Domestic appliances end-use efficiencies: the case of eleven suburbs in greater Johannesburg

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Abstract

Results from an appliance survey indicate appliance saturation and penetration levels suggesting a sizeable domestic appliance load. The largest contribution to the domestic load is mainly from universal appliances. Measurement results of appliance power consumption reveal a wide range of consumption levels in appliances with the same functionality. This was observed in all operational modes indicating lower end-use efficiency in most appliances. Appliances that meet the 1 watt standby minimum power consumption are an exception. Domestic demand tariff is an option to cover the cost to the supplier and to reduce significant demand due to apparent power components. The impact of energy inefficient appliances to the consumer and the utility companies is unknown, indicating a need for consumer education and consumer awareness programs.

Keywords: end-use efficiency, appliance saturation levels, appliance penetration levels, universal appliances, power consumption levels, efficiency standards, consumer awareness.

1 Introduction

Energy efficiency is one effective way of increasing energy security by reduction of overall demand for energy consumption. Energy efficiency can be implemented both at the supply and in the end-uses. Supply side efficiencies govern efficiencies in extraction, conversion, transportation and distribution of energy [1]. Efficiencies in end-uses are primarily to do with efficient utilisation...
of energy which is geared towards the reduction of total energy consumption. End-use energy efficiency is the efficient use of final energy or useful energy in industry, services, agriculture, households and transportation. End-use efficiency implies using less energy for the same level of service.

There are four major household electricity end-uses namely, water heating, space heating, lighting and appliances. Of recent, household appliances have come to represent a significant portion of residential energy consumption due to increased number of appliances. The increase in numbers is mainly driven by the increased use of entertainment, information and communication appliances in households. It has been reported that by 2010, set top boxes (STB) could push domestic electronic energy consumption in Europe to be above that of refrigerators and freezers [2]. In addition, Meier writes, “Energy consumption of appliances is too large to be ignored” [3]. The International Energy Agency (IEA) estimates that appliance efficiency policies put in place in the Organisation for Economic Co-operation and Development (OECD) countries between 1990 and 2002 saved 292 TWh of residential electrically demand and by 2010, 393 TWh will be saved [2]. This is a significant saving in energy.

For many years South Africa has enjoyed low electrical energy prices in all demand sectors. The flip side has been an increased use of electricity across all sectors with little concern on dwindling primary energy sources and climate change. However, of late South Africa has witnessed decreasing electricity reserve margins which have led to general load shedding activity. Therefore, South Africa like many other world economies is grappling with issues of security of electricity supply to sustain its economic growth plan.

In recognition of the benefits that would accrue from the introduction of energy efficiency standards and measures, the Department of Minerals and Energy (DME) released an energy efficiency strategy for South Africa in March 2005 [4]. The Energy Efficient Strategy created an environment for standards to be formulated and regulations to be enacted. In the strategy it is stipulated that in the residential sector a reduction in demand of 10% is expected by 2015 [4]. It is expected that the reduction will be realised through thermal insulation of new homes, appliance efficiency, mass education and awareness campaigns [4].

Energy efficiency of household appliances is characterized by efficiencies in consumption of power in all possible operational modes. Standby power consumption forms an essential component of appliance power consumption and the report for project EURECO emphasizes this through the statement: “It is not possible anymore to deal with domestic electricity consumption without an in depth analysis of the standby power issue” [5].

This paper presents full and standby mode power consumption levels of a selection of appliances found in eleven suburbs of greater Johannesburg metropolitan area. A survey was carried out to ascertain appliance saturation ($s$) and a penetration ($p$) levels, a measurement campaign was carried out to establish appliance power consumption levels. In section 2, the general findings of the appliance survey are presented. Section 3 presents the measurement results, and in section 4 a discussion on the measurement results is presented. Section 5 is the conclusion.
2 General survey results

A survey to establish appliance saturation and penetration levels was carried out in 555 households in 11 suburbs of greater Johannesburg metropolitan. The appliances of interest were appliances with standby power consumption capabilities found in the households and included television sets, Hi-fi systems, Digital Versatile Disks (DVD’s), Video Cassette Recorders (VCR’s), microwave ovens, personal computers (PC’s), computer monitors, printers, mobile phone battery chargers (MPBC’s), and digital satellite television (DSTV) decoders.

Appliance saturation level \( s \) is the fraction of households that own a specific appliance in a household sample [6]. The penetration rate \( p \) is the ratio of total number of appliances found in all households to the total number of households in the sample [6]. Where there is more than one appliance in a household \( p \) is greater than 1 and if each household owns only one appliance then the penetration rate is equal to the saturation rate. In all cases, penetration rate \( p \geq s \).

Table 1 presents the saturation and penetration levels obtained for each appliance.

<table>
<thead>
<tr>
<th>Appliances</th>
<th>Saturation rate((s))</th>
<th>Penetration rate((p))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Television</td>
<td>0.96</td>
<td>1.84</td>
</tr>
<tr>
<td>MPBC</td>
<td>0.88</td>
<td>2.38</td>
</tr>
<tr>
<td>Microwave</td>
<td>0.87</td>
<td>0.93</td>
</tr>
<tr>
<td>DVD</td>
<td>0.67</td>
<td>0.81</td>
</tr>
<tr>
<td>VCR</td>
<td>0.60</td>
<td>0.67</td>
</tr>
<tr>
<td>Hi-Fi</td>
<td>0.60</td>
<td>0.78</td>
</tr>
<tr>
<td>PC/Monitor</td>
<td>0.54</td>
<td>0.65</td>
</tr>
<tr>
<td>DSTV</td>
<td>0.41</td>
<td>0.42</td>
</tr>
<tr>
<td>Printer</td>
<td>0.35</td>
<td>0.4</td>
</tr>
</tbody>
</table>

From table 1 it is clear that there are sufficient numbers of appliances in the household to substantiate a need to look into the appliance load. In 2007, there were a total of just over eleven million households in South Africa implying that indeed the appliance numbers are large [7].

The appliances of interest to this paper are some of what we have coined and defined as ‘universal appliances’. These are appliances common to all suburbs and have saturation levels of 40% or more in all suburbs [6]. These become appliances of interest because they represent large numbers of appliances across the household sample.

3 Power measurement results

Power consumption measurements were done in all operational modes found on an appliance. At any point in time an appliance can be in any of the following
operational modes: Off, active/on, standby active, standby passive, or in other low power modes [8]. The Yokogawa WT210 digital power meter was used for the measurements because it is specifically made to measure up to very low power levels [9]. Instantaneous measurements were recorded for: Real power, active power, apparent power, power factor, peak voltage and current as well as root mean square voltage and current.

Wide range of power consumption levels were observed in all operational modes and were characteristic in all appliances. The expectation that two appliances with the same technical attributes would exhibit comparable power consumption levels was not met.

3.1 Cathode ray tube television sets

Different cathode ray tube television sets with different screen sizes were found in the households. It was expected that power consumption levels would be different across different screen sizes, but there were also variations within same size screen sizes as seen in Figure 1 and figure 2. Figure 1 presents the power consumption levels in active/on mode.

From figure 1 it can be seen that there are visible differences in power consumption levels of the different 72 cm screen sizes, but there is also the case where different screen sizes exhibit comparable power consumption levels. Figure 2 presents the standby power consumption levels found in different cathode ray tube television screens.

![Figure 1: Active/on power consumption levels for CRT TVs [11].](image)
Figure 2: Standby mode power consumption levels for CRT TVs [11].

From Figure 2 it is evident that most of the television sets had standby passive real power consumption of more than 5 Watts. The lowest power consumption level advocated for in standby passive mode is the 1 watt and none of the TVs met this standard [10]. The highest standby power consumption level was recorded to be 14.88 Watts a level almost 15 times higher than the lowest 1 Watt level.

The introduction of non-linear electronic loads in households makes it necessary that reactive and apparent power components are also examined. The levels of apparent power in both active/on and standby passive mode as seen in figure 1 and figure 2 are relatively high. The high levels of apparent power are backed by poor power factors recorded for television sets [11]. This indicates that the cost to the supplier of maintaining the standby function cannot be ignored.

3.2 Hi-Fi systems

Figure 3 presents the real power consumption levels in active/on and standby passive modes in Hi-Fi systems.

All ten Hi-Fi systems presented in figure 3 are mini Hi-fi’s made up of compact disk (CD), tape recorder/player and a tuner. System 7 and 10 have standby real power consumption levels of below 2.5 Watts and the rest of the systems have standby power requirements of more than 4.5 watts. In active/on mode the real power consumption levels vary between a minimum of 5.1 Watts
and a maximum 57.4 Watts. What causes these wide variations in power consumption levels especially when the basic functionality is the same across all ten units? These different power consumption levels in these appliances are locked in for the whole life cycle. In most cases, the decision to purchase a new appliance locks in the power consumption levels for the life cycle of the appliance. In figure 3 it is also evident that appliances with lower power consumption levels are beginning to find their way into the households.

![Figure 3: Hi-Fi systems real power consumption levels [11].](image)

### 3.3 Personal computers

Measurements on personal computers were done in the following operational modes: Active/on, standby passive and soft off. In soft off mode the personal computer is switched off at its power switch physically or by mouse action that prompts the PC to shut down. Detailed power consumption levels in standby passive and active mode have been reported [11]. Of interest in this paper are the soft off power consumption levels presented in Figure 4.

As seen in Figure 4, the soft off real power consumption levels range between 0.6 Watts and 4.7 Watts. The power switch on the PC does not switch off the PC completely, instead it takes the PC to a lower power mode! The question is “Is this knowledge trivial to all the PC users?”
The soft-off levels recorded fall within the standby power levels of Hi-Fi and in terms of energy consumption it can be assumed that every PC in soft off mode becomes a mini hifi in standby mode. In 2006, the total number of PC’s in South Africa was reported to be 5.3 million [12]. If growth is factored in this figure to determine the power losses due to PC’s in soft off the result is large losses. The case of PC soft off mode power consumption levels brings to light issues of consumer education and highlights the severity of the power losses that can occur.

4 Discussion on findings

Three major observations are apparent from the power measurements namely:
- Wide range of power consumption levels in all operational modes
- Lack of Consumer awareness
- Lack of a feel of how much does it costs?

4.1 Wide range of power consumption levels

Differences in power consumption levels can be associated to different design philosophies resulting in mixed efficient levels in terms of power consumption. Where energy efficient standards have been adopted either as mandatory or optional standards there has been reported declining standby and active/on power...
loads. However it is also probable that in countries where there are no appliance energy efficient standards, these countries become dumping grounds for unwanted appliances.

Standards are crucial in eliminating non-compliant appliances from the stock of appliances so that they cannot find their way into households. Currently the process of putting in place appropriate standards is on course in South Africa, and until the process is complete and regulations are enforced, the presence of appliances such as these will not cease!

Manufacturers have introduced eye catching displays that accompany appliance operation especially in audio equipment. Depending on the display implementation the increase in power consumption levels due to the displays can be large and cause considerable differences in a group of appliances. The displays are manufacturers’ attempt to improve on the aesthetics of the appliances to directly affect the consumer’s decision to buy. To what extent should such added functionalities be allowed with no regard to total power consumption of the appliance? Is there a need that energy efficient standards should also cover the maximum allowed power consumption of added functionalities?

4.2 Lack of consumer awareness

Appliance labels are one of the tools used to inform consumers on possibility of savings on power consumption by making appliance power consumption levels available at the point of purchase. The positive impact of consumer awareness on household energy consumption has been established and therefore, energy labels cannot be ignored [13]. There is a good probability that if consumers have the knowledge on possible power savings appliances, then appliances large power consumption levels would not land in their homes given the fact that other appliances with almost half the power consumption levels do exist and perform the same functionality! Consumer awareness is crucial to laying the basis for consumer decision to purchase energy efficient appliances. In South Africa, appliance labels remain a good intention as their implementation is yet to become a reality!

Appliances with soft off capabilities bring about a different aspect of consumer awareness. In most ordinary appliance users minds, the use of power switch is to completely switch off the appliance especially when there are no power indicators e.g. a small lit LED. PC’s do not have indicators in soft off mode maybe it is an attempt to reduce the soft off power consumption level. However, to many ordinary users, the knowledge is “an appliance power switch switches off the power completely and the power consumption is zero”. This is not the case in soft off modes. There is a need to inform the ordinary user to completely switch off the PC at the power plug when the PC is not in use for long period of time e.g. overnight, over a weekend, or during extended absences.

Appliance retail store advertisement magazines could for example be used to include energy consumption information in all operational modes as an initial step to create consumer awareness. Special ways could be devised to make the information portrayed easier to understand. This could be an effective way of
disseminating appliance energy efficient information to allow consumers to make an informed appliance purchase decision.

The concept of Energy star computer monitors can easily be extended to cover cathode ray tube television screens. In developing countries, CRT TVs will continue to be in use for a foreseeable future mainly because of the price tag they carry compared to LCD and Plasma TV screens. Furthermore, from a power consumption point of view, plasma and LCD TV screens exhibit much larger real and apparent power consumption levels in active/on mode when compared to CRT TVs.

4.3 Lack of a feel of: “How much does it cost?”

The amount of apparent power levels required to support appliances found in the households are presented in table 2. The total demands per household in active/on and standby passive modes i.e. the cost to the supplier of maintaining the appliances in their respective operational modes is also presented in table 2. Unfortunately the total demand is not known by consumers and may be not yet quantified by power utility companies. Although not all households own all the appliances, the saturation and penetration levels found in the sample suggest that the figures represent an appreciable demand.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Active/On (VA)</th>
<th>Standby Passive (VA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave Ovens</td>
<td>1390</td>
<td>3.74</td>
</tr>
<tr>
<td>CRT TVs</td>
<td>317.25</td>
<td>15.2</td>
</tr>
<tr>
<td>PC’s</td>
<td>132.22</td>
<td>67.83</td>
</tr>
<tr>
<td>PC Monitors</td>
<td>77.85</td>
<td>9.06</td>
</tr>
<tr>
<td>HI-fi’s</td>
<td>28.77</td>
<td>18.14</td>
</tr>
<tr>
<td>DSTV decoders</td>
<td>37.84</td>
<td>36.93</td>
</tr>
<tr>
<td>Printers</td>
<td>33.79</td>
<td>10.79</td>
</tr>
<tr>
<td>VCR’s</td>
<td>26.78</td>
<td>9.8</td>
</tr>
<tr>
<td>DVD Players</td>
<td>20.21</td>
<td>7.74</td>
</tr>
<tr>
<td>MPBC</td>
<td>6.12</td>
<td>0.69</td>
</tr>
<tr>
<td>LCD Screen TV</td>
<td>151.35</td>
<td>21.76</td>
</tr>
<tr>
<td>Plasma Screen TV</td>
<td>317.25</td>
<td>24.42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2539.43</strong></td>
<td><strong>226.1</strong></td>
</tr>
</tbody>
</table>

If a demand tariff is introduced, it will definitely capture the attention of consumers and they will find ways of minimizing the cost which will result in more attention being paid to energy efficient appliances. Currently in South Africa, there are no charges associated with demand (VA) in the domestic
electricity tariff. May be, there is need for change in the domestic sector because one way of regulating energy end-use is through appropriate energy pricing [1].

5 Conclusion

The saturation and penetration rates of appliances in households suggest that domestic appliance load is of a magnitude that cannot be ignored. Lack of energy efficient standards is a cause of the wide variations in power consumption levels obtained. Room for dumping of energy inefficient appliances is created by the absence of energy efficiency standards and regulations. Added functionalities that add value to the appliance aesthetics but none to its primary function are a common feature on many appliances. These added functionalities are a source of high power consumption levels especially on audio equipment. Consumer awareness on energy efficient appliances influences the decision to purchase energy efficient appliances. Information on power consumption levels presented to consumers should ideally cover all the different operational modes available on an appliance. Finally, in South Africa the Energy efficient Strategy of 2005 has created an environment for standards and regulations. Currently, the process of formulating appliance energy efficient standards, and appliance labelling is in progress.

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References


