Standby: where are we now?

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Abstract

Organised efforts to measure and reduce standby power use have been under way for about a decade. Recent measurements of homes in developed countries show that standby ranges from 60 to 110 W per home, which corresponds to about 4-11% of residential electricity use. Standby in most European homes lies between 50 W and 70 W, with countries such as Denmark at the higher end and Greece at the lower end. Some evidence suggests that these levels have risen rapidly in the past few years as a result of purchases of computers, set-top boxes, and digital appliances. Few data exist for commercial or industrial buildings but standby may be as much as 0.7 W/m² of floor area. About ten voluntary programmes to reduce standby are under way around the world. Three mandatory programmes to limit standby are already scheduled to go into force in 2006-2008, with others likely to follow. A horizontal standard limiting standby in all products would appear to be the most sensible policy but the rising energy use in other low-power modes must also be addressed.

Introduction

The purpose of this paper is to describe recent efforts to measure and reduce standby power use in electricity-consuming products. Standby power use was recognised as a distinct phenomenon about 15 years ago (Meier et al. 1992; Sandberg 1993). Certain appliances—notably televisions and VCRs—drew small amounts of power even though they were not performing their primary functions but in order to maintain auxiliary capabilities, such as receiving a remote signal or powering a clock. At about that time, the number of electrical devices relying on external power supplies (to convert mains AC to low-voltage DC) began to increase rapidly. These drew power even when the device was switched off.

Since the early 1990s, the standby situation has become more complex. It has become broader in the sense that more products are affected. Products drawing standby power have become ubiquitous in homes, offices and in many industrial settings. Standby power consumption in white goods is now commonplace and rechargeable devices—such as mobile phones—are among the most popular electrical devices purchased. At the same time, other low power modes—such as the “sleep” mode—have become more common and other new low power modes below a fully active state have appeared.

As the magnitude of standby energy use became clear, efforts began to reduce it in key products. Energy Star and the European Code of Conduct are among the best known. By 2001, there were at least six different programmes setting limits on standby power in the most common electrical products. These programmes helped stimulate greater interest in reducing standby power in all kinds of electrical devices. The IEA (2001) describes many of these earlier activities.

An important missing element in these programmes was an internationally recognised definition and test procedure for standby, causing every programme to develop its own

definition and test procedure. The wide range of definitions and test procedures led to confusion and inconsistencies not only among programmes but even within programmes. Energy Star, for example, used different definitions of standby in computers, copiers, and TVs. In March 2005, the International Electrotechnical Commission (IEC) tentatively adopted a test procedure for standby power use as described in IEC 62301. The definition of standby in the standard is the minimum power draw of the device while connected to the mains. IEC 62301 was designed to measure power draw in both standby and other low power modes. The IEC test was designed for measurement of standby in appliances, but it is suitable for a much wider range of electrical products with little or no modification. Existing energy test procedures for electrical products that now only capture energy use in the active modes can also capture standby by simply referencing IEC 62301.

Recent Measurements of Standby Power

APPLIANCES AND EQUIPMENT

Standby power use has been measured in thousands of products during the last decade. The largest collection of measurements is the Energy Star database of consumer electronics products (primarily televisions and VCRs)[1]. Other important databases are maintained by the Energy Conservation Center of Japan[2] for the TopRunner programme, the Group for Energy Efficient Appliances, and the Federal Energy Management Program (FEMP)[3]. These databases consist entirely of measurements submitted by manufacturers of their own products. These databases reveal little about the overall status of standby because there is no information regarding sales of each model. Furthermore, the databases cover only the major product categories targeted by programmes and therefore present an incomplete picture of standby use.

Fortunately, numerous independent groups have measured standby in more diverse groups of products. These measurements have typically taken place in stores (so as to capture standby use in new products) and in buildings where the products are actually used.

The Australian Greenhouse Office (AGO 2004a) periodically measures standby power use in new products. In this way, they have characterised the range in standby levels in new products and are able to follow trends in standby use. Figure 1 shows the distribution in standby found for microwave ovens. This distribution is typical for many devices, that is, a cluster spanning a few watts, but with a few devices consuming much more. (There is often no obvious explanation for the units with very high standby because they offer the same features as the units with low standby.) When a large number of product measurements are available, it is possible to follow the trends in standby over time. In the AGO's most recent store survey, over 900 products were metered (see Figure 2). These measurements show that average standby levels fell until about 2002 and since then have stabilised.

Similar measurements of standby power in existing appliances are more difficult because there is no easily accessible collection of existing products. Rosen and Meier (2000) measured standby on several hundred TVs and VCRs while the units were being repaired in a shop. This survey technique will not work for most products with standby because they are typically discarded rather than repaired. An excellent compilation of measurements of both new and existing products has been created by AGO (2004b).

Such measurements make it is possible to estimate an "average" standby for microwaves, TVs, and other products.

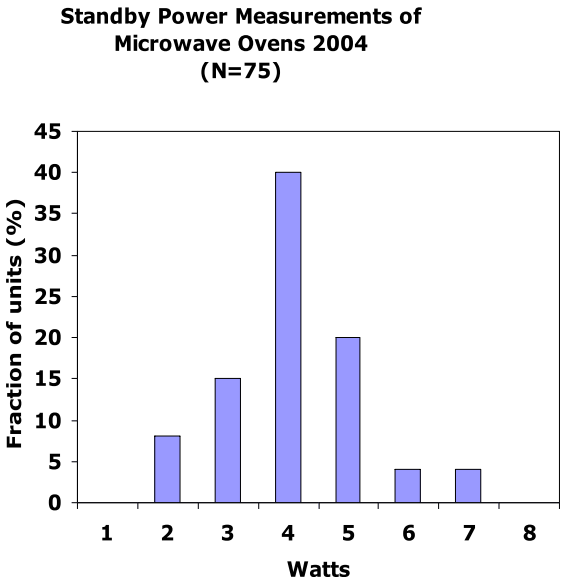

Figure 1. *Measured standby of 75 microwave ovens sold in Australian stores in 2003/4. Adapted from AGO (2004a).*

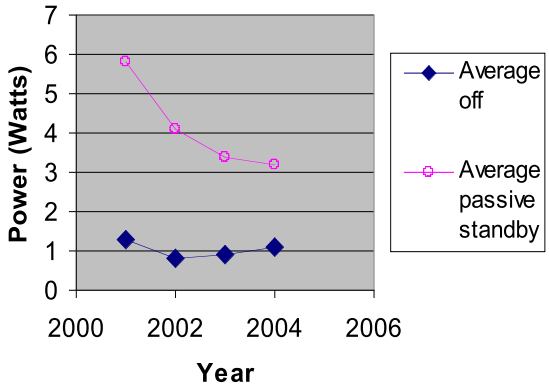

Figure 2. *Measured standby ("off" mode) of 925 products sold in Australian stores in 2003/4. Adapted from AGO (2004a).*

1. These data can be viewed at www.energystar.gov .
2. These data can be viewed at http://www.eccj.or.jp.
3. These data can be viewed at http://oahu.lbl.gov .

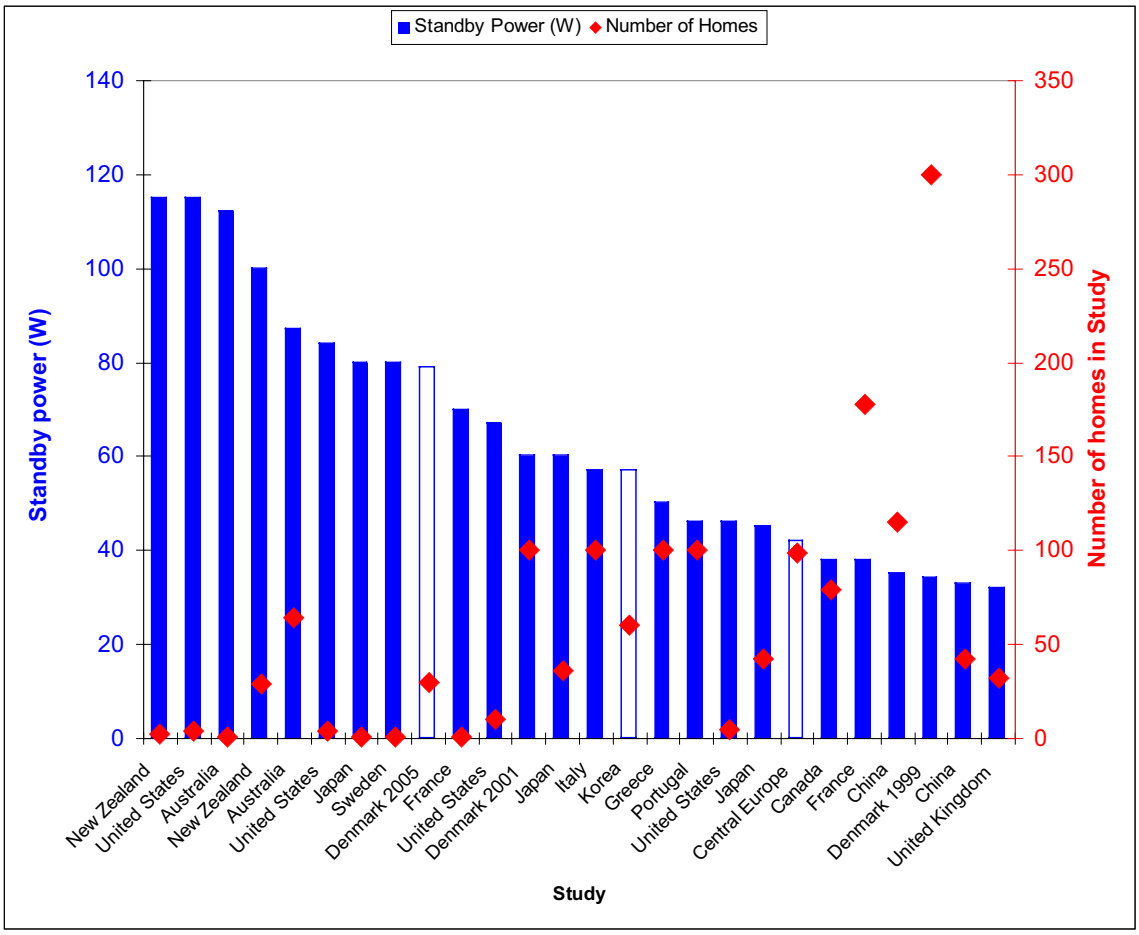

Figure 3. *Summary of measurements of standby power consumption in homes. Adapted from Meier (2002) with new data shown as unfilled bars.*

If repeated for many kinds of devices, and multiplied by their stocks, it is possible to estimate the national electricity consumption devoted to standby. This approach was used for early bottom-up estimates in the United States (Rainer et al. 1996), Switzerland (Meyer & Schaltegger AG 1999), the Netherlands (Siderius 1995) and Argentina (Tanides, Dutt et al. 2000). Such calculations typically underestimate standby because there is no stock information on dozens of minor appliances that draw standby power, such as cordless phones, garage door openers, coffee makers, etc. Even these crude estimates, however, were sufficient to demonstrate that, on a national basis, standby power represented at least 5% of US residential and 3% of Swiss residential electricity consumption.

STANDBY IN WHOLE BUILDINGS

Whole-building measurements are an alternative way to investigate standby power use. By intensively monitoring a representative group of buildings, a survey can establish a reasonably accurate and highly credible estimate of standby power use in that region. This approach can capture the impact of behavioural factors, such as the number of devices plugged in. Behaviour plays an unknown, but potentially large, role in standby power use. In China, for example, consumers traditionally disconnected appliances when not using them. British, Australian and New Zealand homes have switches at the power points, making it more convenient for the occupants to fully disconnect devices when not using them. Whole-building measurements can also capture the standby power draw of devices that are "hard-wired" into building (such as smoke detectors).

Figure 3 summarises 25 studies of standby in residences. These results are based on an earlier compilation by Meier (2002) and supplemented with three studies completed since 2002 (shown as unshaded columns in the Figure). Based on this compilation, standby power use in residences (in developed countries) is 60-110 W, representing 4-12% of total residential electricity use. Standby power use in most European homes lies between 50 W and 70 W, with countries such as Denmark at the higher end and Greece at the lower end. Present (that is, in 2005) levels of standby in European homes are probably higher than reflected in the 2001 measurements because computers, set-top boxes, and digital appliances have rapidly saturated the sector. Unfortunately there are insufficient time-series data to confirm the impact of these purchases.

The whole-building approach suffers from its own sources of uncertainty. First, it is easy to be inconsistent with respect to defining and measuring standby power. Surveys in New Zealand (EECA 1999) and Europe (Rath et al. 1997; Sidler 2000) included the energy consumed by heated towel rails and electric water heaters and virtually every survey acci-

dentally (or deliberately) included some computer-related equipment in sleep modes (rather than off-modes). These actions will result in a higher estimate of standby power.

Most surveys made sincere efforts to measure all the devices but excluded a few because they were either too difficult to access (and the teams did not want to inconvenience the residents) or the teams simply failed to find all the devices. For example, in the Colorado survey (Geller 2002), all the homes had clock-controlled garden sprinklers (each with a large external power supply). The survey team did not notice them until after they had finished measuring four of the five homes. Other frequently overlooked devices included security systems, HVAC controls, garage door openers, and exercise equipment. Ideally the sum of their measurements is compared to the consumption shown on the utility meter when all appliances have been switched "off" (Ross and Meier 2000). This provides a means of confirming that no appliances were overlooked, but it is often difficult to accomplish this external verification without inconveniencing the occupants.

Several surveys, such as those undertaken in China, Canada and Denmark, focused on the large appliances—TVs, VCDs, computers, etc.—and ignored the smaller sources of standby power use. These omissions and oversights mean that actual standby power use was larger than reported. A recent Danish study, for example, found an average of 15 products with standby which drew 73 W per home (Gudbjerg 2005). However, this study measured only office equipment and home entertainment devices; the unmeasured appliances—such as white goods and communications products—could have easily contributed another 20 W per home.

Similar studies of standby do not exist for commercial and industrial buildings. One reason is that definitions of standby power and low-power modes still require standardisation. For example, should the power use of exit lights, servers, elevators and battery chargers for emergency lighting be included? Power use while in sleep mode is also more important in commercial buildings because office equipment is present in larger quantities.

In Belgium, De Groote (De Groote 2001) studied five office buildings. He found that standby was responsible for about 10 to 15 kWh/m^2 of office space. De Groote claimed that the standby equalled about half the total electricity consumption of the best designed new office buildings in Europe. Some of this power use was certainly caused by equipment in their sleep mode (and perhaps some by equipment still in active mode). In Japan, Nakagami (Nakagami 2001) reported that standby was responsible for 10% of total electricity use in one commercial building that his team monitored. Considerable indirect evidence suggests that standby is significant in commercial buildings. For example, a study by the Danish Electricity Saving Trust (Gudbjerg 2005) found that night-time electricity consumption ranged from 11 to 37% of daytime consumption. Much of this is a result of ventilation, servers, night lighting, etc., but clearly some part of the consumption is caused by standby power use. Webber et al. (Webber et al. 2001) performed "night audits" of ten California office buildings. They counted the number and observed the activity modes of the major types of office equipment during the night. Standby power intensity was about 0.7 W per square metre. This intensity is roughly equal to that observed in residences. Their survey found that a large fraction of the equipment never entered the standby mode (because it remained in sleep or active modes during the night).

Measurement activity of standby appears to have fallen in the last few years, especially for whole-buildings. Some of the activity has shifted to cover the broader range of low power modes.

TRENDS IN STANDBY CONSUMPTION

There have been insufficient measurements to determine if standby power use is increasing or decreasing. This uncertainty is a result of several conflicting trends whose net effect is difficult to estimate and because there have been few carefully-controlled long-term studies. Manufacturers have successfully cut standby power use in some important products, notably TVs, computers, and audio equipment. Typical standby levels for new TVs are now below 1 W, down from over 5 W less than ten years ago. In addition, the widespread conversion to switch-mode power supplies in portable electronic equipment has certainly cut standby in those products. On the other hand, the number of products with standby continues to increase rapidly. The Danish study (Gudbjerg 2005) found that the number of products with standby in each home had increased from about 7 in 1999 to over 15 (and probably over 20) in 2005. The actual consumption rose from 300 kWh/year to over 600 kWh/year.

For an increasing number of networked and communications products, the standby consumption is not relevant because they operate most of the time in a higher-power mode (sometimes known as sleep, idle, passive standby, etc.) but still not in an active mode. Standby power consumption as defined by IEC 62301 will have decreased but energy consumption in all low-power modes will have increased. The proportion of time spent in the different modes will depend on the software settings and user behaviour. For this reason, many researchers have advocated focusing on energy use of all low power modes (or "lopomos") rather than only the lowest power mode.

A new trend in standby is the electricity consumption caused by equipment that is built in or "hard-wired". New building codes in North America (and elsewhere) establish minimum requirements for smoke detectors, circuits to prevent electrocution, and other sensors. Many of these components have small, but significant, standby power consumption. New homes are also frequently equipped with security systems, routers, and various remote-controlled doors and shades. These hard-wired standby devices can draw over 70 W before the house is even occupied (Nordman 2005).

From a global perspective, standby power consumption is unquestionably increasing because consumers in the large, developing countries, such as China and India, are still rapidly acquiring products with standby. China alone will probably install 200 million set-top boxes in the next five years, each drawing at least 5 W in standby mode. In the developed countries, electricity consumption in all low power modes is certainly rising—rapidly—and standby is probably still rising.

Recent Actions to Reduce Standby Power Use

At least ten separate programmes are under way around the world to reduce standby power. Table 1 lists government-sponsored programmes and Table 2 lists other voluntary programmes. These programmes together address standby in over 30 different products (shown in Table 3). The actual number of products, however, is somewhat arbitrary because of the increasing ambiguity of categories, especially with the rise of "multifunction" devices for audio, video, and printing services and because external power supplies are components for hundreds of products.

In spite of all this activity, only one country—Japan—currently has mandatory limits on standby[4]. These limits are part of Japan's TopRunner programme and only apply to TVs and VCRs. TopRunner does not specify a maximum standby level; instead the regulation establishes a ceiling on annual energy use, assuming a certain number of operating hours in active and standby modes. Thus, standby is regulated implicitly rather than explicitly (but still forces manufacturers to reduce standby). The regulations will probably be extended to cover digital TVs in 2006. (Table 4 summarises upcoming regulations.)

Australia will be the first country to establish explicit mandatory standards for standby. In 2006, standards for external power supplies, TVs and digital set-top boxes go into force. In 2007, the standby power consumption of other consumer electronics products will also be regulated. Australia plans to revise test procedures to capture standby consumption in wet goods, TVs and monitors. Then it will establish maximum energy consumption limits on TVs (2006), computers (2007) and monitors (2007) and require labels on wet goods to include standby information.

California's mandatory programme, covering external power supplies and a range of consumer electronics, goes

Table 1. Recent government programmes addressing standby power use.

Region and Agency	Year*	Action Related to Standby
Australia Australian Greenhouse Office	2000+	Mandatory and voluntary measures for consumer electronics, office equipment, and external power supplies.
Korea Korea Energy Management Corporation	1999+	Voluntary measures covering at least 18 products, with goal of achieving 1 W by 2010.
United States Federal Energy Management Program (Department of Energy)	2001+	Executive Order on Standby. Covers consumer electronics, office equipment, microwave ovens and room air conditioners. Goal is to reduce standby to 1 W where cost-effective.
United States and Canada Department of Energy and Natural Resources Canada	2004	Dishwasher test procedure revised to incorporate standby for display in energy use label (but not in standard).
United States Environmental Protection Agency	2000+	Energy Star for consumer electronics.
United States Environmental Protection Agency	2004+	Energy Star for office equipment.
California California Energy Commission	2004+	Title 20, California Code of Regulations, covers audio and video products, external power supplies.
Japan Ministry of Economics, Trade and Industry	1998+	TopRunner programme, The annual energy use of TVs, VCRs, computers and some other products are regulated, including periods of operation in the standby mode.
China China Energy Certification Product	2001+	Voluntary labelling programme for TVs, VCRs and other consumer electronics covering standby.
Europe European Commission	1997+	Code of Conduct for external power supplies, digital TVs and broadband equipment.
* A "+" symbol after the year indicates when programme began but expansions or stricter levels have taken place since then.		

Table 2. Recent non-government programmes addressing standby power use.

Name	Year*	Action Related to Standby
Group for Energy Efficient Appliances	1996+	Energy efficiency criteria for a wide range of appliances, consumer electronics, and office equipment. Many criteria include standby power limits.
Blauer Engel	1978+	Mostly follows GEEA or Energy Star specifications but includes standby for clothes washers and dryers.
Nordic Swan	1989+	Mostly follows Energy Star specifications for consumer electronics and office equipment.
International Energy Agency	2004	Identified a standby level in set-top boxes that would be suitable for international harmonisation.
* A "+" symbol after the year indicates when programme began but expansions or stricter levels have taken place since then.		

4. Korea established an explicit limit on standby power consumption and then only for one product, mobile telephones. Curiously, this regulation was established in 2001 to address a perceived hazard of exploding batteries rather than to conserve electricity. The measurement is made after the battery is fully charged so it is not standby as defined by IEC 62301.

Table 3. Appliances whose standby power consumption is addressed by regulations, labels or voluntary programmes listed in Tables 1 and 2.

TVs	Fax machines	External power supplies	Mobile telephones
VCRs	Microwave ovens	Computer displays	Ceiling fans
Audio products	Room air conditioners	Rice cookers	Video game consoles
DVD players	Cordless telephones	Battery chargers	
Set-top boxes	Broadband modems	Toilets (bidets)	
Computers	Dishwashers	Scanners	
Printers	Clothes washers	Intercom systems	
Copiers	Clothes dryers	Heaters (fuel)	

Table 4. Upcoming regulations to limit standby.

Region	Year	Products Covered
Australia	2006-2008	Explicit coverage: external power supplies, digital set-top boxes, home entertainment Implicit coverage: TVs, computers, monitors Labels: wet goods
California	2006-2008	External power supplies, digital TV adapters, compact audio, DVD players
Japan	2006	Implicit coverage: digital TVs
Korea	2010	Explicit coverage for at least 18 consumer products

into force between 2006 and 2008. Then, in 2010, Korea's voluntary programme becomes mandatory. The Korean standards will cover all 18 products presently covered in the voluntary programme (though more products may be added).

Standby is being addressed by several voluntary programmes, each with a different strategy. Energy Star and the Executive Order seek to encourage low-standby products by offering endorsements or the lure of government procurement orders. The Code of Conduct negotiates levels for specific products with manufacturers. Both the Executive Order and the Code of Conduct have influenced standby levels for the products that they cover. The Executive Order probably has had a greater impact because it is linked to US government purchasing specifications. However, its future impact will be limited because the specifications for many of the products are already close to 1 W–the goal set by the Executive Order—and because the range of products is confined to those widely purchased by the government. In contrast, Energy Star and the Code of Conduct have no specific standby target and cover more products, so these programmes are likely to further influence the efficiency of new products.

The most notable development in 2004 has been an international agreement on specifications for external power supplies. Several countries have agreed to harmonise test procedures and efficiency specifications for external power supplies—a key component for virtually every product drawing standby power—which includes both a no-load "standby" specification and an active-mode "efficiency" specification. These countries, including Australia, the United States, China and Europe—are now in different stages of implementation. This agreement will have a worldwide impact because both California and Australia will make these specifications mandatory and because many international manufacturers design their products to comply with the strictest mandatory specification. Any product using a more efficient power supply will have lower standby; as a result, the number of products affected by government standby policies will soon be many times larger.

In 2004, the International Energy Agency (IEA) co-ordinated actions related to cut energy use of set-top boxes. This initiative targeted all power modes, but reducing standby received high priority. Several countries agreed to jointly study the feasibility of a specification based on 8 W active and 1 W standby[5]. This agreement has already been translated into voluntary and mandatory specifications in several regions.

Several countries and regions are considering standby regulations. The European Union may use the proposed Directive for Energy Using Products to regulate standby. A recent conference (Action on 1 Watt, 2005) examined various aspects of possible legislation. Several states in the United States are considering legislation modelled after the California regulations. Finally, the United States as a whole is considering legislation covering standby, although its approach and scope has changed dramatically in different drafts.

To date, most regulatory authorities have maintained a list of products covered by their standby specifications or regulations. (The Korean list is the longest, consisting of 18 products.) This strategy makes sense for a small number of products but becomes unwieldy as the number of products covered increases. In addition, the products are rapidly evolving, converging, combining and splitting, so it is difficult to maintain legally adequate definitions of them. For these reasons, a "horizontal" standard for standby has been proposed. The horizontal standard would require all products, regardless of features, to meet the same standby requirement. Some products will need to be exempted, so the legislation would presumably include a procedure to temporarily exempt them. For example, any product covered by minimum efficiency standards and relying on an energy test

5. They also agreed to examine the feasibility of a requirement that the set-top boxes switch to standby with a simple command from the remote control.

procedure that captures standby might be exempted. (This would automatically exempt refrigerators in most countries and dishwashers in the United States.) At least two entities, the European Union and the United States, are considering legislation containing a "horizontal" approach to limiting standby. The regulations for external power supplies are effectively a horizontal standard because they affect all products connected to them.

Programmes dealing with standby are often administratively separate from those dealing with energy efficiency or active modes of the same products. In the United States, the Executive Order on standby is administered by the Federal Energy Management Program inside the Department of Energy (USDOE), while Energy Star (inside the Environmental Protection Agency) administers the efficiency specifications of office equipment and consumer electronics. A third office inside the USDOE administers the mandatory efficiency standards for appliances. The California Energy Commission will soon administer standby regulations for some products whose other efficiency characteristics are administered by the federal government. In Korea, different offices of the Korean Energy Management Corporation (KEMCO) manage the standby and efficiency aspects of the same products. In Europe, the voluntary agreement pertaining to TVs and VCRs deals only with standby. Since 1999, TopRunner treated standby and other modes in an integrated manner for TVs and VCRs. More recently, Energy Star adopted an integrated approach for new specifications in office equipment and consumer electronics which will capture energy use in all power modes. These arrangements reflect the unusual history of standby power and government policies to reduce it but they greatly complicate an integrated approach to reducing energy use of the products. One drawback of the horizontal standard for standby is that it will reinforce the separation of standby from other low power modes and active modes.

Conclusions

Numerous measurement campaigns around the developed world have shown that standby power ranges from 60 to 110 W per home, which corresponds to about 4-11% of residential electricity use. The estimates for Europe, Australia and Japan are reasonably accurate because they are based on large groups of homes. The situation is less clear for North America and for many developing countries, such as India. Few measurements of standby exist for commercial and industrial buildings; however, the intensity of standby consumption in these buildings is probably similar to that observed in homes, that is, around 0.7 W per square metre. Further measurements in commercial and industrial buildings would be useful to confirm this rule of thumb.

None of the measurements are extensive enough to indicate if standby power consumption is increasing or decreasing. Anecdotal information suggests that residential standby consumption is growing, probably because homes have acquired so many more products with standby. In general, the standby problem has expanded to energy consumption in all low power modes.

Programmes dealing with standby power are poised to change dramatically as activities shift from voluntary to mandatory. The impact of mandatory limits in California, Australia, Korea and Japan will be felt in other regions. Pending legislation in Europe and the United States (as well as in individual American states) may further shift attention from voluntary programmes to mandatory limits on standby. To date, the standby programmes—both mandatory and voluntary—have dealt exclusively with standby, leaving other agencies to address lopomo energy use. The concept of a horizontal standard for standby and the recent specifications for external power supplies have reinforced this administrative approach. A horizontal approach may be simpler to establish and administer but, in the long run, an integrated approach, capturing energy use in all modes, will be needed.

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