An Analysis of Standby Power Consumption in Republika Srpska

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***Abstract*—The household appliances introduce significant power consumption in standby operation mode. In order to develop strategies and methods for standby power consumption minimization, it is necessary to analyze how much power is consumed by the devices that are typically used in residential consumers in Republika Srpska. In this paper, the results obtained by measuring power consumption in standby operation mode are analyzed and methods for its reduction are proposed.**

Keywords-energy efficiency, household appliance, stand-by power consumption

I. INTRODUCTION

The majority of household appliances and office equipment consume certain amount of energy from the grid when operating in standby mode. The devices that can be turned on by using remote controller or pushbutton just seem to be disconnected for the end user. The devices with displaying unit, which provides information about time and other parameters, also consume the energy when disconnected regardless of the turn-off method. For the device is said to be in standby mode when not performing its primary function. Power consumption of these devices is result of operation of power supply circuit (or some of its parts), which is used to supply e.g. remote controller or displaying unit (if there is displaying function in the system). However, this power is usually much higher than required for operation of these circuits [1]. It is known that converters, which are used for supplying the devices, have low efficiency when operating in standby operation mode, i.e. when have output power much lower than rated [1],[2]. Standby power of the devices is usually 0.5-20 W. Total standby power in typical household is approximately 23-125 W [3]-[5], [6]. The old appliances usually have higher standby power. Standby power is also referred to as *vampire power* or *vampire draw* [7].

National level research studies have shown that standby consumption makes 5-26% of total electrical energy consumption of a household [1], [3], [4], [8]. Because of the continuous increase in the number of household appliances, there is a world-wide trend in increasing the standby power consumption. International Energy Agency (IEA) estimated that the world standby power consumption is between 200 and 400 TWh [3]. There are many international and national initiatives for standby power consumption reduction. In 1999, IEA initiated "One Watt Plan", which sets standby power of each device below 1 W before 2010. It is estimated that this should reduce carbon-dioxide emission for 50 million tones before 2010. in OECD (Organisation for Economic Co-operation and Development) countries [9]. At the beginning of 2010, the EU commission announced a directive that limits the standby power to maximum 1 W for household appliances and 2 W for devices that have displaying unit. From the beginning of 2013, this limitations will be 0.5 W and 1 W, respectively [7].

Nowadays, the most of the electrical energy is obtained from energy sources that emit a large amount of carbon-dioxide in the atmosphere. It is estimated that carbon-dioxide emission that comes from the standby power consumption is 1% of total world emission. As a comparison, carbon-dioxide emission of aviation traffic is 3% of total world emission [9]. One method for reduction of electrical energy consumption and carbon-dioxide emission is reduction of standby power consumption [1].

There are two methods for reducing the standby power consumption. The first method is to educate consumers in order to raise awareness regarding the standby power consumption. The second method is to use new technological solutions that reduce the standby power consumption of the household appliances and office equipment [10].

Nowadays, there are many research studies that offer various technical solutions for reducing the standby power consumption. For example, in [11], a circuit for power monitoring of a device for which we want to eliminate standby power consumption was proposed. When standby operation mode is detected, the circuit disconnects the device from the grid and, in that way, eliminates its standby power consumption. In [8], the similar solution, based on microcontroller system that monitors device operation and environment conditions and turns off the device when standby mode is detected or when primary function of the device is not necessary, was proposed. Using a novel concept of control unit, proposed in [1], which uses IR laser and photocell in controlled device, zero standby power consumption can be achieved.

In this paper, measurement results of standby power consumption for household appliances, office equipment and water heating devices are presented. The results were analyzed and suggestions for standby power consumption reduction are proposed.

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The paper is organized as follows. In the second section of the paper, the measured power in standby operation mode is given. Analysis of the results is explained in the third section, and suggestions for standby power consumption reduction are presented in the fourth section.

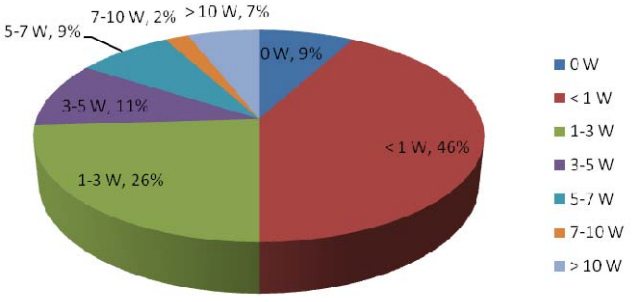
II. Estimation of Standby Power

The power consumption of the devices was estimated using energy cost meter KD302. The basic characteristics of this metering device are:

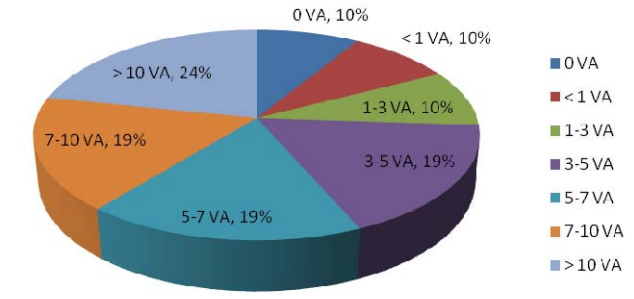
- Operating voltage: 90 to 250 VAC 50/60 Hz.
- Energy Meter/Accuracy: 0.001-9999 kWh / ± 5%.
- Power Display/Accuracy: 0.2 - 3600 W / ± 5%.
- Voltage Display/Accuracy: 90 - 250 V / ± (1% +1).
- Current Display/Accuracy: 0.02 - 16 A / ± (1.5% +25).

In addition to household appliances (TV, DVD, Washing Machine, etc.) we have measured the standby power consumption of the office equipment (PC, Switch, Wireless Router, Printer, Monitor, etc.). Also, we considered the cell phone chargers, and special attention was paid to water heating devices.

In Fig. 1b, a distribution of active standby power for considered devices is shown.



a)



b)

Figure 1. a) Distribution of active standby power for considered devices; b) Distribution of apparent standby power for considered devices.

It can be seen that the majority of considered devices (46%) have standby power below 1 W. This group consists of both office equipment and modern household appliances. We must note that 9% devices from this group have zero standby power, where some of them are marked with Energy Star label. The devices that have standby power greater than 3 W are desktop PCs in turned-off state, as well as older household appliances. We must note that devices whose standby power exceeds the 10 W are CRT TVs. Average active standby power for considered devices is 2.7 W, and average standby power in a household is 23.6 W.

In Fig. 1b, a distribution of apparent standby power for considered devices is shown. Average apparent standby power is 8.2 VA, and in household it is about 74 VA. It can be seen that apparent standby power of devices is several times greater than active standby power, which results in high reactive standby power. In standby operation mode, the devices are mostly inductive, which increases apparent power on the household level. Although apparent (or reactive) power is not accounted for residential consumers, it produces the losses in distributive system and reduces energy transfer capability. From Table I, it can be seen that, for considered sample, the average standby power of household appliances is greater than the average standby power of office equipment.

TABLE I. Standby Power Consumption

Source	Standby Power [W]			Standby Power [VA]		
	Min	Avg	Max	Min	Avg	Max
Household	11.4	23.6	38.5	47.8	74	118
- Home appliances	0.3	3.52	17.5	3.12	10.8	42.3
- Office equipment	0	2.31	13	0	6.9	23.7

A. Water Heater

To determine the energy losses during the water heating, we have measured the energy consumption for two types of kitchen and one type of bathroom water heater. The results of these measurements are shown in Table II.

TABLE II. Water Heater Energy Consumption

Model	Volume[*l*]	Heating energy [kWh][a]	Maintance energy [kWh][b]	Average loss power [W]
Leov, AD-5NM	5	0.263	0.553	23
Inox prerada, DOM 10NM	10	0.529	0.668	28
Koncar, EGV 50.2 TI	50	2.249	1.461	61

a. Initial temperature of water for both types was about 16 ^{O}C, and at the end it was 64.3 ^{O}C for the first, 75.8 ^{O}C for the second, 72 ^{O}C for the third water heater type.

b. Monitoring interval was 24h. The temperature of the environment during the heat maintenance was about 25 ^{O}C.

Based on measurements from the Table II, it can be concluded that the first type of water heater consumes 210% more energy for heat maintenance than is needed for heating its entire content (5 liters). For the second type, this ratio is somewhat better. It consumes 126% more energy for maintenance than is needed for heating 10 liters of water. However, if we express the electrical energy loss as the average power for a period of 24h, we get 23 W for the first and about 28 W for the second water heater type. This was expected, since the surface of the

second water heater is larger than the first. The bathroom water heater has average power loss about 61 W, and the energy it consumes in the period of 24h is 65% of the energy needed for heating the entire content. In comparison to the other devices in household, this is large standby power consumption.

III. Analysis of Standby Power Consumption

Since the primary function of the most of devices during a day is rarely used, in order to simplify analysis, we can assume that they are 24h in standby operation mode.

Based on measurement results shown in Table I, we can conclude that the annual standby power consumption is between 98.55 and 332.6 kWh, which represents 4-14% of total power consumption of a household. If we assume that there are 300,000 households in Republika Srpska (RS), it turns out that the annual consumption of electrical energy caused by standby operation mode is 29.55-99.78 GWh. For this energy, the citizens of RS pay between 2,955,000 and 9,978,000 BAM.

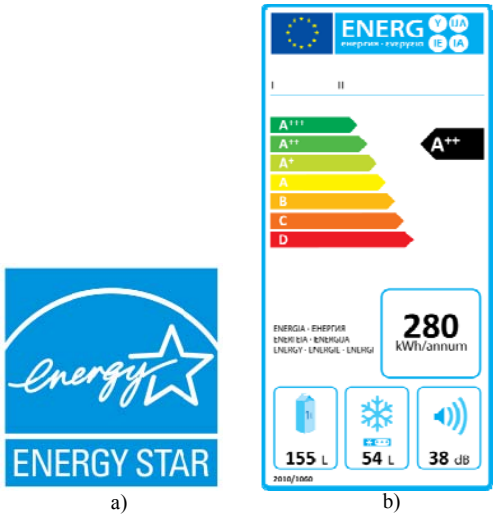
To estimate energy loss caused by the heat maintenance more accurately, we need to assess the habits of population regarding the usage of water heater, and take these results into account in analysis. However, if we assume the worst-case scenario, i.e. water heaters are permanently connected to the grid, based on the results from Table II, we can calculate annual electrical energy consumption in a household. In case of a kitchen water heater, we get about 220 kWh, and for a bathroom water heater about 557 kWh of energy consumption. If we calculate this consumption for RS territory, we get 66 GWh (6,600,000 BAM), and 158.1 GWh (15,810,000 BAM) of electrical energy consumption, respectively.

By summing electrical energy consumption caused by standby operation mode and water heat maintenance, with the assumption that every household has both kitchen and bathroom water heater, we get that total power consumption in RS is between 253.65 and 323.88 GWh, which is comparable with the annual production of the hydropower plant "Bočac".

IV. Reduction Standby Power Consumation

As we said before, one of the methods for reducing the standby power consumption is to educate consumers in order to raise their awareness and make them buy more efficient devices that have low standby power consumption [12]. In RS, there are two standards for marking energy efficient devices.

In 1992, US Environmental Protection Agency (EPA) has introduced the program of voluntary marking named ENERGY STAR (Fig. 2a) that is intended for identification and promotion of energy efficient products manufactured in US [13]. The same year, a directive 92/75/EEC, which regulates electrical energy consumption dependent device marking, is introduced in European Union. Using this directive, the devices are divided into energy efficiency classes marked with letter A to G (A is the most efficient class). Later, after the advancements in the field of energy efficiency, the more energy efficiency classes (A+, A++ and A+++) have been introduced [16]. In Fig. 2b, one example of European Union energy label is shown.

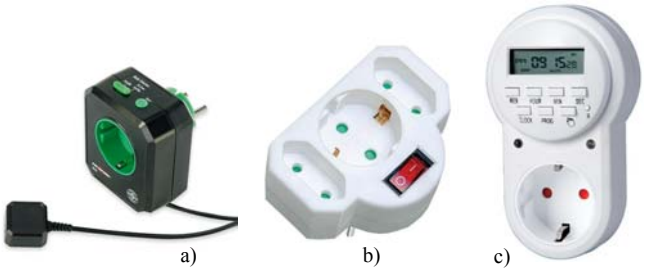


a) b)

Figure 2. a) The Energy Star service mark; b) Example European Union energy label [9].

On European Union territory, ENERGY STAR service mark is used for marking the energy efficient office equipment, and energy efficiency classes are used for labeling the household appliances [14], [15].

By using certain adapters, it is possible to completely eliminate standby power consumption for devices that consume significant energy in standby operation mode. The German company, Ansmann, is one of the manufacturers of adapters that have zero standby power consumption (Fig. 4a) [16]. Also, it is worth mention that is good practice to disconnect all devices from the grid by using switchable power strips in order to reduce the standby power consumption (Fig. 4.b).



a) b) c)

Figure 3. a) Adapter for elimination of standby power consumption; b) Switchable power strip; c) Time switch.

Electrical energy savings can also be achieved in case of the water heater. Namely, based on the measurement results for water heaters, it is obvious that water should be heated just before its usage. For this, time switch Fig. 4c) can be used. In that way, electrical energy losses due to unnecessary heat maintenance are avoided.

V. Conclusion

Regardless of the effort to reduce the standby power of the devices, it can be expected that standby power consumption will grow in the future due to the increased number of devices. One way of reducing energy consumption and carbon-dioxide emission is reducing the standby power consumption. Also, by reducing standby power consumption, consumers can gain

certain budget savings. Currently, these savings at the household level are not significant enough to make consumers reduce standby power consumption. However, as shown in this paper, the savings at the country level can be significant, and this is the main reason why there should exist a national strategy for reducing the standby power consumption of the devices that are sold and used in RS.

To improve the analysis of energy losses due to standby power, it is necessary to estimate and take into account a time of device primary function usage. Also, as mentioned, for a more accurate estimation of energy losses during water heat maintenance, it is necessary to assess the habits of the population in RS. All this may be the subject of our future research.

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