Undesirable Usage of Energy in Residential House

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***Abstract*-In every household there are several appliances that consume energy even after they are turned off. Compared to whole cost for electricity the undesirable energy consumption is rarely noticed. Within this paper the amount and the characteristics of this so called parasitic energy is investigated. Measurements were done at one average household to examine electricity consumption in whole apartment and separately on every device. In addition to active power the reactive part of the power is also investigated. Based on this research it can be concluded that despite the assumption that the device is switched off, the appliances still consume remarkable active and reactive power at standby or off condition.**

I. INTRODUCTION

During the last decades the amount of electronic appliances used in households has raised tremendously. Most of this equipment maintains certain functionality even after turned off. Also the manual turn off switch has been replaced by a remote control mechanism or touch sensitive button, which need constant power to work [1].

Since present household appliances have features such as remote control, memory and clock display, which require electrical energy, they use power constantly during a day, even when they are not in use or are turned off [2]. Due to increasing number of those devices the energy utilized this way is remarkable. This consumed energy which does not serve primary purpose of device is called standby energy or leaking energy [3]. Because the increase of this undesirable usage of energy represents a significant component of residential electricity consumption, it has become a growing concern internationally. Studies have been undertaken to measure parasitic consumption for different types of electrical appliances in different countries. Those studies have focused on measuring active power without considering reactive power. One reason for this is while both are consumed only the active power is taxed directly in domestic households.

Aim of this article is to investigate power consumption of appliances at the regimes where no primary function is served. Additionally reactive power is examined which has not been widely discussed in papers before. In this paper, overview of undesirable usage of energy in residential houses and field measurements of different operating modes for a range of electrical appliances are presented.

II. UNDESIRABLE USAGE OF ENERGY IN RESIDENTIAL HOUSE

Modern household contains a number of electrical entertainment appliances (televisions, VCRs etc), office equipment (computers, printers, monitors etc), clothes washers, dishwashers and adapters and chargers for them. Therewith their standby power usually varies between 1 and 20 W [3]. Although consumption by individual appliances might seem marginal, the cumulative total is significant.

International studies based on experimental campaigns performed at residential houses have indicated a standby power demand per household in the range 23-125 W [4]. Same number in developed countries varies between 20-60 W, and is responsible for about 2% of the total electricity consumption in OECD (Organisation for Economic Co-operation and Development) countries [5]. In Ref. [6] average standby power 67 W was measured wherein minimum value was 14 W and maximum 169 W. Studies in Germany, Japan, the Netherlands, the United States and Australia have found that standby power accounts for as much as 10% of national residential electricity use [3, 6, 7]. The global energy consumption from standby has been estimated by the IEA (International Energy Agency) at between 200 TWh and 400 TWh per year [8].

Most powerful consumers at standby modes in houses are usually TVs and VCRs. It is estimated that they form around 1% of total energy consumption of household in USA [3]. In Ref. [9] average standby power of a device was calculated to be 3.8 watts by considering measured 605 housekeeping devices. A range of equipment is given at Table I.

TABLE I
STANDBY POWER OF DIFFERENT DEVICES [3]

	Minimum	Average	Maximum
Audio			
Portable Stereo	0,7	2,2	3,2
Compact system	1,3	9,7	28,6
Component System	1,1	3	15,1
Radio	0,9	1,7	3,2
Video			
TV	0,3	4,5	21,6
VCR	1,5	5,9	12,8
TV/VCR	1,1	7,6	19,5
Set-top			
Cable Box	4,6	10,8	24,7
Satellite Receiver	8,8	12,6	18,8
Video Game	0,9	1,3	2
Telephony			
Answering Machine	1,8	3	5,2
Cordless Phone	1,1	2,6	5
Home Office			
Personal Computer	0,5	1,7	3,5
Modem, analog	1	1,4	1,8
Total	25,6	68	165

III. FIELD MEASUREMENTS

There is a wide range of appliance types, which have various features and often more than one operational state. In the study active (P), reactive (Q) and apparent (S) power were measured at every regime. All modes are defined in Table II.

TABLE II

DEFINITIONS OF DIFFERENT MODES

Mode	Definition
Disconnected	Appliance is not connected to grid
OFF	Appliance is switched off, but is connected to grid
Standby	Appliance is on, but is not providing a primary function
ON	Appliance is providing a primary function

Each investigated device is orderly described in Table III with measured power components under normal working conditions. It is seen that beside active power (346 W) the generated reactive power (136 VAr) is remarkably high, which results in total 501 VA.

TABLE III

MEASURED ON MODE POWER OF APPLIANCES

Nr.	Name	P (W)	Q (VAr)	S (VA)
1	SAMSUNG CRT TV 2	95,3	81,2	125,2
2	VESTEL CRT TV	60,5	-67,8	91,5
3	SAMSUNG CRT TV 1	53,4	-55,1	79,5
4	DELL laptop	43,1	-23,5	51,5
5	ViewSonic monitor	30	-38,3	49
6	PANASONIC VCR	14,3	-18,8	24,1
7	CHUNG PUNG air cleaner	12,1	10,6	16,1
8	HP Photosmart printer	7,3	-11,3	14,2
9	NOKIA cell phone charger	6,9	-7,4	13,4
10	KAONMEDIA TV-tuner	6,5	-9,6	11,7
11	AMINO TV-tuner	4,8	-7,3	8,9
12	PHILIPS radio	4,3	4,6	6,3
13	PANASONIC phone	4,8	3,3	5,8
14	PANASONIC phone charger	2,9	3,1	4,2
	Total	346,1	-136,2	501,4

1. *Appliances at Standby Mode*

Same equipment can have quite different standby power as seen at Fig. 1. For example three televisions had standby active power values as 12.7, 3.3 and 3.0 watts. As one was highest consumer of all, the other two were in the other end of comparison. At standby mode smallest active power consumer was a monitor with 0.5 W. Total active power of measured apparatuses at standby state was 56.5 W. This makes 16.3% of total power when appliances are providing their primary services.

Ten devices out of 14 in this study could be switched to standby mode. Their active power values at standby regime are given at Fig. 1.

In addition to active power many devices consume or produce also the reactive power. Reactive power values of ten measured devices in standby regime are shown at Fig. 2. Highest reactive power belonged to one CRT television and lowest to phone with 18.9 and 3.1 VAr respectively.

By compering active and reactive power (Fig. 1 and Fig. 2) it is clearly seen that for different devices they are positively correlated. Also it must be notice that reactive power of apparatuses is whether inductive or capacitive. At figures the data are in absolute values with no remark about the direction of reactive power.

At standby regime air cleaner, one CRT television and phone charger had inductive reactive power value. Other devices showed capacitive reactive power. Sum of reactive power of all devices was 67.4 VAr which makes 49.5% of total when primary function is served.

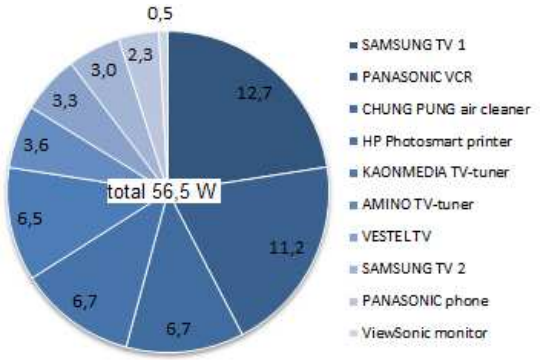

Fig. 1. Active power of devices at standby mode in watts.

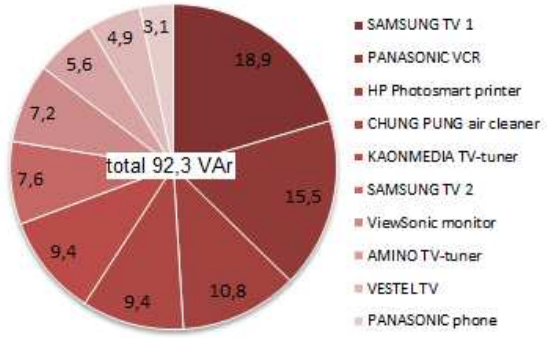

Fig. 2. Reactive power of devices at standby mode in vars.

2. *Appliances at OFF Mode*

Usually apparatus can be turned off, which in common sense means no power consumption afterwards. In this case only half of all measured 14 appliances had possibility to switch off. Active power values of measured devices are shown at Fig. 3. Highest consumer at offline mode was printer and lowest cell phone charger with 6.1 and 0.2 watts respectively. Total active power at this state was 18.2 watts which constitutes 5.3% of total power of online regime.

Reactive power of offline devices are given at Fig. 4. By comparing the results laptop had the highest value of reactive power (16.6 VAr) and cell phone charger had the lowest (0.7 VAr). At offline mode only air cleaner, radio and phone charger had inductive reactive power. All other apparatuses had capacitive reactive power. Sum of reactive power of all devices was 18.5 VAr which makes 13.6% of total reactive power of appliances at state where primary function is provided.

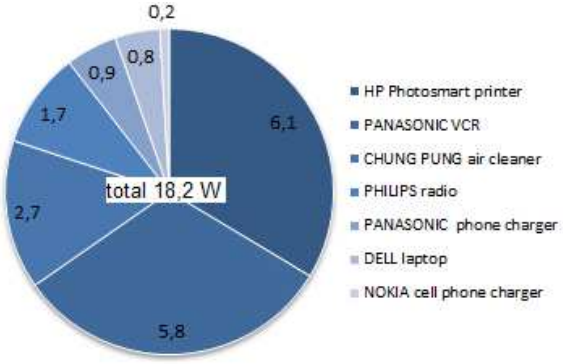

Fig. 3. Active power of devices at OFF mode in watts.

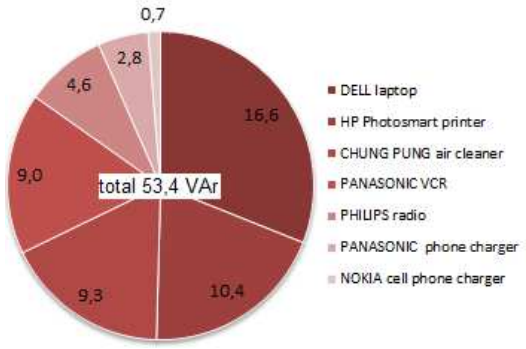

Fig. 4. Reactive power of devices at OFF mode in vars.

3. *Comparing Standby and OFF Mode with ON Mode*

Some of the apparatus cannot be turned off or switched to standby mode. Furthermore, in some cases the switching only means turning off a light which do not change the power consumption significantly [3]. It is also clearly seen from Fig. 5 where some of the appliances have standby power over 90% compared to on regime power. Switched off equipment show even more than 40% of on regime consumption, which in case of printer is 80%. It has also been reported that some appliances may use more energy in standby than in main operational mode [5].

More drastic is situation in case of reactive power. Proportions comparing standby and turned off mode reactive power with primary function serving condition value are much higher than in case of active power. Almost the half of devices had standby reactive power more than 70% comparing with power when main functions are served. Corresponding numbers are seen on Fig. 6.

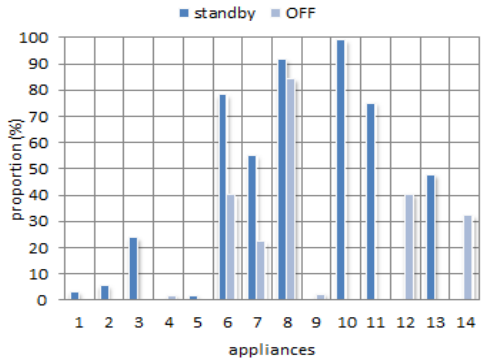

Fig. 5. Standby and OFF mode active power proportions to ON mode value.

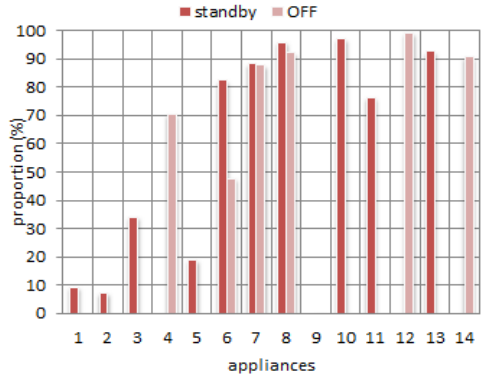

Fig. 6. Standby/ OFF mode reactive power proportions to ON mode value.

Numbers 1 to 14 in Fig. 5 and Fig. 6 are describing measured appliances. Order of those appliances is same as previously defined in Table III.

IV. CONCLUSION

Since modern household appliances have features which require electrical energy when not providing their main service, they use power constantly during a day despite they are not in use or are turned off. This consumed energy which does not serve primary purpose of device is called standby energy or leaking energy.

This research acknowledges indicated figures for a standby active power demand in different studies. Per household it is found to be in between 20–60 W, which is confirmed by measurements carried out for this paper. Average standby power of a device is commonly less than 5 W.

Novelty is discovery that apparatuses also consume or produce a great amount of reactive energy beside active energy and they are positively correlated. It appears that parasitic reactive power of devices is even higher than parasitic active power.

Average parasitic reactive power at standby regime was calculated to be 9.2 VAr and at offline mode 7.6 VAr. While active powers were 5.7 W and 2.6 W respectively. High rate of power in this study is associated with CRT television, VCR and printer at standby condition and laptop and printer at offline state.

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