Computer Applications in Electrical Engineering
Vol. 12 *2014*

Influence of computer equipment for power demand and consumption of electricity in companies

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This paper concerns the analysis of power and energy consumption of computer workstations in companies. The following cases were analyzed: the position with the desktop computer the position with mobile workstation and the position with the laptop. We compared demanded power and electricity consumption of such posts pointed out advantages and disadvantages of the use of the above types of computer workstations in the context technical (electricity use) and economically.

KEYWORDS: electricity consumption, power demand, the computers in the energy balance

1. Introduction

Nowadays, computers are an essential tool for working in the offices. Perform their tasks can be simple (not requiring high performance computing, eg preparation of documents) or with a high computational complexity (eg. computer aided design) Such a diversity of tasks makes available many types of computers dedicated to specific applications: from ultrabooks (laptops with low power consumption), by laptops (portable computers general purpose) and desktops (typical desktops) to powerful workstations (portable and stationary).

Despite such a wide range of applications, these devices have one with fundamental feature of an electrical point of view: they are non-linear loads with varying load. Non-linearity is associated with the presence of rectifier circuits in power supplies. Load variation, in turn, is related to the method of operation - complex computational tasks require increased power consumption. In addition, modern computers, especially portable, equipped with advanced technology to help optimize (minimize) energy consumption.

Moreover, in the case of large companies, especially commercial, service or universities, computers represent a significant proportion of used equipment. Proper selection of computer hardware, not only for performance, but also energy consumption can contribute to a reduction in electricity consumption, which directly affects to the costs of the company.

These issues are dealt with primarily in the context of legal requirements [8, 13] and the chosen focus of the grid, for example Through the issue of harmonics [1, 4, 7] or optimal use of the required power and electricity [3].

This paper concerns the question of estimating power demand and electricity consumption of modern computers. It will show the differences between the example desktop computer mobile workstation and laptop.

2. Results of measurements

2.1. The method of measurement

The study was conducted for three computers: desktop, mobile workstation and laptop. Stationary set consisted of: central unit, monitor, keyboard and mouse. In contrast, the mobile workstation is representative of middle-class devices. In turn, tested laptop was a representative of the DTR segment (desktop replacement), which had to replace a desktop computer.

For each stand the study was carried out for variable duty cycle services including: system start-up, working with text, web browsing, and for the purposes of registration, the maximum power drawn by the system running synthetic benchmarks to analyze the system performance [9].

For the measurement of parameters the power network analyzer Fluke 434 [6] was used and for the analysis FlukeView and Excel spreadsheet software were used.

2.2. The results of the measurements

Analyzed computer set consisted of: Intel ® Core ™ i7 950, 6 GB RAM, 1 TB HDD, monitor 22" The elements were connected to a power strip, and the parameters of electricity measured at the input. The power supply of the computer, with power 500 W, was equipped with a system of active Power Factor Correction PFC. This type of power supply have ensure power factor close, often equal to unity. In turn, Thermal Design Power TDP, the power that the processor gets (and calls in the form of heat) [4], in the system under consideration is 130W, and it is the most energy-intensive part of the kit.

The other hand position of the workstation has a configuration containing the Intel® Core™ i7-3520M processor with TDP 35W, 8 GB RAM, 320GB HDD, and was equipped with a matrix of diagonal 17". The entire complement power supply with a rated power of 240 W. In turn, the laptop was equipped with a low-voltage Intel® Core™ i7-3537U processor with TDP 17 W, 8 GB RAM, 1 TB HDD, and a matrix of diagonal 17.3". Parameters were measured at the input of the power supply with power rating of 65 W.

Figure 1 shows the results of power consumption of each set for modeled cycle.

The difference in power consumption are obvious and in line with expectations, ie a desktop gets the most power, a mobile workstation about 4 times less than the desktop and the laptop several times less than the

workstation. Table 1 shows the results of a detailed analysis of the above; where P_{min} – the smallest measured value of power, P_{max} – the largest measured value of power, P_{avg} – the average measured value of power, $P_{mednian}$ – the median of the measured values of power.

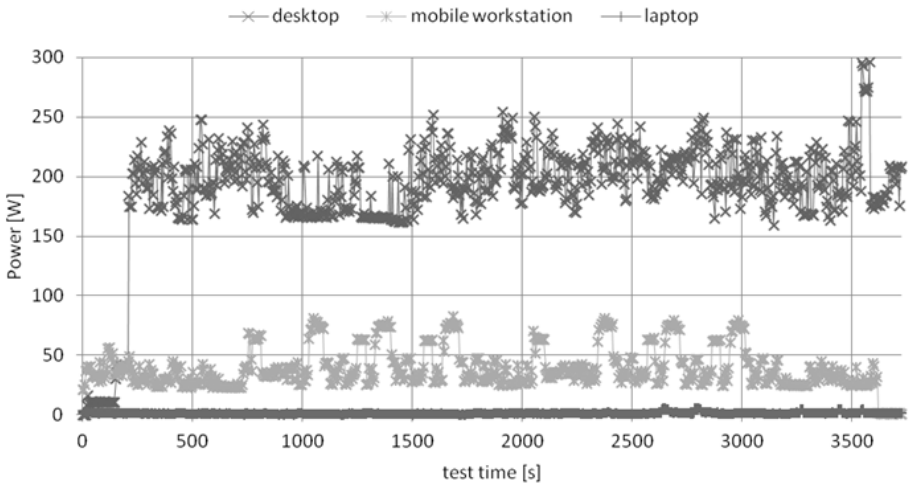

Fig. 1. Power consumption during test

Table 1. Power consumption of the various types of computers

	Computer type		
Parameter	**desktop**	**workstation**	**laptop**
P_{min} [W]	0,00	0,83	0,00
P_{max} [W]	296,00	82,50	5,83
P_{avg} [W]	189,42	39,18	1,19
P_{median} [W]	196,25	34,50	1,17
standard deviation	47,78	17,04	0,84
coefficient of variation [%]	25,23	43,48	70,82

The results from the above table demonstrate the variability of the load, represented by the coefficient of variation and standard deviation. You can see that desktop is characterized by the most stable power consumption, in turn power consumption the laptop is the most variable.

Next figures will show differences in extreme cases for power consumption: desktop and laptop with low voltage CPU. Figures 2 and 3 shows the line current and power factor respectively.

As we there is a huge difference in line currents, desktop needs almost ten times higher current. But in case of power factor, desktop is better choice. The value for it is equal 1 (expect few seconds at the beginning of attempt) where laptop value is very low, about 0.2. this is connected with Power Factor Correction PFC module which is included in desktop power supply – laptops don't have this feature.

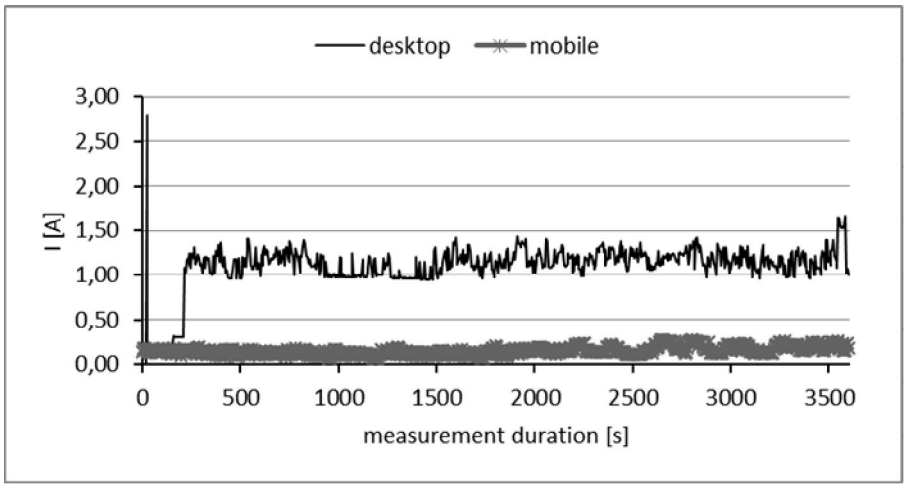

Fig. 2. Current consumption during test

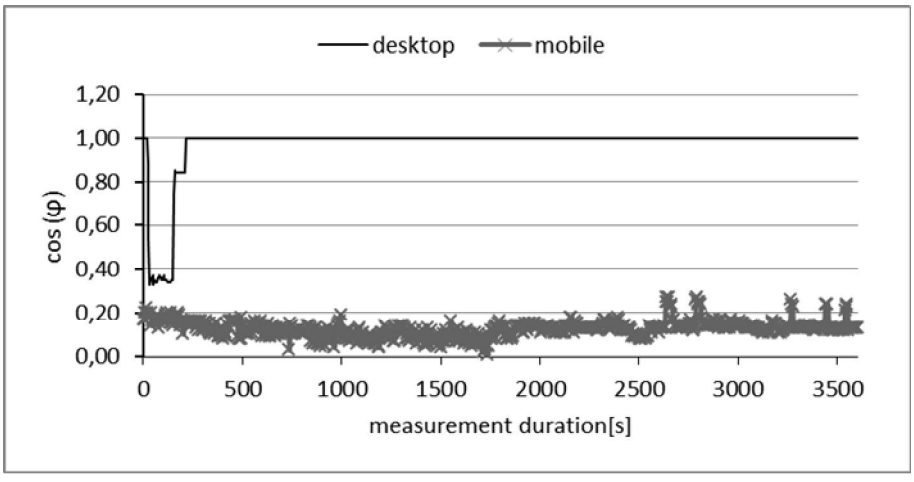

Fig. 3. Power factor during test

Figures 4 and 5 shows content of individual harmonics in supply voltage IHDu and content of individual harmonics in supply current IHDi for desktop and laptop respectively.

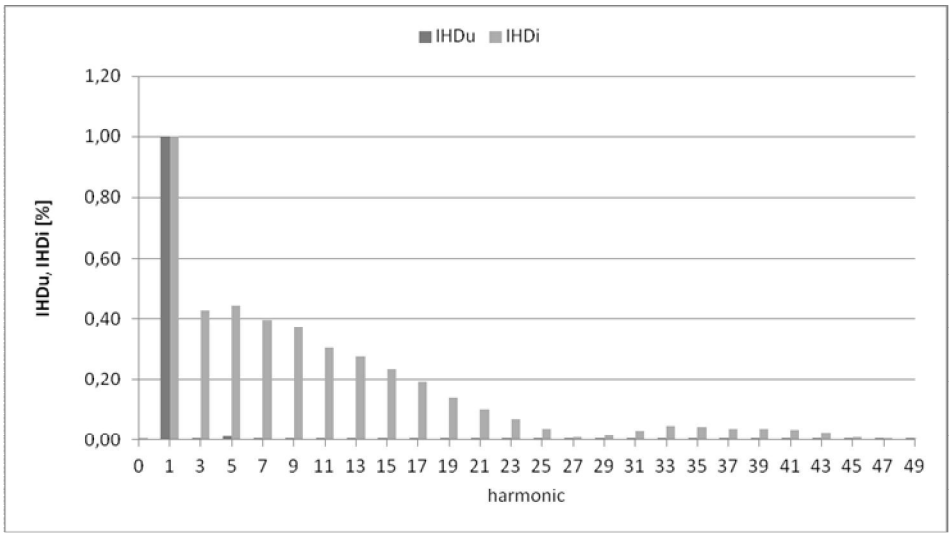

Fig. 4. Harmonics in power line for desktop

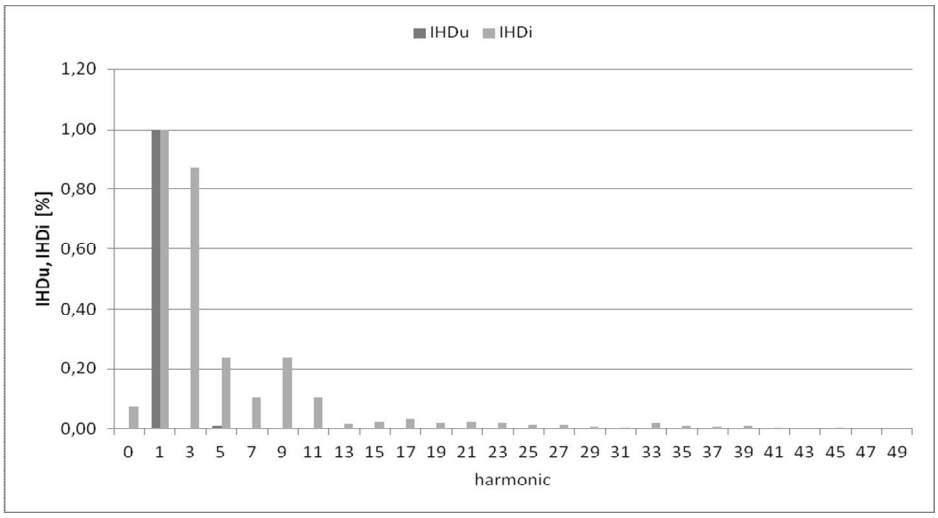

Fig. 4. Harmonics in power line for laptop

As we can see there is no significant harmonics in voltage in both cases. Both computers have a number of harmonics in current. But in desktop are all (up to 21st) harmonics with values from 10 to 40 %, where laptop has a very large 3rd harmonic (over 80%) and only values 5th and 9th harmonics exceed 20%. and 7th and 11th have values larger then 10%.

The values of power factor and of harminics for mobile workstation were similar and the current was slightly higher then laptops.

3. Analysis of measurements

Analyzing the results of the measurements should pay attention to two aspects:

- way of working the different types of computers,
- the legitimacy comparing the absolute values.

In the case of the way computers work should not be forgotten that the laptop can work without a power source, usually no longer than 3 hours at an average load. The second consequence of the presence of a battery in a laptop is increased power consumption while charging the battery. In contrast, the current consumption of desktops are used for general office printing is more stable.

In turn, comparing the absolute values makes sense for the analysis of a large group of computers. Individually tested workstation availed (comparing the maximum values) of 28%, a laptop and only of 2% desktop computer active power. Table 2 presents the results of a simulation of electricity consumption by individual stand within a year and within five years – a typical lifetime of such equipment. It was assumed that computers work in a company only on weekdays 8 hours per day, which gives 2008 hours per year.

Table 2. Electricity consumption by individual computer stations

	Type of computer		
Power consumption [kWh]	**desktop**	**workstation**	**laptop**
p.a.	394.07	69.28	2.34
within 5 years	1970.35	346.38	11.71
difference	-	-1624	-1959
difference in %	-	-469	-16721

The above table shows how big can be reduced energy consumption by using mobile technologies - mobile workstation consume within 5 years of 1.6 GWh, and laptop with a 1.9 GWh less electricity than a desktop computer For example corporations, where a significant number of computers are being used, often hundreds, these value may constitute a significant item in the budget. Thus, analyzing 100 units should be noted that the exchange of desktop computers, portable workstations allow the purchase after 5 years 7 new machines of this type. In turn, desktop replacement laptop will thereafter purchase for the difference in energy costs 23 units This calculation is indicative only and takes into account the current cost of electricity without the other components of charges related to the distribution and transmission of these

components will take into account that the result will be even more beneficial [12, 14].

Comparing to the results measured 10 years ago [7] it can be noticed that there was no change in a desktop IHDu (negligible values) and a change in IHDi.

Older PC power supplies generated harmonics from 3th to 7th with varies values from 10% (7th) up to 30% (in idle even 70%) for 3rd while the others were negligible. Nowadays 3rd harmonics il lower (about 40%) but there are harmonics up to 21st. it can be connected with the use of more precisely thyristor rectifiers and PFC systems.

4. Summary

Contribution to carry out the analysis presented was a tendency to replace desktops to mobile, especially in small organizations This trend appeared on the alignment the prices of stationary and portable equipment The portable computer occupies less space, consumes less power and can be used outside the workplace Moreover, usually the computer is turned on after returning to work and shut down at the end of the day. A portable computer when it is not used consumes significantly less energy than a desktop.

The measurements and simulations confirm the legitimacy of such proceedings. In the case of 100 computers power demand is greatly reduced, thereby reducing the cost of electricity. The negative effect of such actions is to increase the inequality of power consumption, harmonic generation to the grid and increase consumption of reactive power [4].

However, the main problem for the company are additional costs which it must bear a computer to meet legal requirements Archaic laws regarding health and safety of computer stations originates from the year 1998 and since then have not been updated [11]. For laptop meet these conditions must be equipped with a separate keyboard and monitor This results in increasing the price of a set of at least 400 zł [14]. These additional costs will be met when the difference exceeds the energy consumption in the case of 1 MWh rates from the group C, or B [12] after at least two years. The above analysis is estimated, because only covers the cost of electricity, and ignores any reduction in other fees associated with even power distribution and the possible reduction of required power.

Besides, progress in the construction of power supplies, which took place in recent years, resulted in a decrease in the share of 3rd harmonic current phase and increasing the share of harmonics in the range of 9th to 21st.

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