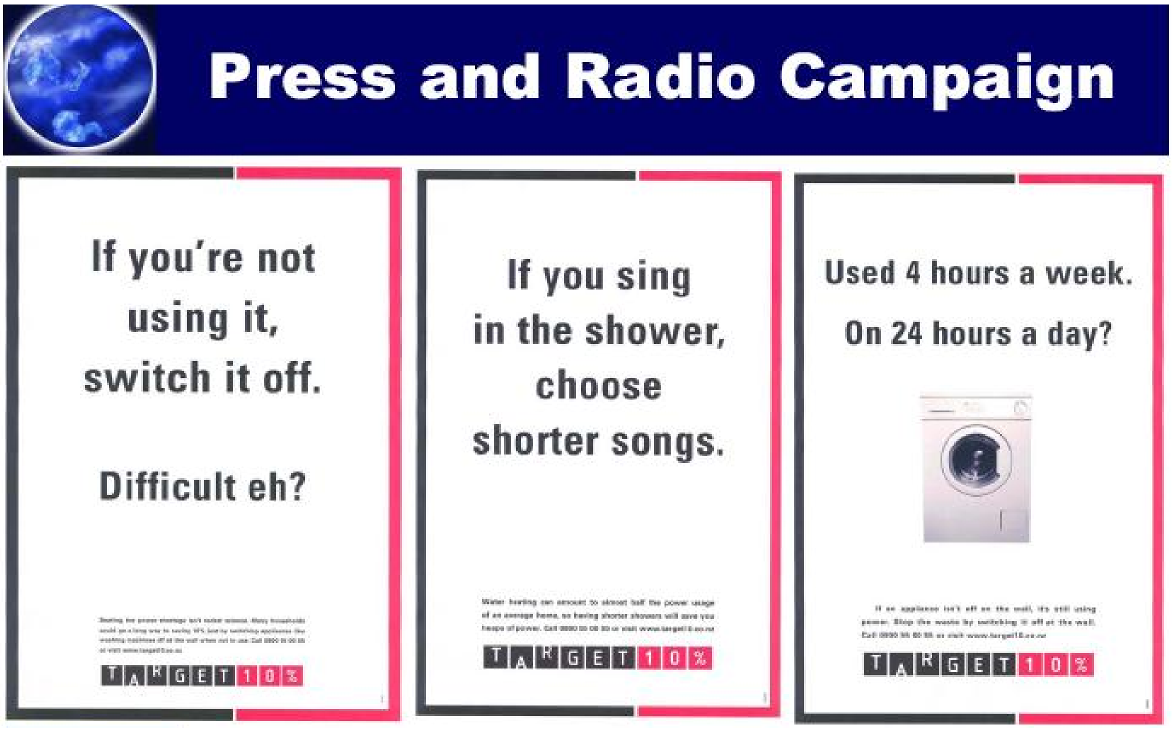
Source: compiled by the author

The green procurement mechanism has been in place in countries, such as Japan, Korea, the USA and China. Although an effective policy tool that can be a perfect incentive for producing and purchasing energy efficient appliances, green procurement alone cannot solve the standby power consumption and needs t be combined with other instruments. In general, the most obvious disadvantage of economic instruments is that the consumers are not always motivated by the price of a product, as they do take into account its features and functionality (IEA 2001).

Informative instruments are the ones that are commonly used in many countries of the world (Japan, Korea, China, Australia, Taiwan, the USA, Canada and some EU countries) to address the standby consumption problem. The variety of informative tools includes educational programs, media campaigns, public awareness activities, awards, labeling schemes and others. These instruments can be divided into two groups: programs oriented to change user behavior and those providing information for the consumer (labels), basing on which he or she will make a decision about purchasing an appliance (Figure 3).

A very good illustration of the user-oriented policies is New Zealand's 10% target energy saving campaign launched in May 2003. The campaign had such a great impact that the 10% saving target had already been reached by June 2003 (Staley 2003)! Such results were achieved through intensive advertisement on the radio and in the newspapers (Figure 4). This advertisement directly targets the standby power consumption by appealing to the consumers to unplug the equipment when not in use.

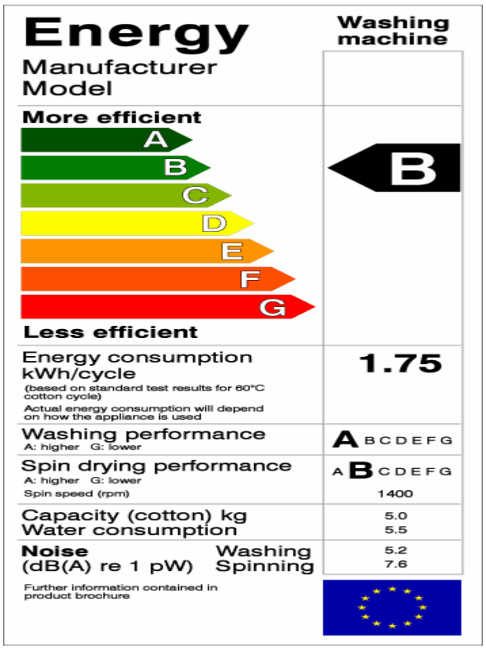
Figure 4 New Zealand's 10% Target Energy Saving Campaign



Source: Staley (2003)

The other type of informative instruments relies on labeling schemes. The existing labels can be grouped into comparative, endorsement and dis-endorsement ones (Harrington 2008). EnergyConsult (2007a) defines comparative labels as those that "commonly use a scale with absolutely defined efficiency categories". The EU energy efficiency label for washing machines (Figure 5) is a good example of a comparative label. In contrast, an endorsement label "indicates that products belong to the "most energy efficient" class of products or meet a predetermined standard or eligibility criteria such as ENERGYSTAR" (appliance instructions). A dis-endrosment label is a warning one which signals the failure to meet the standby standard. These labels will be in use in Korea starting from 2009 (Figure 6). It is noteworthy that the warning label has a mandatory character in Korea and failure to place the label on a product, if it is needed, will entail a fine of US$ 5,000 (Kim 2008). Overall, the labels can be either voluntary or mandatory.

Figure 5 EU Energy Label for Washing machines



Source: Department for Environment, Food and Rural Affairs (2005)

Figure 6 Korea Warning Label

Source: Kim (2008)

In general, informative instruments to address the standby power are very common worldwide but their effectiveness is limited due to the fact that the number of appliances and their functions do not cease to grow, overwhelming a consumer with too much information and making it hard to make a decision (Harrington 2008). Just as the above mentioned instruments, the informative tools should be used in conjunction with other targeted measures.

As for the regulatory instruments, they are still not commonly used, although IEA has been calling for adopting the One Watt target since 1998. The initial Plan was edited and resulted in the One Watt Horizontal Approach which will be dealt with later. To date, only Australia and Korea have committed to apply the target through the national programs which consist of several stages, from voluntary to mandatory ones. Japan and the USA have also used IEA's idea but developed their own policies (Meier and Siderius 2006). The most obvious advantage of a horizontal One Watt target is that it is quite easy to implement (Harrington 2008; Meier and Siderius 2006), however a number of exemptions will have to be made, for example, for medical equipment. Also, this approach does not consider all functions and usually applies to low power modes only, which might lead to the elimination of low power modes in order not to follow the requirements (Harrington 2008).

Furthermore, Minimum Energy Performance Standards (MEPS) are another mandatory measure adopted by some countries. These may be implemented as a specific instrument to achieve the One Watt target. The Australian Government (Ministerial Council on Energy 2002) defines MEPS as "…a regulatory tool used to remove the right to sell products that do not meet the minimum energy efficiency levels". In Australia MEPS are mandatory for some products produced or imported to the country and failure to comply with the requirements results in penalties and sanctions. Although MEPS have a good potential as a policy tool, the main disadvantage is that the technology develops very rapidly and there is always a danger that government might focus on the 'wrong' MEPS (Kim 2008).

2.4 Approaches to Standby Regulation

There are a number of approaches to tackle the standby power use, starting from total energy use, which covers all modes, to individual specifications and to horizontal functionality. Meier and Siderius (2006) note that although the individual specification approach is the most commonly used one right now, it also has some flaws, which encourage search for other solutions. The advantages and disadvantages of each approach are summarized in Table 1. It should be noted that the annual energy use approach is in fact a vertical measure as compared to the horizontal specification. The main feature of this approach is that the standby mode is included into the on mode and producers are encouraged to improve the overall energy efficiency performance of an appliance (Meier and Nordman 2006). However, researchers point out that the future of the next generation policies belongs to the horizontal specification (Meier and Siderius 2006; Harrington 2008).

Table 1 Approaches to standby regulation

Approach	Description	Advantages	Disadvantages
Annual Energy Use	Establishes a typical duty cycle including specified times in standby, active,	Flexibility for manufactures to find a cost-effective way to	Does not assure low standby; difficult to gain data on number of

	and intermediate modes	reduce consumption; applicable to product with low total energy consumption	operation hours for each mode; difficult to establish a test procedure
Individual Specification	Establishes unique standby specification for each product independently of other specifications	Products may be easily added or removed from the list of products to which it is applied; individual limits for products reflect specific circumstances; pressure on manufacturers to improve; allows different target for different modes	Might be difficult to manage as manufactures will add or remove some features; unclear in case the products merge (e.g. TV+VCR); too many product types exist; requires a tight definition of each product which can hamper product innovation and performance
Family Specification	Establishes standby limits for groups of similar products (e.g., office equipment, telephony, etc.)	No need to list each product	Some products might have functions or features belonging to another family of products
Dual Specification	Establishes separate limits for each product on active energy use and standby power	As the energy efficiency standards are regularly updated, it will be easy to add requirements for standby	Cannot be applied to unregulated products
Functional Specification	Establishes a standby level based on	Flexibility for manufacturers to add	Standby allowance will be not exceeding 0.25 W

	functionality or services available in the product	more functions; no need to define each product; consistent treatment of products based on their functions	which means a small amount of annual energy use. Might be not worth the administrative efforts
Horizontal Specification	Establishes a single limit on standby for all products, but with a list of exceptions	Technically feasible, easy to implement; no need to re-set the target	A list of exemptions has to be maintained; range of active functions are not taken into account; applies only to the lowest modes (Harrington 2008)
Horizontal Functionality (Harrington 2008)	Establishes a target for all product types and all low power modes, setting a power budget for each function, covering a wide range of generic functions	Takes into account variety of functions in one or several modes; covers all lopomos and networked products; a good medium term solution; keeps up with innovation	Might be hard to manage

Adopted from Meier and Siderius (2006), Harrington et al (2007)

To sum it up, a variety of approaches can be adopted to tackle the standby problem, but all of them have a number of limitations to consider. Overall, researchers (Harrington 2008; Meier and Lebot 1999) agree that the IEA's One Watt Initiative is a measure that should certainly be implemented in order to make progress in reducing standby power consumption. However, Harrington (2008) goes further by proposing adopting horizontal functionality approach in addition to the One Watt Initiative, with a perspective of totally replacing the One Watt measure with it afterwards. The rationale for adopting such a medium term solution and replacing the One Watt standard after a while is that technological development will sooner or later allow most of the products to be below this target, so the ‘one-size-fits-all’ approach will eventually become impractical.

A similar approach is proposed by Fraunhofer IZM (2007) in the EU EcoDesign Directive preparatory studies. The European Framework Directive for the setting of eco-design requirements for Energy-using Products (EuP) is focused on increasing energy efficiency of appliances from a life cycle perspective (Directive 2005/32/EC). It encompasses a wide range of electronic products and specifically targets standby and off mode losses of appliances (Mudgal 2008). The authors of the preparatory study report on standby and off mode losses suggest adopting a two-tier scheme (Table 2) to allow for re-design of the products. As demonstrated in Table 2, the approach distinguishes three main functions – off, passive standby and networked standby- and envisages power allowances in the range from 0.5 W to 5 W, depending on the mode, on the final stage of the implementation. According to the recent press release by the European Commission (Europa 2008), the regulation for reducing standby consumption of office and household equipment has been endorsed by Member States’ representatives and is to be adopted by the European Parliament later on. The official communications says that the maximum allowed consumption of the targeted product will be 1 and 2 Watts starting from 2010, and will decrease to 0.5 and 1 Watt from 2013 (Table 3). Thus, the EU is going beyond the uniform One Watt limit proposed by IEA.

Table 2 Two-tier implementation scheme proposed to be adopted in the EU

Mode Type	**Tier 1 (app. Date 2010)**	**Tier 2 (app. Date 2012)**
Off-mode for rated output < 10 W	1 W	0.5 W

Off-mode for rated output > 10 W	1 W	0.75 W
Passive standby	2 W	1 W
Networked standby[6] "Type I"	3 W	1 W
Networked standby "Type II"	4 W	2 W
Networked standby "Type III"	10 W	5 W

Adopted from Fraunhofer IZM (2007)

Table 3 Standby limits approved by Member States' representatives in 2008

Mode Type	**Tier 1 (app. Date from 2010)**	**Tier 2 (app. Date from 2013)**
Off mode	1 W	0.5 W
Passive standby (only reactivation function)	1 W	0.5 W
Passive standby (reactivation + display/clock)	2 W	1 W

Adopted from Mudgal (2008); source: Europa (2008)

[6] Detailed explanation of networked standby types can be found in Fraunhofer IZM (2007)

3 Methodology

The aim of the present study was to assess the energy savings potential in standby consumption in Hungary through comparison of standby power of new appliances available on the market and those currently used in households.

3.1 Definition of standby modes

In this research the IEC's definition of standby (see Literature Review Chapter, Figure 2) was adopted, as required by the Asia- Pacific Partnership (APP) Basket of Products project. More specifically, a distinction between the following modes was made:

Table 4 Definition of standby modes used in the survey

Power – Active standby	Active standby is when the appliance is on but not performing its main function. For example, the DVD may be on but is not playing or recording. This mode is usually only present in devices (a) where there is a mechanical function which is not active (eg DVD drive or motor) but where power circuits are on, or (b) where a device has a battery and the device is charging
Power – Passive standby	When a product or appliance is not performing its main function (sleeping) but it is ready to be switched on (in most cases with a

	remote control) or is performing some secondary function (e.g. has a display or clock which is active in this mode).
Power – Off	The product must have a power switch located on the product. Off mode is when a product or appliance is connected to a power source but does not produce any sound or picture, transmit or receive information or is waiting to be switched "on" by the consumer. If the product has a remote control, it cannot be woken by the remote control from off mode – it can only be activated via the power switch on the product. No display should be active in off mode. While the product may be doing some internal functions in off mode (e.g. memory functions, EMC filters) these are not obvious to the user. An LED may be present to indicate off mode.

Adopted from: Energy Consult 2007

In this study mainly the passive standby mode was used for the comparison of standby power between new products available on the market and in the households. However, in some cases (for example, computer speakers), the passive standby was not available and the power readings in active standby mode were used. For more details regarding types of standby mode used please see 3.3, Table 6.

3.2 Data Collection

To reach the aim of the research, field measurements in Hungarian stores were undertaken. The measurements took place within the framework of the APP Basket of Products project in two major retail stores in Budapest, which ensured a wide range of product models and brands. The measurements involved metering of 14 core types of products and several additional ones. The overall number of appliances metered in stores was 350. Type of major appliances metered is outlined in 3.3, Table 5.

The in-store survey was conducted with the help of a portable Energy Logger 3500 meter (Figure 7), which was systematically plugged in to measure standby power consumption of each appliance. The resolution of the device is 0.1 W and the precision is ±1% and 1 digit. Products in each category were selected randomly, but an effort was made to meter appliances produced by various manufacturers. In order to ensure a representative sample, at least 20 products of each type were measured, where possible. The data from the meter was input into an excel data sheet, previously adapted from Energy Consult (2007a). According to the type of product, energy consumption in different modes was recorded, as well as the details of an appliance (price, model, size, presence of energy labels etc).

Figure 7 Voltcraft Energy Logger 3500

Source: www.conrad.cz

Later on the data from the field measurements in the stores were compared to the data obtained from the REMODECE (Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe) project for the years 2007/2008 and those provided by Valentova (2007). The project allowed pooling data on standby power consumption of appliances in 95 Hungarian households. The in-situ measurement of standby power was carried out with the help of Sparometer (Figure 8) and included metering of all appliances that had more than one mode, i.e. on, off and passive standby modes.

The consistency of data in both projects was ensured by following well-defined and precise methodology provided by the project initiators. All the data obtained were reviewed and validated before the analysis.

Figure 8 Sparometer used for spot measurements in households

Source: http://webshop.nesa.dk

3.3 Data Analysis

Due to the fact that not all types of appliances measured in the stores could be found in sufficient numbers in the households, the following categories[7] were used for the comparative analysis:

Table 5 Appliance categories

Category	**Appliance**
Cooking	Microwaves
White goods	Washing machines (top loaders, front loaders)
Computers	Monitors
	Laptops
Computer Peripherals	Speakers
	Printers (Laser, inkjet)
Television	TV Sets (LCD, CRT)
Home Entertainment	DVD Players
	Hi-Fi Stereos
	Portable Stereos
Telephony	Cordless Phones

Also, given that VCRs are becoming obsolete products (Energy Efficient Strategies 2006), these appliances were excluded from the comparative research.

[7] However, the overview of appliances available on the market also included some other household products (see Chapter 4)

In some cases, it was not possible to meter an appliance in a certain mode. Table 6 summarizes the modes in which each appliance type was tested for the purpose of comparative analysis.

Table 6 Modes tested for each appliance type

Appliance	Passive Standby	Active Standby	Off
Microwave	♦		
Washing Machine		♦	
Monitor			♦
Laptop			♦
Speakers		♦	
Printers		♦	
TV- CRT	♦		
TV-LCD	♦		
DVD Player	♦		
Hi-Fi Stereo	♦		
Portable Stereo	♦		
Cordless Phone	♦		

The data analysis was performed with the help of Microsoft Office Excel[8].

[8] Microsoft® Office Excel 2003. Microsoft Corporation

3.3.1 Estimations of Energy Savings Potential

The energy savings potential in standby power consumption in Hungary was calculated for two scenarios. The first "Best Performer" scenario considered savings potential based on the assumption that all households will eventually exchange their appliances for the new ones available on the market (best performer in each appliance type) by 2013. The technological change which might decrease the standby power consumption in future appliances is disregarded in this scenario. The year 2013 is taken as a reference year since the EU regulation on reducing standby power consumption of residential and office equipment will be fully operational by this time, therefore it is assumed that new appliances on the market in 2013 will not consume more than it is set in the EU regulation[9] (Europa 2008). The future penetration rates of major household appliances are assumed to remain stable or increase slightly, as the most rapid growth of the number of household appliances occurred in the 1990s, when the Hungarian market became more open for a variety of Western goods. At the same time, the living standards were improving significantly, and new consumption patterns were adopted by the population (Hungarian Central Statistical Office 2008). So it is assumed that the saturation levels of basic household equipment examined in this study are already quite high and will not change significantly over the coming years.

For Best Performer scenario first the average standby consumption per appliance type in households was calculated using the following equation:

$$AvSC_a(W) = \sum P_a / N_a \ ,$$

where $AvSC_a$ – average standby consumption of an appliance type (W)

P_a – standby power of an appliance taken from the spot measurement (W),

[9] For 2013 Standby limits see Table 3

N_a -number of appliances of a certain type in households in the sample;

Furthermore, in order to estimate the energy savings potential in standby consumption (by appliance type) on the national level, the following equation was used for the extrapolation:

$$SP_a(GWh/yr) = \frac{(AvSC_a - P_{BP}) * T_d * 365 * p * N_{hh}}{10^9},$$

where SP_a – savings potential by appliance type, (GWh/yr)

$AvSC_a$ – average standby consumption, (W)

P_{BP} - standby power of the best performer, (W)

T_d - Time an appliance is in standby mode per day (hours)[10]

p – penetration rates[11]

N_{hh} – number of households in Hungary in 2013[12]

As one of the objectives of the present study is to compare standby consumption by appliance type, the standby consumption was calculated with the help of the equation:

$$SC_a(GWh/yr) = \frac{AvSC_a * T_d * 365 * p * N_{hh}}{10^9},$$

where SC_a – national standby consumption of an appliance type per year (GWh/year)

$AvSC_a$ – average standby consumption of an appliance type (W)

T_d – time in standby mode of an appliance type per day (hours)

p – penetration rates[13]

N_{hh} – number of households in Hungary in 2008[14]

[10] Source: Fraunhofer IZM (2007)
[11] Source: Hungarian Central Statistical Office 2006
[12] Source: Novikova 2008
[13] Same as in Footnote 10
[14] Source: Hungarian Central Statistical Office 2005

Finally, total energy savings potential in all types of appliances was estimated by adding up the savings potential of all measured appliances:

$$SP_{HU}(GWh/yr) = \sum SP_a \,,$$

where SP_{HU} – energy savings potential for Hungary, (GWh/yr)

SP_a – energy savings potential by appliance type (GWh/yr)

The second “1/0.5 Watt” scenario is based on the assumption that by 2013 the EU policy on the energy using products will be fully operational in Hungary and that the household appliances will be replaced by the new ones fully meeting this policy target, i.e. having standby power not exceeding one Watt or staying within 0.5 W limit, depending on the type of appliance[15]. The calculation of the energy savings potential followed the same logic, and involved replacement of the power of the Best Performer by 1 or 0.5 Watt:

$$SP_a(GWh/yr) = \frac{(AvSC_a - P_{1W/0.5W}) * T_d * 365 * p * N_{hh}}{10^9}, \; SP_{HU}(GWh/yr) = \sum SP_a \,,$$

where SP_a – savings potential of an appliance type

$AvSC_a$ – average standby consumption of an appliance type

T – time spent in standby mode per day *(hours)*

$P_{1W/0.5W}$ – 1 Watt/ 0.5 Watt

p – penetration rates

N_{hh} – number of households in Hungary in 2013[16]

SP_{HU} – savings potential for Hungary, GWh/yr

[15] 0.5 W limit applies to products in off mode or those that can be reactivated in passive standby. 1W limit is imposed on the products in passive standby which can be reactivated and have an electronic display or clock.
[16] Source: Novikova (2008)

3.3.2 Estimations of CO_2 Emissions Reduction

As noted by Lebot *et al* (2000), power generation for standby mode is responsible for approximately 1% of CO_2 emissions in the OECD countries. Urge-Vorsatz et al. (2002) estimated that residential standby consumption in Hungary accounts for 0.7 % of total national CO_2 emissions. Since the time when this research was conducted, most of the appliances have developed new functions and in some cases, new modes, which might result in a higher level of CO_2 emissions as compared to 2001. Therefore, the current contribution of standby consumption to the CO_2 emissions, as well as the reduction potential as of 2008 was calculated using the following equations:

CO_2 emissions and % of total CO_2 emissions from household electric appliances and lighting were calculated in the following way:

$$E(MtCO_2) = SP_{HU} * EEF \quad ,$$

$$E_{SB}(\%) = \frac{E}{CO_{2/ann}} * 100$$

where *E*- annual reduction of CO_2 emissions from standby ($MtCO_2$)

SP_{HU} - energy savings potential for Hungary, (GWh/yr)

EEF – electricity emissions factor for the year 2008/2013 (gCO_2/kWh)[17]

E_{SB} – percentage of annual CO_2 emissions from standby (%)

$CO_{2/\,nat}$ – annual CO_2 emissions from household electric appliances and lighting (Mt)[18]

3.4 Limitations

[17] Source: Novikova (2008)
[18] Source: Novikova (2008)

Although efforts were made to ensure that the data is up-to-date and the calculations are as precise as possible, the present study has several limitations. With regard to the data from the REMODECE project and those obtained from Valentova (2007), it was not possible to make a probability sampling of Hungarian households due to time and financial constraints. Therefore, participating households were chosen through personal contacts basing on their interest and willingness to participate. Also, some of the appliances were significantly underrepresented in the households (for instance there were just a few portable stereos), which makes it difficult to make valid comparisons with the appliances on the market. In addition, products such as CRT monitors are mostly removed from the market (in big retail shops not a single one was found), although they are still used quite widely in the households. Therefore no comparison was made for some types of appliances.

As far as the measurements are concerned, at times some of the appliances in the households or shops were not available for metering due to the restricted access to cables and plugs. Moreover, some of the products might have had power management features or just needed a significant amount of time in order to get a stable reading from the meter, which was not possible to perform in the field conditions. With regard to specific appliances, it was especially difficult to meter laptops in the shops, as in most of them the batteries were removed for security reasons. Although the staff agreed to insert the batteries for metering, it turned out that most of the batteries were uncharged, which was reflected in high power readings.

Furthermore, the statistical data, such as penetration rates, for some of the appliances necessary for savings potential estimation were not available and several assumptions had to be made. These assumption concerned speakers, monitors, and TVs (for more detail see 4.3).

Finally, as far as the results of the study are concerned, it should be taken into account that only major household appliances were part of the survey, while there might be other energy consuming products, such as set-top boxes or hard disk recorders that could affect the final figures, although they are not so spread in Hungarian households yet.

4 Results and Discussion

4.1 Trends in Standby Power Use of Appliances in Stores and Households

During the field measurements in the shops in total 350 appliances were metered. For the comparative analysis only core appliances (Table 5) which can be easily found in most households are described in the study. However, when analyzing the trend in the new appliances available on the Hungarian market (see 4.2), other relevant household appliances are included.

In all the appliance types the minimum power in standby mode (Best Performer in Table 7) did not exceed 1.5 W. However, the maximum power was as high as 12.8 W (printers) and 16 W (Hi-Fi). In general, the average power was in the range between 0.7 and 4.5 W, making LCD computer monitors and LCD TVs the overall Best Performers and CRT TVs – the Worst Performers in terms of average standby power in products offered for sale.

Table 7 Standby Power Consumption of New Appliances on Display on the Market

Appliance	No. of Appliances Metered	Best Performer[19] (W)	Worst Performer (W)	Average Power Use (W)	Mode
Microwave[20]	25	0	3.6	1.9	Passive

[19] In this study Best Performer refers to the minimum power reading in the appliance type. Conversely, Worst Performer denotes the highest power reading.

Washing Machine	30	1.2	5.8	2.8	Active
Computer Monitor (LCD)	30	0.2	0.8	0.7	Off
Computer-Speakers	30	1.4	4.5	2.4	Active
Laptop	25	1.1	7.2	3.7	Off
Printer	44	0	12.8	4.1	Active
Hi-Fi Stereo	30	0	16	2.8	Passive
Portable Stereo	26	0	3.4	2	Passive
TV-CRT	22	1.4	11.4	4.5	Passive
TV-LCD	30	0.1	1.9	0.7	Passive
DVD Player	31	0	3.6	1.2	Passive
Cordless Phone	27	0	3.2	1.4	Passive

The household appliances sample consisted of 342 electric products from 95 households (Table 8). As the CRT computer monitors were found in 25% of households, they were also metered, although these products are mostly unavailable on the market. The spot measurement revealed that 6 out of 12 product types had a minimum power in standby mode equal to 0 W, while the maximum power recorded was 62 W for CRT computer monitors

[20] Only microwaves with electronic displays were metered as the standby power of the ones without the display is normally zero.

(see Best and Worst Performer, Table 8). Overall, the average power in standby mode ranged between 1.6 W (washing machines) and 9.4 W (CRT monitors), pointing to the Best and Worst Performers among all appliances in the household sample.

Table 8 Standby Power Consumption of Appliances in the Households

Appliance	**No. of Appliances Metered**	**Best Performer[21] (W)**	**Worst Performer (W)**	**Average Power Use (W)**	**Mode**
Microwave	22	0.9	4.2	1.0	Passive
Washing Machine	10	0.9	2.4	0.3	Active
Computer Monitor - CRT	24	1.1	62	9.4	Off
Computer Monitor- LCD	26	0.3	6.8	1.6	Off
Computer-Speakers	32	0.8	8.9	2.9	Active
Laptop	13	0	9.9	2.5	Off
Printer	28	0	6.3	2.9	Active
Hi-Fi Stereo	40	0	28.4	5.2	Passive

[21] In this study Best Performer refers to the minimum power reading in the appliance type. Conversely, Worst Performer denotes the highest power reading.

TV-CRT	72	0	45.9	8.0	Passive
TV-LCD	16	0	4.0	2.0	Passive
DVD Player	38	0	12.1	3.1	Passive
Cordless Phone	21	1.4	4.8	2.8	Passive

As for the average standby power of appliances in the households compared to those on the market, Figure 9 demonstrates that the power of household appliances exceeds the power of new products on sale in 7 product types. This means that most of appliance types have probably improved overtime in terms of standby power and now consume less than those products currently used by the household (Table 9). However, this assumption cannot be supported with any evidence, as there is no baseline data from the Hungarian market, as well as the information about the age of products in households. The most striking difference is in the power of CRT TVs (3.5 W difference) and Hi-Fi stereo (2.4 W difference).

In contrast, standby power of new microwaves, washing machines, laptops, and printers has increased as compared to the power of household stock of the same products (Table 9). The increase in consumption by printers in the shops might be due to the presence of several color laser printers which are not common in households. Increased consumption of new microwaves and washing machines might be explained by the fact that the average standby power use of these household products was quite low, since simple models without electronic displays and clock were predominant in the sample. It is also important to note that although the general trend in standby power of new products is going down, so far only LCD monitors and TVs in the stores would comply with the One Watt standard.

Figure 9 Average Power Use (W) of Appliance Types in Shops and Households

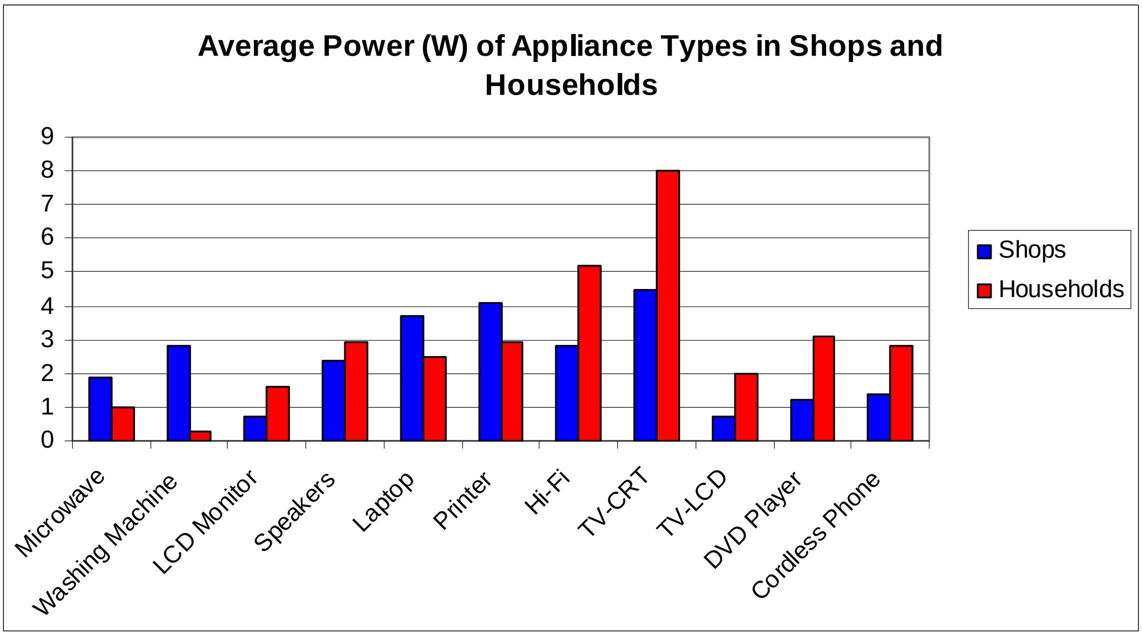


Table 9 Improvement/Deterioration in Standby Power of New Appliances on the Market as Compared to Household Stock

Appliance Type	Improvement (W)	Deterioration (W)
Microwave		0.9
Washing Machine		2.5
LCD Computer Monitor	0.9	
Speakers	0.5	
Laptop		1.2
Printers		1.2
Hi-Fi Stereo	2.4	
TV - CRT	3.5	
TV - LCD	1.3	
DVD Player	1.9	
Cordless Phone	1.4	

4.2 Trends in New Appliances Available on the Market in Hungary

4.2.1 Presence of Energy Labels on New Appliances in the Stores

During the field measurement in the stores special attention was paid to the presence of energy labels on the new appliances in the stock. The reason for this particular focus is on the one hand, the debate about the need and effectiveness of the labels (see for e.g. Bertoldi *et al* 2002) as a way to reduce standby power (by motivating consumers to make conscience choices). On the other hand, this issue is topical for the EU, as the necessity for special mandatory standby labels on a country level is discussed in some member states, for example, in Germany (Schlomann *et al* 2005). To date, a variety of voluntary labeling schemes for different products exists in the EU, however energy labels are required only for the following household appliances according to the EU regulations:

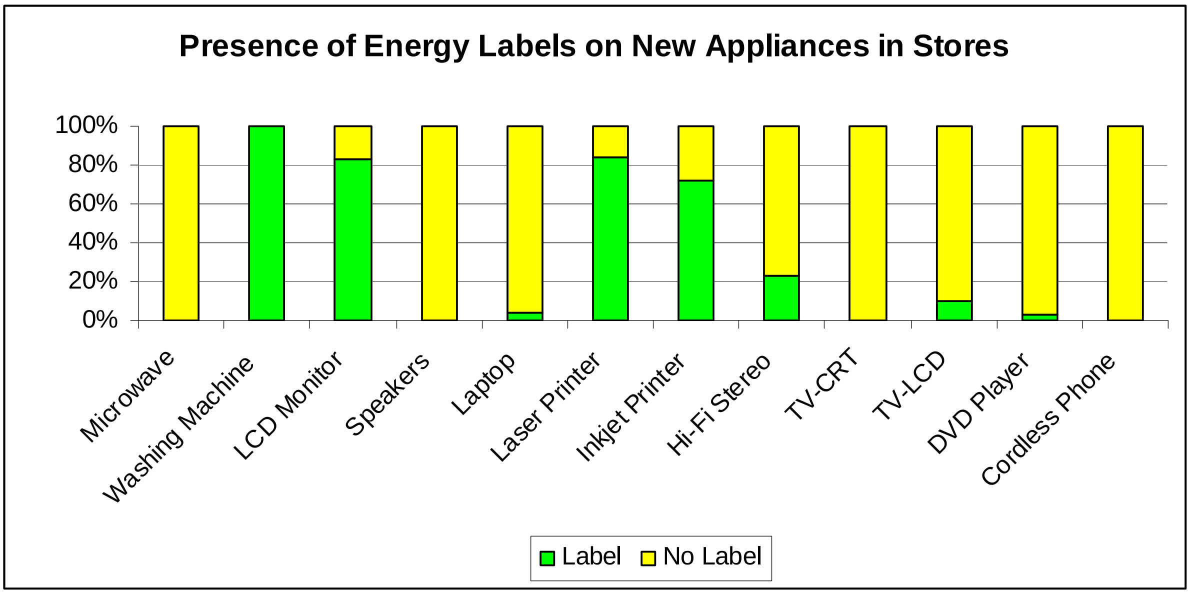
- electric refrigerators, freezers and their combinations
- electric ovens
- air-conditioners
- dishwashers
- lamps
- dishwashers
- washing machines
- combined washer-driers
- electric tumble driers

As for the labels on appliances in Hungary, it was found that energy labels are mostly common for washing machines, LCD monitors and printers, while in other appliance types it is a rare thing to encounter an energy label (Figure 10). Most of the energy labels that were identified fell into the category of endorsement labels (Energy Star, TCO'03, EnergySaving and Energy), except for washing machines that displayed a comparative energy label (A-type label). It is interesting that 100% of the measured washing machines had the A-type label. These data are consistent with the findings of Bertoldi and Atanasiu (2007), who noted that the share of the A and A+ types is continuing to grow in New Member States. Types of energy labels found on the appliances in the Hungarian stores are highlighted in Table 10.

Table 10 Energy label types on new appliances in the Hungarian stores

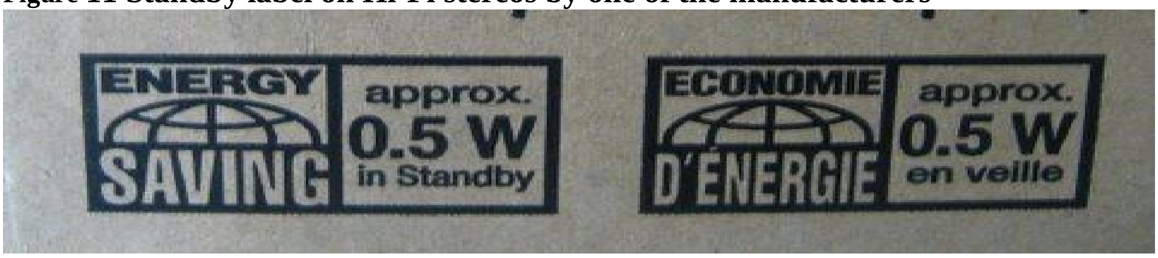
Appliances Type	**Endorsement**	**Comparative**
Washing Machine		A Type EU Label
LCD Monitor	Energy Star; TCO'03	
Printers	Energy Star	
Laptops	Energy Star	
Hi-Fi Stereo	Energy Star; EnergySaving Standby Level	
LCD TV	Energy Star; Energy	
DVD	Energy Star	

Figure 10 Presence of Energy Labels on New Appliances in Stores



A special standby label (Figure 11), which indicated approximate power consumption in standby mode, was among interesting findings. This label was present only on three Hi-Fi stereos produced by one of the well-known manufacturers of household appliances. The declared values on the label were 0.5, 0.6 and 0.7 W in standby mode. However, the power consumption taken from the meter was zero for all three appliances. It is also noteworthy that there is no information about this label on the environmental page of the official website of the producer. Instead, the website highlights only the EnergyStar affiliation and various environmental awards. Other product types of the same brand did not display this label either.

Figure 11 Standby label on Hi-Fi stereos by one of the manufacturers



Source: taken by the author

The EnergyStar labels were found mostly on computer equipment (multi-functional devices, printers, and monitors) and to much lesser extent on the audio-visual equipment (Hi-Fi stereo, DVD players and some TVs). Surprising, only a small fraction of appliances had labels on the product itself. In 70% of cases the labels could only be found on the boxes. This fact can mislead customers as they might be unaware about the presence of a label on the box. Moreover, in some stores boxes might be kept in the storage rooms away from the shoppers.

Alternatively, consumers in some cases are able to access the information about energy consumption in different modes in the user's guide or manual. However, it is very likely that the consumer will find out this information only after the purchase, while trying to install the equipment at home. Therefore, the value of such 'late' information will be quite low as the buying decision will not be affected (Fraunhofer IZM 2007). On the other hand, some users may decide to unplug the appliance every time it is not in use, when they see the consumption in standby mode indicated in the manual. The question then will be how long (if at all) this energy conscious behavior will be sustained by the user?

Overall, lack of energy labels, and standby labels in particular, in Hungarian stores points to a certain gap in the policy tools to tackle standby issue, on the one hand, and a window of opportunity, on the other. However, given that most of the electronics are likely to be imported to Hungary from elsewhere, the solution of the problem lies on the EU level, rather than on the national one, although some member state are already making attempts to implement it on the country level (Schlomann *et al* 2005).

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4.2.2 Presence of Off Switch in New Appliances in Hungarian Stores

An off switch is a button which turns an appliance off, disabling the display, if any, and making it impossible to activate the product with a remote control. Ideally, an appliance does not consume any power when turned off with the hard switch. Figure 12 illustrates that the off switch is available in 7 appliance types out of 12 metered. Among the products that do not have such a switch or in limited number, the most crucial in terms of facilitating energy efficient user behavior are laptops[22], Hi-Fi stereos, and DVD players, as they consume more than 1 W in passive standby (3.7 W, 2.8 Wand 1.2 W, respectively). The absence of the off switch in cordless phones is apparently justified by the function – it would be impractical to turn off the phone every time, as the base should be on to ensure normal functioning of the receiver. The rationale for not placing a hard switch in microwave might be the presence of electronic clock, since turning the appliance off will mean disabling this function. Only one microwave out of 30 metered had an off switch at the back of the product. Surprisingly, its standby power consumption with the switch turned down was not zero but 1 Watt.

As for LCD TVs, only around 25% of all metered products had the off switch. Half of the TVs with an off switch had a 0 W consumption in the relevant mode (Figure 12). The average power use in off mode was 0.2 W. It is striking that in 90% cases the off switch was not on the most visible place on TVs, where a user would normally expect to find it (at the bottom of the screen: in the middle or in the right-hand corner), but on top or behind the screen. This might decrease significantly the use of the switch, simply because the user might overlook it. Unlike LCD TVs, the CRT ones all had an off switch and their power use in the off mode did not exceed 0 W.

[22] In case of laptops, the start-up key is not considered an off switch, as some laptops may have the off button on the side or at the bottom, which is extremely rare.

All sampled washing machines had an off switch or turn, however only one appliance did not draw any power in off mode (Figure 12). The average consumption in this mode was 0.6 W, while the minimum power use was 0 W and maximum – 3.5 W.

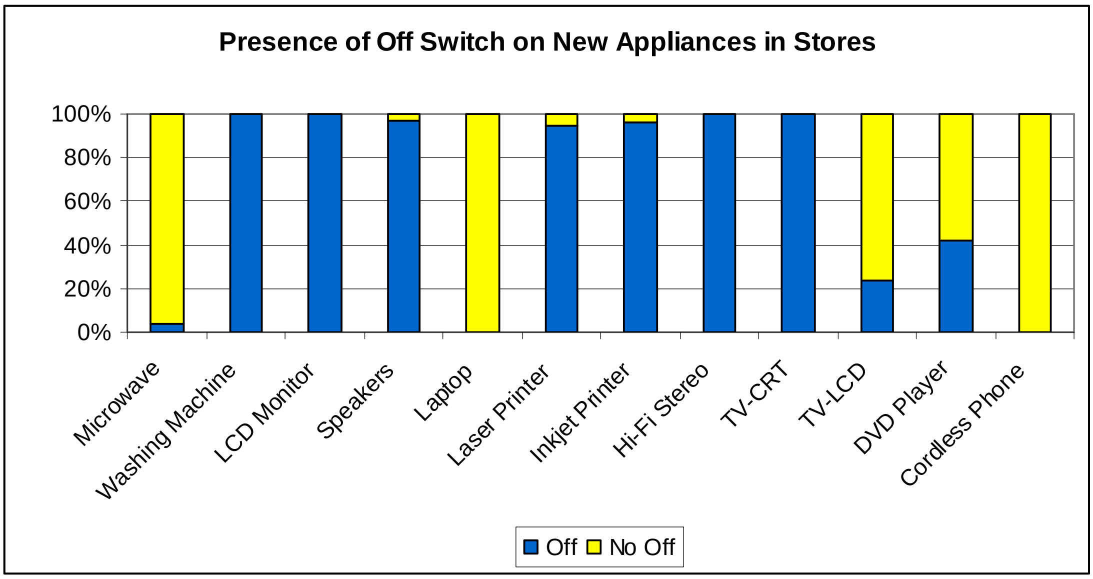
Only 3 out of 18 metered laser printers had 0.6 W consumption in off mode. These three appliances were produced by the same company which explains the same value in off mode and points to brand-specific difference. In contrast, only 20% of inkjet printers had 0 W consumption in the given mode. The average consumption of this product type in off mode was 1.4 W, with the minimum power use of 0 W and maximum – 4.4 W.

Almost the same average consumption in off mode was noted for portable stereo and it was equal 1.3 W. It should also be pointed out that 19% of sampled portable stereos did not have an off switch at all, but their average passive standby consumption was 1.3 W as well (Figure 12).

Furthermore, computer monitors were measured when turned off. Their average passive standby was 0.6 W, which is just 0.1 W less than in passive standby mode.

Finally, all but one computer speakers had an off switch, and all but one drew some power in the off mode. The average standby power consumption in this mode turned out to be 1.1 W, which is slightly less than consumption in active standby (2.4 W).

Figure 12 Presence of Off Switch on New Appliances in Stores



4.2.3 Standby Consumption of New Appliances Produced by Different Manufacturers

While measuring the standby power use of new appliances in the store, the information about different brands available on the Hungarian market was also collected. If the store survey becomes annual or at least regular in Hungary, these data will be useful for drawing comparison on the progress/regress of the brands in terms of standby consumption on the market and thus for putting pressure on manufacturers to improve the products (EnergyConsult 2007b). In the meantime, taking into account lack of baseline data for comparative purposes and an academic character of this work, the brands are not disclosed in the present study.

Regarding the standby power consumption of different manufacturers, several important observations have been made. Namely, almost one third of all appliances had more than one 'best' Performer in a given product type. For instances, Hi-Fi stereo was the appliance type with the highest number (5) of different brands having 0 W consumption in standby. This fact might mean that the reduction of standby use to the minimum is technically feasible and is already accomplished by several manufactures. However, a striking detail is that in some cases, one and the same brand fell into the category of both ‘best’ and ‘worst’ performers within one and the same appliance type, depending on the model (very often several models of one and the same brand in a product category were available). From the consumer’s perspective, this makes it virtually impossible to make conclusions about which appliance to choose in a given product type (only relying one the power consumption in standby and not on functionality, of course), as the standby power use varies significantly even from model to model, let alone from brand to brand. One the other hand, these data demonstrate that the manufacturers whose products have the lowest power use are not yet consistent in this issue and need to improve standby power use on a model-by-model basis.

4.2.4 Presence of Electronic Display or Clock in New Appliances in Hungarian Stores

Electronic displays or clocks are one of the reasons why household and office equipment consume power in standby mode (Schlomann *et al* 2005). The presence of this function in the metered appliances is highlighted in Table 11.

Table 11 Presence of Electronic Display/Clock in New Appliances

Appliance[23]	Number of Products with Display/Clock	Total Number of Products Metered
Microwave	25	30
Washing Machine	25	30

[23] Appliances where this function is not available in general (TVs, monitors etc) are not included into the table

Laser Printer	2	19
Inkjet Printer	2	25
Hi-Fi Stereo	30	30
DVD Player	31	31
Portable Stereo	25	25
Cordless Phone	0	30

As seen from Table 11, the electronic display is very common for washing machines. Those that did not possess a display showed lower standby values: the average for products without the display was 1.7 W versus 2.8 W for the appliances with this feature (see Table 7).

In contrast, only 5 printers (laser: 1 color and 1 black and white, 2 inkjet and 1 camera printer) had an electronic display. The standby consumption of these appliances was in the range between 3.2 and 11.7 W, which is higher than the average consumption of this product type (for more detail see Table 7).

The general upward trend in the number of appliances that have electronic displays or clocks, noted by Fraunhofer IZM (2007), is valid for the Hungarian market as well. Most of the equipment where this function might be incorporated already possesses it. This has an implication of increasing the overall standby consumption of household and office products in the years to come (Bertoldi and Atanasiu 2007).

4.2.5 Comparing Trends in New Appliances in Hungary, the Czech Republic and Australia

In order to see whether the overall downward trend in the standby consumption of the appliances on the Hungarian market is consistent with the trends in other countries, the data from the shops were compared to the data obtained from the recent store survey in Australia (Energy Efficient Strategies 2006) and the Czech Republic (The APP Basket of products project 2008). The average power consumption of major household products is summarized in Figure 13. Australia as a country for comparison was chosen due to the fact that store surveys are regularly carried out there, so a large pool of information is available thanks to the efforts of the Government to reduce standby power consumption. In addition, the methodology of the survey in Hungary is the same as in Australia. The Czech Republic participated in the store survey in 2008 as well, following the same methodology, so it is of interest to compare results with another CEE country and see if there are any regional differences.

Figure 13 shows that the biggest difference in average standby power use of new appliances on sale is for computer speakers, with the lowest value in Hungary (2.4 W) and the highest in Australia (7.5W). This significant difference between Hungary and the Czech Republic can be explained by the dominance of different manufacturers: around one third of sampled speakers in Hungary were produced by one manufacturer, while in the Czech Republic 52% of all speakers belonged to one and the same producer. However, this assumption cannot be supported by the data from Australia.

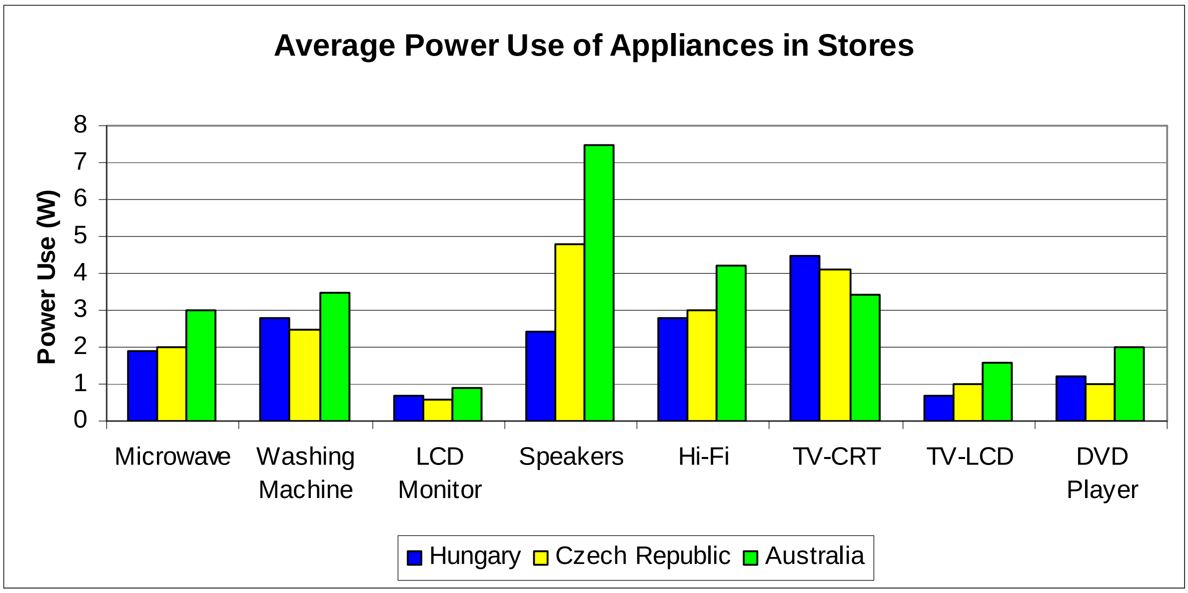
In general, average standby power of selected appliances is higher in Australia than in the given CEE countries, except for CRT TVs. It is noteworthy that the consumption of washing machines and microwaves is almost as high in CEE countries as in Australia (Figure 13).

As for the CEE region, the average standby power use of new appliances on the markets does not differ greatly, and in 50% of cases is slightly higher in Hungary than in the Czech Republic (Figure 13).

Overall, in three countries only LCD monitors, LCD TVs and DVD players have a consumption not exceeding 2 W (Figure 13). Other appliance types are still far from the one Watt target.

Apart from the market share by different manufactures in the examined countries, such factors as models and features offered specifically for some regions could account for the differences. Finally, the fact that there is a slight time lag between the survey in Australia (2006) and the CEE region (2008) might also indicate a general downward trend in standby power of major household appliances.

Figure 13 Average power use by appliance type on sale in Hungary, the Czech Republic and Australia



4.3 Estimations of Energy Savings Potentials

In order to estimate energy savings potential from replacing the existing household equipment with the Best Performers available on the market, as well from the implementation of standby limit measure for different appliances, a bottom-up method relying on statistical data was used. Table 12 shows penetration rates and average hours in standby mode for each appliance type, as well as the consumption by appliance type in Hungary. Since penetration rates for speakers in Hungary are not available, an assumption was made that 50% of owned computers have speakers. Regarding monitors, the penetration rates for personal computers were used. Also, type of TV sets was not available in the statistical data, so the given penetration rate was used for all types of TVs. Lastly, time spent in standby mode by microwaves was taken from the statistic of Australian Greenhouse Office (2003), due to the unavailability in other sources.

Table 12 Penetration rates, usage patterns and power consumption of some household appliances in Hungary

Appliance	Penetration Rates in Hungary, pieces per 100 households (2006)	Standby mode (hours/day)	Consumption (GWh/year)
Microwave	80	19	22.203
Washing Machine	83	3.0	1.091
Computer Monitor - CRT	41	9.6	54.044
Computer Monitor - LCD	41	9.6	9.199
Computer-Speakers	20.5	2.4	2.084
Laptop	3	9	0.986
Printer	n/a	1.9	n/a
Hi-Fi Stereo	35	17.1	45.461
TV- CRT	144	12	201.930
TV- LCD	144	12	50.483
DVD Player	36	15.6	25.431
Cordless Phone	n/a	22.6	n/a
Total standby power consumption	-	-	412.912

Data sources: Hungarian Statistical office (2006), Australian Greenhouse office (2003), Fraunhofer IZM (2007)

As demonstrated in Table 12, the highest standby power consumption is estimated to be in CRT TVs and monitors, as well as in LCD TVs and Hi-fi stereos. Total standby power consumption in households thus translates into 4.1% of total energy consumption by household electric appliances and lighting[24] and accounts for 0.143 Mt of CO_2 emissions[25], which represents 4% of total CO_2 emissions from household electric appliances and lighting, as of 2008.

The savings potentials which can be achieved for each appliance type are highlighted in Table 13. In case of Best Performer scenario, the biggest savings in the amount of 166 GWh per year are achievable for CRT TV, if they are replaced by LCD ones (Table 13). The LCD TVs that are currently used in households can also save as much as 48 GWh per year if they are replaced with more efficient products of the same type, available on the market. A considerable energy savings potential (53 GWh per year) lies in the replacement of CRT monitors in the households. This potential is very likely to be realized quite soon as the CRT monitors are being phased out. The substitution of laptops can bring rather small savings in the amount of 0.5 GWh per year. Apparently, this is due to quite low penetration rates of this product in the Hungarian households.

In contrast, the replacement of washing machines with new ones on sale will not lead to the energy savings at all, as the consumption of new appliances sold currently will be higher by 3 GWh per year (Table 13). This phenomenon can be explained by the presence of older and less consuming washing machines in the households, and the fact that the older models in most cases have no electronic controls and display and normally consume 0 W in active standby.

[24] Total energy consumption by household electric appliances and lighting estimated as 10.1 TWh for 2008 (Novikova 2008)
[25] Total CO_2 emissions from household electric appliances and lighting estimated as 3.4 Mt (Novikova 2008)

The energy savings potential in case of the One Watt scenario was found to be lower than in the Best Performer Scenario, although of the same order of magnitude: 338 GWh/yr versus 367 GWh/yr (Table 13). This phenomenon can be attributed to the fact that most of 'Best performers' in the shops already consume less than 1 W in standby, except for CRT TVs (see Table 7). Therefore the implementation of the One Watt scenario for most sampled products in Hungary will bring fewer savings, given the efficiency of the current stock in the stores. Overall, the estimations of energy savings potential are in line with the potentials for Best Performer scenario: the biggest savings are envisaged for CRT TVs, the smallest ones – for laptops, and no savings can be achieved in case of washing machines for the same reason (for more details about the amount of savings see Table 13). The only big difference in savings potential between the two scenarios is in the microwaves (Table 13). In the One Watt/0.5 Watt scenario there is no savings potential due to the fact that the average consumption by microwaves was estimated to be exactly 1 W.

Table 13 Savings Potentials for Best Performer and One Watt/ 0.5 Watt Scenarios

Appliance	Best Performer Scenario (GWh/year)	One Watt Scenario[26] (GWh/year)	0.5 Watt Scenario[27] (GWh/year)
Microwave	22.192	0	n/a
Washing Machine	-3.272	-2.545	n/a
Computer Monitor - CRT[28]	52.869	n/a	51.145
Computer Monitor-	8.045	n/a	6.321

[26] The savings potential was calculated only for appliances that fell into the category of appliances that should not exceed 1 W in standby by 2013, according to the EU regulation
[27] See footnote 15
[28] In this study CRT monitors are considered to be eventually replaced by LCD ones

LCD			
Computer-Speakers	1.078	1.365	n/a
Laptop	0.552	0.591	
Printer - Inkjet	n/a	n/a	n/a
Hi-Fi Stereo	45.438	36.700	n/a
TV - CRT[29]	166.511	n/a	189.217
TV- LCD	47.935	n/a	37.844
DVD Player	25.418	17.219	n/a
Cordless Phone	n/a	n/a	n/a
TOTAL	366.766	337.857	

Furthermore, replacement of the existing stock with new and less energy consuming appliances will result in the CO_2 emissions reduction. An overview of savings that can be achieved in two scenarios is presented in Table 14. Overall, the difference between the two scenarios is insignificant, which suggests that the best available technology on the Hungarian market already meets (with some exceptions, of course) the future standby limits, and thus the limits could have been more stringent.

As for the limitations of the scenarios, it should be taken into account that these potentials are calculated only for the most common energy using products in the Hungarian households (in terms of penetration rates). However, there are other appliances that consume significant amount of energy and possess new features (for instance, fridges and boilers) and those that are likely to be more common in households soon (for example, set-top boxes are expected[30] to increase on the market due to the transition to digital broadcasting). Another issue is

[29] Same as in footnote 12
[30] Bertoldi and Atanasiu 2007

related to the statistical data. First of all, the penetration rates for cordless phones and printers were not available in the Hungarian Statistical Office. Secondly, there was no comprehensive information about the user behavior, i.e. time the appliances are left in certain modes. So the average hours for each mode found in the literature had to be used for calculations. Finally, without the times series statistical data and the rate of exchange of common household goods, as well as rate of technical development, it was impossible to make an exact prediction of the future standby consumption of products and their savings potentials. Therefore, the estimations of the given study can only be indicative of the order of magnitude of possible energy savings.

Table 14 Overview of Savings Potential for Best Performer and One Watt Scenarios

Savings Potentials	**Best Performer Scenario**	**One Watt Scenario**	**0.5 Watt Scenario**
Energy Savings Potential	367 GWh/year	338 GWh/year	
CO_2 Savings Potential[31]	0.115 Mt/year	0.106 Mt/year	
% of CO_2 Emissions from Household Electric Appliances and Lighting[32]	3.4	3.1	
% of Energy Consumption by Household Electric Appliances and lighting[33]	3.4	3.1	

[31] CO_2 electricity emission factor for 2013: 314 gCO_2/kWh (Novikova 2008)
[32] CO_2 emissions from household electric appliances and lighting estimated as 3.4 Mt for 2013 (Novikova 2008)
[33] Total energy consumption by household electric appliances and lighting estimated as 10.8 TWh for 2013 (Novikova 2008)

4.3.1 Comparing results with previous studies on standby consumption in Hungary

Before comparing the results of the present study with the previous research on the topic it is necessary to note that to date, there have been no research of the standby consumption of new electric appliances on the market in Hungary. Moreover, there might be some differences in the methodology used, so the figures obtained are not fully comparable, although they are of the same order of magnitude with the previous results.

Strukanska (2001) used a whole-house measurement method, sampling 30 households in Hungary and extrapolating the data to the national level. The author estimated that the total standby power consumption in Hungary in 2001 was 1.07 TWh/year, which makes it 3.73% of national electricity consumption. As for the CO_2 emissions from standby power, it was calculated to be 0.5 Mt per year (Strukanska 2001). Comparing the results from the current study (Table 14) to Strukanska's research, it is clear that the new appliances available on the Hungarian market today consume less then back in 2001, having in mind that the number of households has increased from 3,850,000 (Strukanska 2001) to 4,001,976 (Hungarian Central Statistical Office 2005), and so have the penetration rates of the most common household appliances.

In more recent research Valentova (2007) estimated that standby, or lopomo, consumption in Hungary is around 8-10% of the total national electricity consumption by households. The higher percentage in this study might be due to a slightly different 'basket of products' sampled (wider than in the given work; also, lighting was included), as well as the method of measurements – along with the spot instantaneous measurements long term ones were used, which made it possible to record the exact amount of time spent in standby for most of appliances. In addition, Valentova used different data for the projection of penetration rates up to 2020 (Valentova 2007). Consequently, the savings potential in case of the One Watt scenario is also higher in Valentova's study: 649 GWh/year (for comparison see Table 14). Finally, CO_2 emissions reduction potential is slightly higher in Valentova's (2007) research: 0.3 Mt versus 0.1 Mt in the present study.

5 Recommendation for realizing the savings potentials

First of all, it should be noted that the energy savings potential from the replacement of the existing stock of the most common household appliances in Hungary is feasible, but at the same time is likely to be extended for several years, as the household appliances are not exchanged in one day due to relatively long life expectancy of such products. Secondly, it is obvious that the potential might be much higher if there are supportive activities and measures aimed at increasing awareness about and regulating the standby issue on the national level. The following measures on different levels can be undertaken by the government in order to reach this objective:

- Repeated information campaign carried out simultaneously through different media – television, radio, and newspapers, supplemented by close involvement of major retailers of household equipment. It is extremely important not to underestimate the role that retailers and distributors can play in influencing public opinion and raising awareness. A consumer's buying decision is affected not only by the repeated message from the media, but also by a qualified shop assistant who can provide valuable information about the products' features and characteristics and give advice as to the most optimal/energy efficient product to buy. Therefore, the next key issue is to ensure that electronics stores are informed about the characteristics of appliances that they offer, including standby consumption. In some cases such information is available from the manufacturers but is somehow neglected in the stores and not properly displayed. In order to overcome this obstacle, a series of workshops and trainings might be organized by the government which would gather manufacturers, retailers, distributors and consumer organizations to discuss better ways of displaying this information to consumers and the ways to do it.

- Another related informative instrument is labeling. Given that in most cases the energy efficiency labels were available only on the boxes of appliances in the stores, it is highly advisable to negotiate the placement of the label with manufactures, or if the appliances are produced outside Hungary, to put pressure on whole-sale distributors to provide products only with proper labeling, i.e. on the product itself.
- As a way to support the estimated energy savings potential, it is advisable to strengthen green procurement rules which are reported to be weak due to lack of proper coordination on the governmental level, understanding of the concept and practical experience (GreenLabelsPurchase 2006). Providing best available technology to the public institutions, together with the information about standby losses and appropriate behavior to avoid them, might have a spillover effect: employees, having received new appliances for office use and a short training/seminar on standby issue will be empowered to use a more energy efficient equipment at home and change user behavior.
- Finally, standby power store surveys with similar methodology as in other countries (for example, Australia) should become regular in order to monitor the progress of new appliances appearing on the market, draw trends in standby power use locally and as compared to other countries, and put pressure on manufacturers or distributors that do not comply with the measures. Also, regular survey the results of which will be publicly available, will keep the standby issue in the focus of attention of media, public and the government.

6 Conclusions

Reduction of household standby power consumption in the EU is expected to bring up to 50 TWh/year of the energy savings and reduce CO_2 emissions by 14 Mt by 2020 (Europa 2008). Looking at individual EU countries, to date there has been no research on the features and energy savings potential of the best available technology on the Hungarian market which will inevitably replace existing household stock, given the rate of technological development and consumption. As several estimations of the amount of standby consumption in Hungary exist, the present study was aimed at estimating the energy savings potential by drawing on the previous research and conducting an in-depth survey of major household appliances on sale in Hungary.

Regarding the average power consumption in standby mode, it was found that current household stock consumes more power than new appliances of the same type available on the Hungarian market. The exceptions are microwaves, washing machines, printers and laptops. The average power consumption of new appliances was in the range of 0.7 - 4.5 W, compared to 0.3 -9.4 W by products in households. The “best performers” in the stores were found to be appliances with LCD technology (0.7 W per hour in standby both for monitors and TVs), while CRT TVs turned out to be “the worst” products with an average power consumption of 4.5 W per hour. In contrast, the best performers in the household stock were washing machines, and the worst ones – CRT computer monitors.

As far as trends in new appliances on sale are concerned, energy labels are one of the features most commonly encountered in washing machines, LCD monitors and printers. The majority of labels belonged to the endorsement type, such as EnergyStar. Comparative labels were found only on the washing machines. A special standby label which manifests power use in the standby mode was discovered on Hi-Fi stereos produced by one of the well-known manufacturers. Another interesting finding is the fact that very often labels were available only on the product package, which means that consumers are mostly unaware of their presence.

Off switch was present on 7 appliance types out of 12 metered. In 90% of cases, off switch was found at the back of LCD TVs instead of more usual front panel. Such placement can reduce the motivation for consumers to use the switch. Another important finding is that all appliances except for CRT TVs drew some power when switched off with the special button.

As for the standby consumption of appliances produced by different manufacturers, it was found that very often there was more than one “best performer” in the product type which demonstrates technical feasibility of reducing standby consumption to the minimum. However, one and the same brand could often end up in the “best” and “worst” performer groups, depending on the model of an appliance. This phenomenon makes it extremely difficult for consumer to make a purchasing decision from standby consumption perspective, and shows the need for manufactures to improve certain models.

The prevailing number of products metered in the shop had electronic displays or clocks. The standby consumption of products with displays or clocks was higher than of those that did not possess this feature. This trend of increasing number of electronic features and consequently, standby consumption is consistent with Fraunhofer IZM’s (2007) findings.

Comparing the trends in standby consumption of products on sale in Hungary to other countries where a similar survey has been recently conducted, it is evident the regional differences do exist. The biggest difference in standby consumption was stated for computer speakers: 4.5 W in Hungary versus 7.5 in Australia, which might be explained by presence of different models and manufacturers. Overall, the average standby power was found to be higher in Australia than in Hungary or the Czech Republic, except for the CRT TVs, while there was no significant difference between the two European countries. LCD monitors, LCD TVs and DVD players turned out to be the only products consuming not more than 2 W in standby in all three regions of the world.

Finally, it was found that currently standby consumption of major household equipment is responsible for 4.1 percent of energy consumption and 4 percent of CO_2 emissions from electric appliances and lighting in Hungary. As for the energy saving potential, in case of replacement of current household appliance stock with the best available technology, it is 367 GWh per year, which translates into 3.4 % of energy consumption by household electric appliances and lighting in Hungary. The CO_2 emissions from the standby power consumption can thus be reduced by 0.115 Mt per year, or 3.4 percent of total CO_2 emissions from household electric appliances and lighting. The energy savings potential resulting from the implementation of 1 and 0.5 W limit by 2013 is estimated to be 338 GWh per year, or 3.1% of energy consumption by household electric appliances and lighting and 3% of total CO_2 emissions from household electric appliances and lighting (0.106 Mt). Such a small difference between the two scenarios shows that most of the new appliances available on the Hungarian market are already very close to meeting the future limit, and suggests that the standby limits to be introduced in 2013 could have been even more stringent, as the manufactures can easily meet the targets.

Although the standby regulations are adopted on the European level, there is a number of supporting measures that the Hungarian government could implement in order to realize the energy savings potentials. One of them is to repeatedly carry out information campaigns complemented by the training for shop assistants who can potentially raise consumers' awareness and influence purchasing decision by providing relevant information on standby consumption. Another measure is to put pressure on the domestic manufacturers regarding labeling of the products (i.e., putting label on the product itself). Lastly, strengthening green procurement rules and conducting regular standby store surveys for comparative purposes is highly desirable in order keep the standby problem in perspective and realize the estimated savings potential.

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