Standby Consumption in Households
State of the Art and Possibilities for Reduction for Home Electronics

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Introduction

An increasing number of appliances features a standby mode in which the appliance does not fulfil its primairy function for which it has been purchased, but will still use (some) electrical power. Although power consumption per appliance in this mode is in most cases low compared to consumption in the operating mode, it may result in a considerable energy consumption. Appliances are tend to be left in standby mode for relatively long periods of time, while the total numbers of appliances left in standby mode are large.

Because of the low power levels involved, standby energy consumption is often neglected when looking at household energy consumption. However, an investigation of standby consumption in the Netherlands (Siderius 1995) showed that on average about 10% of household electricity consumption is standby consumption. Investigations in Germany (Rath et al 1997) and Japan (Nakagami et al 1997) came up with the same result.

This article gives an overview on issues regarding standby consumption in households, concentrating on home electronics. First a definition of the standby mode is given, and attention is paid to the composition of the household standby consumption. Some market trends are indicated for category of appliances that make-up the largest part of standby consumption: VCR, hifi-sets, TV, decoders. Developments in appliances and consequences for standby consumption are indicated. Also technical possibilities to reduce standby energy consumption are shown. The article concludes with a short description of initiatives that have already been taken to reduce standby consumption and a discussion of further possible actions to reduce (standby) power consumption.

Standby Consumption of Household Appliances

The word 'standby' refers to the situation where the appliance does not perform it's main function but is ready to do so. However, in most situations also the electricity consumption of auxiliary or support functions and the consumption in the off mode is calculated as standby consumption. Therefore a general definition of standby electricity consumption is the electricity consumption of the appliance in the mode where the appliance doesn't fulfil it's primairy technical-economical function but still uses electricity from the mains (Molinder et al 1997). Auxiliary functions are e.g. a clock on a microwave oven or a display on a fridge. Battery charging can be regarded as a support function, especially when the battery is already charged but the users leaves the appliance — e.g. a dustbuster — connected to the mains.

The standby mode should not be confused with appliances that are continuously in the on-mode, e.g. ventilation. The difference can be explained by the function fulfillment of the appliance: if the appliance fulfills the primairy function, it is by definition *not* in the standby mode. Whether the primairy function is actually used, is another question. For example radios and television sets are often playing without anyone listening or watching; yet they are in the on-mode and not in the standby mode. Note also that standby energy consumption is not indicated as useless or energy losses. Although certain types of standby consumption can be considered as useless — e.g. when an appliance is off and still consumes electricity — in general standby consumption serves a certain function, be it a secondairy function. It goes without saying that standby consumption of most appliances can be reduced, but this is also true for consumption in the on-mode.

Before in the next section possibilities to reduce energy consumption will be discussed, first the amount and composition of standby energy consumption will be presented. Figure 1 shows the decomposition of household standby energy consumption.

Although there are differences between countries regarding the list of appliances with standby consumption, figure 1 shows that more than half of the standby energy consumption is within the category 'audio, video and communication', e.g. VCR, TV, hifi-set, printer, etc. Table 1 gives a more detailed overview of this category and figures from various sources.

Table 1. Standby power consumption (W) of audio, video and communication appliances

Appliance	Siderius (1995)	Rath (1997)	Nakagami (1997b)	Sandberg (1994)	Sidler (1996)
VCR	12.0	15	7.5	10	10.8
TV	7.5	12	1.9*	7.5	9.9
Hifi-set	10.0	12	8.8*	6	7.9
Amplifier	3.5	9	n.a.	1	n.a.
Tuner (/receiver)	3.5	n.a.	n.a.	2.5	n.a.
Portable equipment	5.0	4	n.a.	1.1	n.a.
Decoder (digital)	9 - 15**	n.a.	n.a.	n.a.	12.2
Satellite receiver	13.0	20	n.a.	8	14.8
Printer	6.8	10	1.7*	n.a.	n.a.
Answering machine	3.0	4	n.a.	2.5	2.5

*average including appliances with 0 standby power consumption

**base on Siderius (1997)

Differences in values in table can have various reasons. Firstly, various methodologies are used: direct measurements at home, literature search, laboratory measurements. Secondly, values are average values, so the sample on which the values are based has a large influence (also because samples are relatively small). Thirdly, values refer to different years. And last but not least, appliances can differ.

Because the category 'audio, video and communication' has the largest share in household standby consumption, this article will concentrate on (selected) developments in the category of Home Electronics.

Developments in Home Electronics and Consequences for Standby Consumption

Although it may seem that the world of Home Electronics is dynamic market in which new products appear every year or faster, the basic products in this category have a long history and really new developments — like the VCR, the CD-player or digital TV — need (at least) 5 to 10 years before they gain a substantial share of the market. What is changing fast, is the outside design of the appliances and the prices. Prices of home electronics have been on a stable level or are even (slight) decreasing for some years. In fact this means that expressed in real terms, prices have decreased every year by 2 or 3%. Only new appliances or new features that are perceived as relevant by consumers can stop this price erosion for a while.

In this section attention will be paid to the VCR, TV, hifi-sets and satellite-receivers and digital decoders.

VCR

Nowadays the VCR is a commonplace product in the majority of European homes, penetration rates vary between 50 and 80 %. Standby power consumption is an important issue for VCRs because these appliances are almost 23 hours per day in standby mode, and — unlike TVs — cannot be switched off. Even if this was

possible most people probably wouldn't do it because most VCRs loose their information stored in memory and the possibility of programming in advance to record is lost.

It is expected that — also looking at penetration rates in the U.S. and Japan — 80% is a maximum penetration rate. However, there might be a shift towards more expensive types, e.g. hifi stereo VCRs.

The standby power consumption of a VCR can be subdivided into two modes: standby passive and standby active. Standby-passive — which is commonly called standby mode — is the mode in which the appliance is connected to a power source, does not perform any mechanical function and is waiting to be switched into another mode on receipt of a signal from the consumer. Standby-active — a ready to record mode — is the mode in which the appliance is connected to a power source, does not perform any mechanical function, is in an active mode communicating for part or all of the time, or is waiting to be switched to "on (record)" by means of an internal or external signal.

Since most VCRs have the feature to start recording at the reception of a special broadcasted signal, the standby-active mode in general requires more power than the standby-passive mode. This is because in the standby-active mode (at least) the tuner has to stay on to receive the broadcasted signal.

Values for standby-passive power consumption range from 1 to 12 W; for standby-active power consumption values are: 5 to 20 W.

The following components are responsible for the standby consumption of an average VCR (see table 2).

Table 2. Composition of VCR standby power consumption (Source: Siderius (1995))

VCR functional block	% of total standby power consumption
Inefficiency power supply in standby mode	40
Display	21
Digital circuits that remain on	14
Analogue circuits that remain on	18
Mircocontrollers	6
IR-receiver and amplifier	1

Table 2 gives also insight into possibilities for reducing standby power consumption. Various options are already implemented in some VCRs on the market: improved power supply, display off, etc. Although it should be possible with the help of a timer to implement a standby active mode with a power consumption of 1 W (or less), there no such VCRs on the market (yet).

Forecasts of standby energy consumption of VCRs (Huenges Wajer 1996) indicate an increase in consumption for the 15 countries of the EU from 9600 GWh per year in 1995 to 11200 GWh per year in 2010 (base line scenario). Also a maximum savings potential of 6100 GWh per year in 2010 is indicated (scenario a).

TV

Penetration rate of TVs is already on average 130% in Europe, and it is expected to grow further. Figures from the Netherlands show an increasing number of second (40% in 1996, compared to 33% in 1991) and third (14% in 1996 compared to 8% in 1991) TVs in households. Furthermore sales figures for TVs indicate following trends:

- more widescreen TVs
- more TVs with a scan rate of 100 Hz (which result in a more stable picture)
- the average screen size of the (main) TV increases
- more TVs are equipped with surround sound or stereo

However these trends do not have an impact on standby power consumption of TVs. Standby power consumption of TVs varies from 0.1 W to 15 W, with an average value between 6 and 7 W. Since TVs do not yet have a standby-active mode — which means that the TV is able to communicate with an external source — it is relatively simple to reduce standby power consumption of TVs to (below) 1 W. The only components that have to be powered in the standby mode are an infrared receiver for the remote control signal, a (mandatory) LED to indicate the standby mode, and an IC to generate a 'wake-up' signal. This can be powered directly from the mains by a simple bridge rectifier. Also options exist where a separate standby power supply is used. This power supply can be designed for a high efficiency at a small load. Using the main power supply also in standby mode results generally in a lower efficiency because the power supply has to be designed for 2 different working points, e.g 5 W standby and 60 to 90 W in the on mode.

Another way to reduce standby power consumption is the auto power off (APO) feature. TVs with this feature switch themselves off from the mains after being a preset period — mostly 1 hour — in standby. After the TV is switched off, power consumption is zero. However, compared to the normal standby mode there is some decrease in user comfort because the user has to switch the TV on at the set and cannot use the remote control.

Forecasts of standby energy consumption of TVs (Huenges Wajer 1996) indicate an increase in consumption for the 15 countries of the EU from 4800 GWh per year in 1995 to 7800 GWh per year in 2010 (base line scenario). Also a maximum savings potential of 3500 GWh per year in 2010 is indicated (scenario a).

Hifi-sets

Although the product group 'audio equipment' is very heterogeneous, hifi-sets account for the largest share of the sales in this market segment. Within the category 'hifi-sets', micro and mini sets account for a growing market share. Furthermore the percentage of sets with remote control — and thus with a standby mode — is increasing. Figures from the Netherlands indicate that in 1994 about 45% of the installed hifi-sets had a remote control; the estimate for 1997 is 60 %. Power consumption of hifi-sets in the standby mode has a large variation: sets with a consumption of 1 W exist, but also do sets with a consumption of more than 20 W. The standby consumption depends on the part of the set that is left 'on': in some sets all parts are powered in standby mode, only the illumination of the set goes down. Other sets have a clock that is also on and lit in the standby mode.

Technically speaking it is no problem to achieve a standby consumption of 1 W (or lower). It is mainly a matter of careful design and costs, e.g. for a separate standby power supply.

Furthermore, power management is a sensible way to reduce power consumption of hifi-sets, also in the standby mode. With power management implemented, only those parts of the hifi-set are powered that are actually active. For example, when the cd inside the cd-player is finished, power management shuts off the power to the cd-player and the amplifier and enters a standby mode.

Forecasts of standby energy consumption of hifi-sets (Molinder et al 1997) indicate an increase in consumption for the 15 countries of the EU from 4500 GWh per year in 1996 to 6500 GWh per year in 2010 (business as usual scenario). Also a maximum savings potential of 6500 - 2300 = 4200 GWh per year in 2010 is indicated.

Satellite receivers and digital decoders

The word 'satellite receiver' is mostly used to designate analogue receivers. With the (expected) introduction of digital broadcasting in European countries, an appliance is needed that can convert broadcasted digital signals into a signal that can be used by the TV. This appliance is called an integrated receiver decoder (IRD). An IRD will be able to receive signals from satellite (with the help of a dish), from cable and digital terrestrial broadcasted signals.

The penetration of satellite receivers in a country depends on the penetration of cable TV (CATV) and on the programmes that are broadcasted by satellite. Thus countries with a high cable TV penetration, like the Netherlands and Belgium (both about 90 %), in general have a low penetration of satellite receivers. On the

other hand countries like Germany (around 50% CATV penetration) have a high penetration of satellite receivers. When digital broadcasting is replacing analogue broadcasting every household needs either an IRD or a new TV with an built-in IRD. The consequences for energy consumption of the IRD depend on:

- the efficiency of the power supply of the IRD
- the power consumption of other hardware in the IRD (this depends e.g. on the type of IRD: cable, satellite, terrestrial or hybrid)
- various modes in functionality (and power consumption) such as a standby mode

Figure 2 shows a (simplified) functional lay-out of an IRD and Table 3 gives an estimation of the power consumption (in the on-mode) for various functional blocks of the IRD.

Table 3. Estimation of power consumption (in on-mode) for components of the IRD (Source: Siderius (1997), Harrison (1997))

Component	**Power consumption in *on*-mode [W]**
Tuner-demodulator	3.0
Demultiplexing, MPEG-decompression and memory	1.5
Operating system (central processor)	1.0
Video and PAL encoder	1.0
Modem	1.0
CA-system	1.0
Display	1.0
SCART connection	2.0
Other	0.5
LNB control (for satellite IRD)	3.5
Total power consumption components	15.5
Efficiency power supply [%]	80
Power consumption power supply [W]	3.9
Total power consumption IRD	19.4

Current values for power consumption in standby are about 9 W. Looking at power consumption values of state-of-the-art IRDs, their seems little room for improvements. However, if the IRD has no standby mode or is forced to be in the on-mode for 24 hours per day, there is a large impact on energy consumption. A power consumption of 20 W continuously results in an energy consumption of 175 kWh per year. Therefore not only efficient components but most of all a low power standby mode is critical for minimizing IRD energy consumption. To achieve this — unlike with the other appliances — not only the manufacturer of the box has to be involved, but also the service provider and the manufacturer of the conditional access system. Conditional access means that only those who are authorized to receive a certain service (mostly because they pay for the service) can use this service. For this purpose it is necessary that the identity of the (user of the) IRD can be retrieved and checked. This required regular communication of the IRD with other parts of the system. In most cases service providers, which sell e.g. pay-tv services to consumers, set up the specifications for the IRD. Some (draft) specifications require that the IRD is on 24 hours per day to enable the service provider access to the box at any time. These boxes also do not have an on/off switch, thus in practice forcing the user to leave them on 24 hours per day. Although many technical specifications for the IRD are standardized, issues regarding the implementation and use of a standby mode are not. Integration of the IRD in the TV would require agreement on a standard conditional access system.

Because of uncertain developments — when will digital TV have a substantial penetration?, will the standard IRD have a standby mode? — it is difficult to forecast standby power consumption of IRDs. Molinder et al (1997) estimate for the 15 countries of the EU an energy consumption of 19000 GWh per year in 2010 (business as usual scenario). Also a maximum savings potential of 19000 - 5500 = 13500 GWh per year in 2010 is indicated.

Some Notes on Costs

An important question when discussing possibilities for savings is: Are the possibilities for savings (design options) cost effective for the consumer? Although electricity prices are known and thus the money savings can be calculated from the energy savings, it is rather difficult to estimate costs. Cost estimation requires two steps: what are the costs at the basis — the costs for the manufacturer to implement a design option — and how will these cost be passed on to the consumer.

The costs (for a particular manufacturer) for implementing a design option can vary from almost 0 — or even savings — to very high, depending on the timing of the design option in the redesign cycle of the manufacturer. If a separate redesign of the power supply has to be planned to make it more efficient only, costs are probably prohibitive. Furthermore, the price range of the product plays a role: in a high end product there is mostly more margin to spend on improving efficiency; in low end sets there is not.

That the above reasoning does at the moment not lead to more efficient home electronic appliances is due to the fact that design capacity can only used once. Although certain design options for more efficiency might cost nothing, they also give at the moment little or no benefit to the manufacturer because most consumers are not willing to pay more for energy efficiency. Thus, when looking at investments of design time, it is generally more profitable to invest design time in improving picture or sound quality then to invest in improving efficiency.

Measures to reduce standby power consumption

For several years the standby power consumption has the attention of energy agencies, governments, the European Commission and last but not least the manufacturers.

In this section some initiatives to reduce standby power consumption of TVs and VCRs are presented.

GEA-VIA: voluntary information activities

Based on the philosophy of the Swiss Energy 2000 system, a number of European energy agencies and federal institutes established in 1997 Voluntary Information Activities regarding Home Electronics. The goal of the cooperation is to harmonize activities in the field of reducing standby consumption in order to promote the most efficient 25% of all models available in the market. Several countries run activities for models that meet the criteria. Criteria a revised regularly in close cooperation with industry (EACEM).

Criteria for standby consumption are 3 W for TV (1998) and 4 W for VCR (1998).

EACEM voluntary agreement on TVs and VCRs

As a follow-up of the participation in the EU study on standby consumption of TVs and VCRs EACEM (European Association of Consumer Electronics Manufacturers) started negotiations with the European Commission on a voluntary agreement on standby power consumption of TVs and VCRs. This agreement was established in 1997 and will be in force from 1-1-2000. TVs and VCRs will then have a maximum standby power consumption of 10 W, and each company signing the agreement will have an average lower than 6 W. Furthermore, industry commits themselves to further activities to reduce (standby) power consumption of appliances.

Energy Star

The Energy Star label for TVs and VCRs was launched in January 1998. TVs and VCRs can apply for an Energy Star label when they satisfy the following criteria for standby power consumption: 3 W for TVs, 4 W for VCRs. These criteria have been harmonized with the GEA-VIA values.

The issue of standby consumption is — for TVs — in the U.S. more important than in Europe, because TVs do not have an on/off switch that shuts them off from the mains. In Europe, about 50% of the consumers switch off their TVs when they do not intend to watch for a longer period, e.g. overnight.

Japanese target values

In Japan MITI has issued target values for standby power consumption of TVs and VCRs (Nakagami and Litt, 1997) which are just below the Energy Star values. However, for TVs energy efficiency in general is indicated by a target value that includes off, standby and on mode.

U.S. 1W proposal

From a technical perspective it is clear that standby power consumption of most appliances need not be larger than 1 W. This is the basis for a proposal initiated by Lawrence Berkeley National Laboratory (LBNL) in the USA to create a dynamic such that no appliances will use more than 1 W in the standby mode. National governments and manufacturers have been invited to subscribe to this international target and LNBL hope to build enough momentum to bring this target into being as soon as possible

Table 4 gives an overview of current initiatives.

Table 4. Overview criteria for standby power consumption of various initiatives

Initiative	TV [W]	VCRTV [W]	Remarks
GEA voluntary information activities	3	4	1998-1999 value
EACEM voluntary agreement	6	6	2000; average per manufacturer, max 10 W
Energy Star	3	4	1998-2000 value
Japanese target values	2.5	5	VCR value calculated from duty cycle

The presented measures to reduce standby power consumption can be seen as complementary, either geographically or regarding market approach. The GEA voluntary information activities and the EACEM voluntary agreement are European initiatives, Energy Star is targeted at the US market, and the Japanese values are for appliances sold in Japan. Regarding the market approach, the EACEM voluntary agreement aims at improving the least efficient appliances on the market (push strategy), whereas the GEA VIA approach tries to pull the market towards lower standby power consumption.

Broadening the perspective; future work

In this article attention was focussed on some aspects of electricity consumption of Home Electronics, i.e. the standby power consumption. The standby mode discussed can be regarded as a 'passive standby' mode: the appliance is waiting for a command (from the user or an external source) to be switched in the on-mode. However, it is expected that in the near future appliances — especially in the Home Electronics category — will also have an 'active standby' mode. In this mode the appliance is communicating with the outside world, e.g. it is asking the service provider to down load an update of an EPG (Electronic Programming Guide). In general more power is needed in the active standby mode, because more parts of the appliance are functioning.

Furthermore also the on mode requires attention from an energy saving perspective. As TVs get larger screen sizes and more sound power installed (surround sound), the power consumption in the on mode increases.

Last but not least, ever more appliances are equipped with a standby function. Although for some appliances initiatives exist, a general approach is missing, except the 1 W initiative from the LBNL in the USA.

So, the following items will be of interest in further reducing standby power consumption in the future:

- active standby mode

- power consumption in the on mode
- general approach to standby power consumption

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