STANDBY POWER CONSUMPTION OF DOMESTIC APPLIANCES IN SOUTH AFRICA

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ABSTRACT

South Africa's demand for electricity will exceed Eskom's peak installed capacity by 2007. The all important Demand-side management (DSM) techniques employed also focus on the domestic sector. One area that has not been investigated adequately are the losses due to the standby power. It refers to the small amount of power consumed by an appliance, even when it is not in use. Many appliances are controlled remotely and cannot be switched off completely, unless they are unplugged. The purpose of this paper is to estimate how much power is wasted in South Africa due to household appliances being in the standby mode.

1. INTRODUCTION

According to Edlington and Marker [1], standby power has become of growing global concern over the past decade. Research conducted in 2001 has revealed that standby power consumption accounts for nearly 12% of Australia's household electricity usage. These losses amount to $500 million and are generating more than 5 million tons of carbon dioxide per annum.

Any modern household, also in South Africa, includes a proliferation of electronic devices, which are consuming electricity even when they are switched "off". There are several names for this category, including "standby use", "minimum use", and "leaking electricity". While "standby use" is technically more accurate, the expression "leaking electricity" is rapidly gaining popularity because it is easier for the general public to understand [2], [3].

Leaking electricity is a global phenomenon. The biggest culprits are internationally traded appliances, such as audio/visual equipment. Many other appliances also consume electricity while in the standby mode namely air conditioners, washing machines and microwave ovens. Many of these appliances are virtually identical in all countries because only a few, large, multinational companies manufacture them and as a result, data collected in one country often applies to the others as well.

2. ELECTRICAL POWER WASTAGE IN SOUTH AFRICA

2.1 SITUATION ANALYSIS

The demand for electricity in South Africa is increasing due to economic growth and the electrification of previously disadvantaged communities. Figure 1 shows how the percentage of the population with access to electricity has increased from 61.3% in 1995 to 84.9% in 2004. If no new generating capacity is added, Eskom will be unable to meet the peak demand by as early as 2007. The problem would then continue to get worse and by 2010 Eskom will not be able to meet the demand in some areas during off-peak times [4].

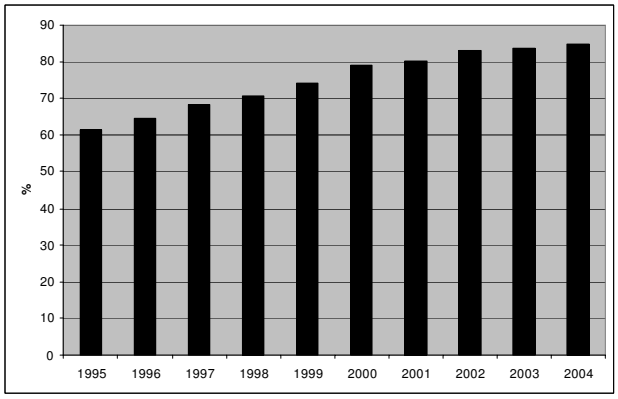

Figure 1 Percentage of population that have access to electricity [5]

In the past it would have been simple to solve the problem of increased electricity demand by simply building more power stations. Each power station does, however, have an impact on the environment. Coal, natural gas and oil fired power stations produce high levels of CO_2 , the gas primarily responsible for producing the green-house effect. Nuclear power stations produce no such emissions, but instead produce radioactive waste products that need to be handled and stored carefully. Even power stations that produce no waste or emissions, for example hydro-electric stations, have an environmental impact. The flow of rivers, for example, are affected and dams have to be constructed. This damages wildlife habitats. Besides the environmental issues, power stations are costly and typically take 10 to 12 years to construct. Simply building more power stations is therefore not the solution. As part of the DSM programme, South-Africans must be encouraged to use electricity sparingly and more effectively.

2.2 GOVERNMENT REACTION

South Africa has to take into account two potentially conflicting objectives when it comes to electricity production:

2.2.1 International Objectives

South Africa subscribes to the Kyoto Protocol, which advocates the worldwide reduction of CO_2 emissions.

The Protocol set the quotas to decrease the emission of greenhouse gases. This makes the option of using additional coal fired generating capacity unlikely.

2.2.2 National Objectives

One major objective since 1991 is to provide electricity to previously disadvantaged communities. This increases national energy demand. Since constructing more power stations is not an immediate option, the only remaining option is to make better use of the existing electricity generating infrastructure. This can be achieved by encouraging reduced or more effective electricity consumption and stricter regulations on the efficiency of household appliances. These are finally to be regulated in future by an energy efficiency labelling system [6], [7].

2.3 ESKOM REACTION

Eskom has begun to tackle the problem of increasing consumer demand for electricity by introducing Demand-Side Management (DSM). DSM means the planning, implementation and monitoring of end-user's activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand.

The prime objective of DSM is providing constant, efficient use of electricity. The result is lower demand for electricity during peak times, thus managing the consumer electricity demand effectively [8].

Eskom formally recognized DSM in 1992, and its' first DSM plan was produced in 1994. Since then Eskom has spearheaded many DSM initiatives nationally and continues to lead the way in promoting the efficient use of electricity. Eskom has made DSM a priority [8] and this includes the reduction of standby power consumption.

3. TYPES OF PASSIVE POWER USAGE

The following types of wastage occur :

3.1 STANDBY POWER WASTE

When you turn off a VCR or TV with a remote control, it continues to consume energy in the standby or sleep mode because the power supply inside is still "on", powering the remote control receiver. Even though the remote control receiver consumes very little power (approximately 0.1 W), power supplies that use inefficient technology such as linear transformers, are not smart enough to reduce consumption during the standby state and end up wasting several watts of power. This is what we refer to as standby power consumption or power waste.

3.2 NO-LOAD POWER WASTE

No-load power waste is a subset of standby power waste. No-load power is the energy used by a device when it is disconnected from its load and performing no function. For example, a cell phone charger that is plugged into the wall, but not connected to the phone will still consume power. This power is often dissipated as heat and makes the charger warm to the touch.

4. SOUTH AFRICAN APPLIANCE PURCHASE AND USAGE PATTERNS

Electric hot-water cylinders (geysers), stoves and refrigerators are the largest energy consumers in local households. In contrast, devices like television sets consume relatively little energy. This project does not focus on the efficiency of appliances or how much electricity they consume during normal operation, but rather how much they consume when they are 'off' or in the standby mode. It is therefore necessary to define the areas of focus and the reasons for those choices.

The energy usage pattern of the typical South African household has changed over the past 10 years mostly due to increased electrification. In a study performed on two newly-electrified settlements it was found that the biggest growth with regards to the purchase of new appliances was experienced in the refrigerator, television and hi-fi categories [9]. The most popular appliance being the television set.

Measurements performed by Eje Sandberg of Sweden showed the three worst appliances with regards to standby power consumption to be Video Recorders, Satellite Receivers (Cable Boxes), Television sets and mini Hi-Fi equipment.[10]. This research therefore focuses on television sets, DVD Players, Video Recorders and mini Hi-Fis.

In order to calculate how much of the total electricity demand in South Africa is due to "standby use", it is necessary to know how many of the offending devices are in use, and also how long these devices spend in the standby mode.

In Table 1 the number of specific types of audio/visual equipment present in South Africa are shown

Table 1 Audio/visual devices present in the South African home in 2004. [5]

Type of Device	Number Present
TV	7 220 000
Hi-Fi	5 872 000
VCR	3 133 000
MNET/DSTV Decoder	927 000
DVD Players	903 000

The average South African spends approximately 14.8 hours per week watching broadcast television [11]. If one were to assume that the television set is also used for 14.8 hours per week to watch DVD or video, this means that the average television is in use for 29.6 hours per week. One week is 168 hours long. This would mean that television sets are in standby for 82% of the time. Weekly DVD/VCR usage would also be 14,8 hour per week. This equates to DVD/VCRs being in standby 91% of the time. It is not known how long mini Hi-Fis spend in standby mode neither were any assumptions made in this regard.

The above figures will be used for all calculations in the remainder of this research.

5. METHODOLOGY

To confirm the consumption figures of appliances, direct measurements of the current consumed by each appliance type was done while in normal operation and standby modes. For the purpose of this investigation, the consumption of an appliance was measured at the power socket outlet (pso). For this purpose, a Fluke 43 Power Quality Analyser and Fluke 80i-110s AC/DC Current Probe were chosen

Although the Fluke 80i-110s current probe is capable of measuring very small currents, its accuracy does drop when very small currents are being measured.[12] In order to improve the accuracy, a toroidal coil was constructed, as shown in Figure 2.

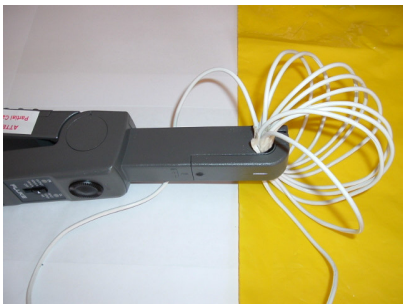

Figure 2 Construction of toroidal coil and use with the Fluke 80i-110s current probe

Current from the load is passed through the coil. The current probe is then clamped around the coil during measurements. This multiplies the current in the probe jaws by a factor of 10. Using this method improves accuracy by providing a more substantial current for the probe to measure. This means that if an appliance is using 100mA of current, the probe will see 100mA x 10 = 1A. To correct for the presence of the 10-turn coil, the Fluke 43 was set to use a 1V/A (Volt per Ampere) probe whenever the current probe was set to its 100mV/A range. The Fluke 43 was set to use a 100mV/A probe whenever the current probe was set to its 10mV/A range.
This means that with the probe set to its 100mV/A range and the Fluke 43 to use a 1V/A probe an accuracy of <0.3% of reading + 5mA can be expected [12]. A piece of 2-core cable was placed between the device to be measured and the pso. Inserted into one of the conductors of the 2-core cable is a 10-turn toroidal coil. During measurements the coils were fanned out as shown in Figure 2. The jaws of the current probe were clamped over the coil. For power measurements the Fluke 43 also requires a voltage pickup.

All measuring equipment was calibrated and tested for accuracy by Eskom at the current range anticipated before the commencement of this investigation.

6. RESULTS

The measured power consumption of new TV sets, VHS video recorders and mini Hi-Fi's, respectively are shown Tables 2 to 5.

Table 2 Power consumption of Television sets

Screen Size	Model	On (Watt)	Standby (Watt)
137 cm	Samsung SP54T8	206	2.9
111cm	LG RT44NA21T	208	10.5
106cm	LG MT42PM12	265	3.8
84cm	Sony KV-XA34	125	1.1
	Samsung 3426	131	2.5
74cm	Sony KV-SR29	120	1.4
	Panasonic 29FJ20	82	1.2
	Samsung CS29Z6	185	1.8
	Philips 29PT7322	114	1.3
64cm	Sony KVSW25	75	1.2
	Philips 25PT4323	53	1.2
	Tedelex EC2559	75	3.2
54cm	Sony KVHW212	53	1.0
	LG CT20F95M	58	7.1
	LG 20J 50/55	58	11.6
	LG 21CB55	60	8.0

Table 2 shows the power consumption levels as measured for new television sets. It can be seen that the consumption during standby operation does not vary much, with most sets using between 1 and 3 Watt of power during standby. The highest standby power consumption was in the 54cm and 111cm categories noticeably by television sets manufactured by LG.

Table 3 Power consumption of DVD players

Type	Model	On (Watt)	Standby (Watt)
DVD player/VHS	LG V872 NWK	13.9	3.2
DVD/HD Recorder	LG 7624 W	26.1	1.6
DVD player/VHS	Samsung DVD-V5500	13.7	6.1
DVD Player	Samsung DVD P450	9.5	0.7
DVD Player	Samsung DVD P250	7.1	1.1
DVD Player	Sanyo DVD-SL38KR	6.1	4.6
DVD Recorder	Sony RDR HX710	29.2	5.0
DVD Player	Sony DVP-NS52P	6.6	0.2
DVD Player	Sony DVP-NS50P	6.7	0.2
DVD player/VHS	Tedelex TE800DV/VCR	15.7	5.0
DVD player/VHS	Telefunken TDV3000(A)	14.8	5.4
DVD Player	Yamaha DVD S540	8.7	0.75

Table 3 shows the power consumption levels as measured for new DVD players, DVD/VHS combinations and DVD recorders. The standby power consumption of DVD players was extremely low, with most players consuming between 0.2 and 1.1 Watt during standby. One exception was a DVD player from Sanyo, which consumed 4.6 Watt during standby. Overall, DVD recorders and DVD/VHS combination players consumed more power during standby than DVD players.

Table 4 Power consumption of VHS video recorders

Model	On (Watt)	Standby (Watt)
Akira VCR S608(S)	7.8	2.0
Panasonic NV-MV21	7.6	3.8
Telefunken TVCR610(B)	8.0	2.9

Table 4 shows the power consumption levels as measured for new VHS video recorders. Only three recorders were available for measurement with their standby power consumption not varying much between recorders.

Table 5 Power consumption of Mini Hi-Fi's

Model	On (Watt)	Standby (Watt)
Denon UDM 31	15.3	0.9
JVC MX-JE31	22.8	17.4
Panasonic SA-AK330	22.8	0.6
Panasonic SA-AK630	24.8	0.6
Panasonic SA PM91D	23.2	0.6
Philips FWD M35	18	13.9
Philips FWD 570	32.5	1.5
Samsung MM-C8	21.8	9.6
Sanyo MP8000	14.2	1
Sanyo PT85	6.4	3.3
Sanyo DC088	22.8	12.9
Sony MHC-RG575S	25.7	17.8
Sony MHC-RG170	22.8	17.4
Technics SH-EH590	34.7	0.5

Table 5 shows the power consumption levels as measured for new mini Hi-Fi equipment. In many cases there was little difference between the amount of power used during normal operation and during standby. The best performers were from Panasonic who used less that 1 Watt of power during standby. Other devices namely from Sony, Philips and JVC performed poorly.

7. ANALYSIS OF RESULTS

Having established the individual power consumption value of each chosen appliance, the generic ranges may be presented as shown in Figure 3.

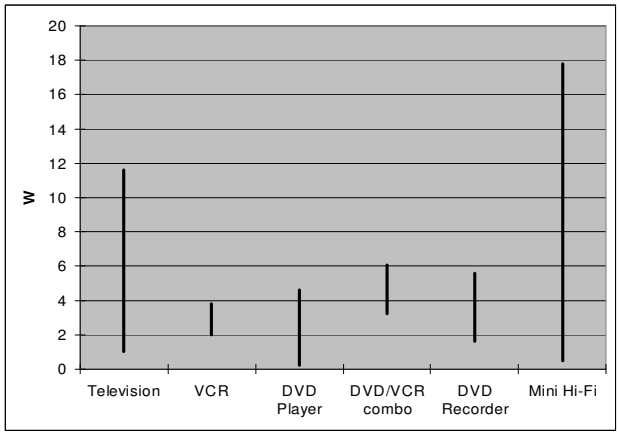

Figure 3 Range of standby power consumption for each type of appliance in watt

According to Figure 3, television sets and Hi-Fis are some of the worst offenders when it comes to standby power use.

This confirms measurements performed by Eje Sandberg. [10]. The large range of standby consumption for televisions is due to sets with a screen size of 54 and 111cm. The ranges of standby power may be presented according to TV screen size (figure 4) and make (Figure 5).

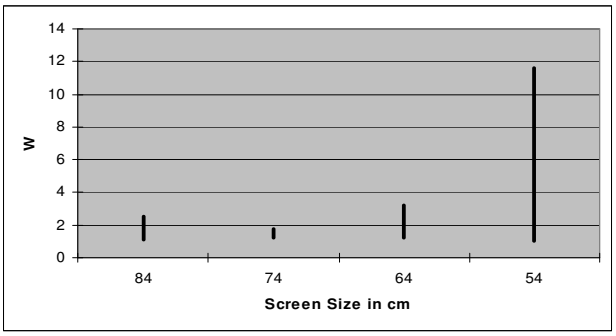

Figure 4 Range of standby power consumption for Television sets ordered by screen size

Figure 4 shows that 54 cm sets have a considerably larger standby power consumption range than sets with larger screens. Since only one 111cm set was available for measurement it was purposely omitted from Figure 4.

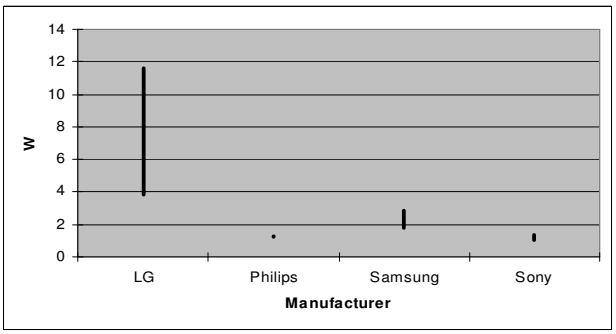

Figure 5 Range of standby power consumption for Television sets ordered by manufacturer

Figure 5 shows that sets from LG had the largest range of standby power consumption of all sets tested. At national level, the ranges of national standby power consumption in Megawatt for each class of device tested, are as shown in figure 6.

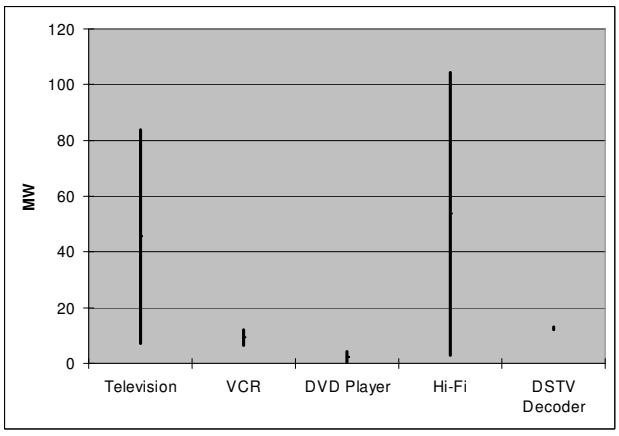

Figure 6 Total range of national standby power consumption in Megawatt

Once again, television sets and mini hi-fi's have the widest range of standby power consumption.

It is estimated that on average television sets in South Africa are in standby 82% of the time and DVD/VCRs 91% of the time. Tables 6 and 7 accordingly demonstrate the estimated amount of electricity used by Television sets, VCRs and DVD Players in the standby mode in one year.

Table 6 Total range of national standby power consumption in kWh/year for two scenarios

Appliance	kWh/year Pessimistic	kWh/year Optimistic
Television (82% standby)	**601 607 366**	**51 862 704**
VCR (91% standby)	**94 905 087**	**49 950 046**
DVD Player (91% standby)	**33 112 432**	**1 439 671**
TOTAL	**729 624 885**	**103 252 420**

Table 7 Total range of national standby power consumption in Megawatt

Appliance	Pessimistic (MW)	Optimistic (MW)
Television	**83.752**	**7.22**
VCR	**11.9054**	**6.266**
DVD Player	**4.1538**	**0.1806**
Hi-Fi	**104.5216**	**2.936**
DSTV Decoder	**12.051**	**12.978**
TOTAL ALL DEVICES	**216.3838**	**29.5806**

Figure 7 Total range of national standby power consumption as a percentage of total national electricity consumption

South Africa consumed 197 400 GWh of electricity in 2003 [13]. Using the data from Tables 6 and 8, the standby range of energy consumed may be calculated as follows :

$$\frac{104}{197400} \text{ to } \frac{730}{197400} \text{ or } \mathbf{0.052\% \text{ to } 0{,}369\%}$$

The standby power losses due to domestic appliances at national level thus lie between 0,05 % and 0,36% of national electricity consumption.

Since the domestic sector constitutes 17,9 % of total power consumed [14], these values translate to a range from 0,9 % to 6,5 % of the total domestic electricity consumption. The worst case is thus approximately one half the value measured in Australia [1].

Table 8 Electricity production, consumption, imports and exports for South Africa (2003) – [13]

2003	GWh
Electricity - production	**215 900**
Electricity - consumption	**197 400**
Electricity - exports	**10 140**
Electricity - imports:	**6 739**

8. CONCLUSION

Although domestic appliance standby mode only accounts for between 0,9 % and 6,5 % of total domestic demand, it does warrant keeping a check on future trends. An additional small saving in national electricity consumption could be realised if audio/visual appliances were designed to consume less power in the standby mode. Consumer awareness of standby power consumption should be increased by launching publicity campaigns or by an energy efficiency labelling scheme by the Department of Minerals and Energy. Further investigation into the reason for the high standby power consumption range of 54cm televisions and mini hi-fis is recommended as these are the most common audio visual devices sold due to competitive pricing in the market.

REFERENCES

[1] Edlington C and Marker T.: "Profiling standby power in Australia" *Proceedings of the 3rd International Conference on Energy Efficiency in Domestic Appliances and Lighting,* Turin, Italy,Vol.1, 1-3 October 2003, pp. 309-314.

[2] Meier, Alan and Huber. Wolfgang: "Leaking Electricity in the USA" *Berkeley Lab (LBNL) USA* 2000, pp1-2

[3] Sandberg, E. "Electronic Home Equipment: Leaking Electricity." *The Energy Efficiency Challenge for Europe 1 (1993)*: European Council for an Energy Efficient Economy, pp 1-2

[4] Goldstone, C.: "Save electricity or face cuts, says city". *The Mercury*, Durban, Feb 9, 2005,

[5] South African Advertising Research Foundation. *AMPS 2004 Report,* pp 7-8

[6] Uken E.: "Energy efficiency labelling of domestic appliances". *Proceedings of the International Conference for the Domestic Use of Energy,* Cape Technikon, Cape Town, October 1993, pp 43-47.

[7] Suprenant L, Wegelin J, Egan C, and Mulholland C..: "Creating relevant appliance labelling campaigns –the results of the South African national telephone and national omnibus surveys". *Proceedings of the International Conference for the Domestic Use of Energy,* Cape Peninsula University of Technology, Cape Town, March 2005, pp 75-79.

[8] http://www.eskomdsm.co.za ESKOM DSM implementation website, last accessed in July 2005

[9] Holtz, WH: "Energy and appliance usage after electrification": *Eskom Distribution* (Cape Town)

[10] Meier A.: "Measurements of Standby Power—A Survey of the International Literature", *Lawrence Berkeley National Laboratory,* August 2002, pp 1-8

[11] GfK NOP (linking the top 10 market researchers in Europe and the US): http://www.nopworld.com/news.asp?go=news_item&key=179

[12] FLUKE: "80i-110s AC/DC Current Probe Users Manual" *Fluke Corporation,* USA

[13] http://www.cia.gov/cia/publications/factbook/

[14] SA National Electricity Regulator: "Electricity supply statistics for South Africa in 2003" *NER Report,* 2003, 50p.

Presenter:
The paper is presented by Albé Bredekamp

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