# ENERGY MANAGEMENT IN A LABORATORY COMPUTER GRID

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**REZUMAT. Disponibilitatea limitată a resurselor energetice impune ca în toate procesele şi acţiunile noastre să găsim abordarea optimă de consum. În următorii 5 ani, în sectorul IT, se prevede o dublare a consumului de energie. Statisticile arată că, în ¾ din timpul de funcţionare, un calculator stă pornit inutil, de aceea este necesară o monitorizare strictă a reţelei şi transformarea ei într-o reţea verde, prin eliminarea regimurilor idle şi prin închiderea automată a componentelor neutilizate.**

**Cuvinte cheie:** reducerea consumului, calculator, reţea verde, data center.

**ABSTRACT. Limited availability of power resources requires that for all our daily processes and actions to find the perfect approach for saving energy. IT energy consumption is expected to double in the next five years. As statistics show that computers are switch on ¾ time for nothing, it's necessary to monitor the energetically parameters and to help the grid became more green, by eliminating "idle" regimes in the operation of computers and by automatically turning off unused components in specified functioning moments.**

**Keywords:** energy saving, computer, green grid, data center.

## 1. INTRODUCTION

Europe 2020, the EU's growth strategy for the coming decade on five ambitious directions - employment, innovation, education, social inclusion and climate/energy, animates us with the statement "in a changing world, we want the EU to become a smart, sustainable and inclusive economy". There can be seen that into this whirl of of adopting all the criteria and objectives of sustainability (and therefore of efficiency), many mistakenly perceive the concept of saving. It's about those who are trying to incorporate modern saving measures in a system that is surpassed as technique and concept. In addition, it is difficult to keep the proportions of consumption (on the resources of any kind) and the same level of comfort, when the process is moral and technologicaly outdated. When applying these measures is no longer in charge of the system designer or supplier, an essential factor in successful implementation of modern energy saving measures is consumers' behavior, as they are reluctant and still largely influenced by economic incentives.

Fortunately, even if radical measures are required, any system can be transformed into one intelligent. Today we can investigate everything from home energy meter, power turbines to the network. In practice, electricity begins to look more like a communication network, than a traditional network. An example is that we can connect to the electrical network thousands of sources of power, non polluting, renewable, unconventional. All such instruments generate new data that, using advanced analytical techniques, can be transformed into perspective, so that good decisions can be taken in real time.

## 2. MITHS AND CERTITUDES ON COMPUTER'S UTILIZATION

Limited availability of power resources requires that for all our daily processes and actions to find the perfect approach for saving energy. Even if energy efficiency problem has been extensively treated, linking it to intelligent networks, especially to ICT systems, there appear plenty of research challenges. When dealing with energy consumption and green ITC, there are plenty of reviews. The rapid growth of computer grids raise issues of energy consumption and $CO_2$ emissions. Even the emissions are not proportional to energy consumption, and consumption is not proportional to energy use, there can be made savings through the rational use of these systems.

Further will be presented some common biases spread about using the PC and managing its power consumption:

"Turning off the PC damanges the computer": is a misperception of many users who want to prevent any failure of power supply. In fact, the IT systems nowadays are designed to support minimum 40000 on/off cycles.

"Turning off the PC use more energy than leaving it on": it's definitely a matter of convenience. The surge of power when a computer is shutting down lasts a few seconds and is negligible compared to the sustained energy used by keeping it on during periods of inactivity [1].

"Screen saver saves energy": is a hasty conception, arising from the lack of basic technical knowledge or bad intuition. Screen savers were originally designed to help protect the lifespan of monochrome monitors, which are now technologically obsolete, and are often employed with low timeout values so that sensitive data cannot be viewed by others. The computer is still in use, so screen savers do not save energy unless one actually turn off the screen or, in the case of laptops, turn off the backlight or enable the "power saving" function [2]. Safest measure is to turn off the monitor when not using the computer, the more so as the life of the monitor is related to the amount of time it is in use.

"There is no difference between "system standby," "hibernate," "monitor power management," and "turn off hard disks"": is another erroneous vision due to lack of basical IT knowledge. The only thing these four operatings have in common is they are all sleep mode features. A Northwestern University Information Technology report [3] shows that:

- "System standby" wane monitor and computer power use down to 1–3 W each, wakes up in seconds and saves up to 75 $ per PC annually;
- "Hibernate" wane monitor and computer power use down to 1–3 W each, wakes up in more than 20 seconds and saves up to 75 $ per PC annually;
- "Turn off monitor" wane monitor power use down to 1–3 W, wakes in seconds or less and saves up to 40 $ per PC annually;
- "Turn off hard disks" saves very little energy. Hard drives physically spin when in use, which requires more power, but very few compared to the system total need of power.

Hence, all regimes and all the use states of a PC consumes energy, but obviously in different proportions (see table 1).

*Table 1*

**Power consumption of PC in different operating modes [4]**

| **Computer** | **Conventional Unit** |
|---|---|
| **Average power for** | **Watts** |
| Active mode | 115.0 |
| Idle mode | 84.0 |
| Sleep mode | 6.0 |
| Off mode | 3.0 |
| **Difference: Active mode vs. off mode** | 113 |
| **Difference: Idle mode vs. off mode** | 81 |

## 3. CASE ANALYSIS

Aiming at the application of a power-saving methodology and starting from the components of a standard PC's consumption (table 2), the paper presents a study on a common computer grid, from the "Computer Programming Laboratory" of the Faculty of Automation and Computers in Iasi. The computer network consists of 36 workstations (monitor, central processing unit, keyboard and mouse), rather old Pentium IV model, 2.4 GHz and LCD monitors. The PC's were used by students in the usual pace of work, the reference period being two weeks – 10 effective operating days, 4 hours per day. On each computer was installed an energy tracking software, that records the workstation's power consumption, as long as it is turned on - during laboratory classes.

*Table* 2

**Peak power PC consumption on components [IBM, Intel datasheets]**

| **Component** | **Peak power [W]** | **Count** | **Total** |
|---|---|---|---|
| Monitor CRT | 80 | 1 | 80 |
| Monitor LCD | 50 | 1 | 50 |
| CPU16 | 40 | 2 | 80 |
| Memory 184pin | 9 | 4 | 36 |
| Disk24 | 12 | 1 | 12 |
| PCI slots 22 | 25 | 5 | 50 |
| Motherboard | 25 | 1 | 25 |
| Fan | 10 | 1 | 10 |
| **Total system** | | | **263 / 313 W** |

The software, Joulemeter, is a Microsoft release, a software-based solution that measure the energy usage of virtual machines, servers, desktops (figure 1), laptops, and even individual software running on a computer and is a proper tool for to improve power provisioning and consumption costs in various scenarios ranging from data centers, enterprise computing, and battery operated machines.


**Fig. 1.** Joulemeter software tool to measure the energy usage of a computer.

## 4. RESULTS

The consumption records after 2 weeks of usual operation, made in an Excel database, were collected on all 36 computers in “Computer Programming Laboratory”. Since the software timestamp was set for 1s, the amount of data was very high. Processing all the record has required the use of filters, macros and average functions for each Excel data file, to separate data according to type of activity undertaken by the student on the computer. The chart in figure 2 render the power consumption, on elements, for a random workstation, revealed on time-pattern, for a 2 hours application class (100 minutes of continuous usage).

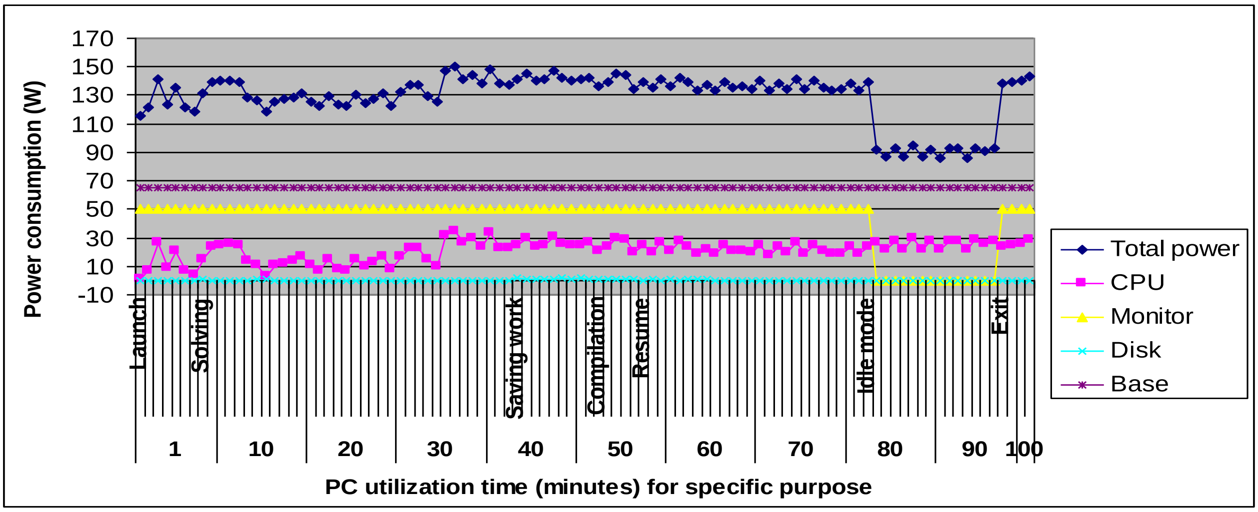


**Fig. 2.** Example of a random PC power consumption during a class, give on each type of student activity: launching application, solving tasks, saving data work, compilation, resuming work, oral discussion (idle mode) and exiting the applications.

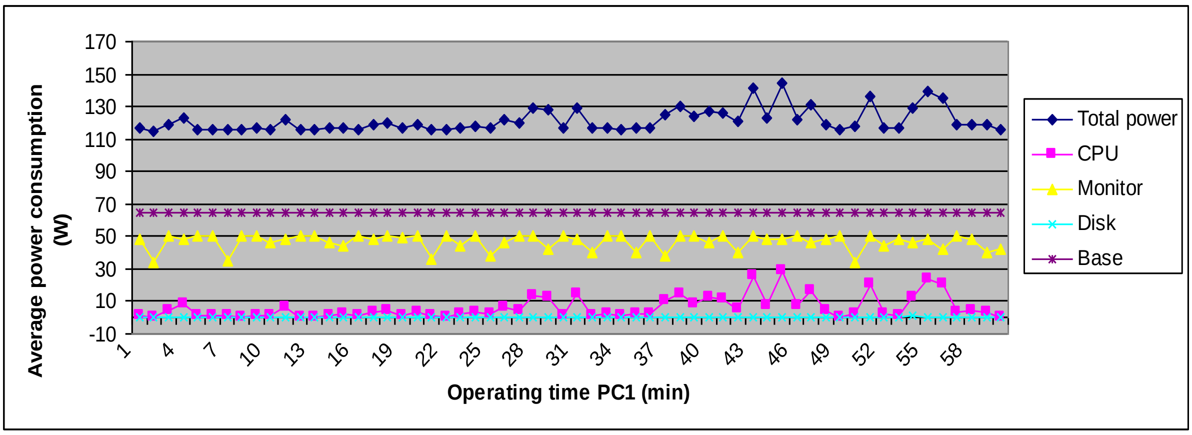


**Fig. 3.** Specific power consumption for PC1.

Based on the records made in the 40 hours summed of utilization, for each workstation was made an hourly averange consumption, on components (CPU, monitor, hard disk and motherboard). The power data were divided into subgroups of 3600 consecutive values (as the timestamp is 1s), then calculated averages for subsets of 60 consecutive values each, obtaining 2400 new strings of power values with 60 elements. Performing the average of Pn (where n is the rank of string and corresponds minute) from the ranks of the same name, resulted the specific power consumption. In figure 3 it's shown the power chart for PC1, therefore the hourly consumption (table 3).

*Table 3*

**PC1 hourly specific power consumption**

| **Total power** | CPU | Monitor | Disk | Base |
|---|---|---|---|---|
| **121,201** | 6,07 | 46,51 | 0,153 | 65 |

Average power consumption for the all the 36 computers has the graph in figure 4. Thereby can be defined an "equivalent computer" which will take the consumption characteristics rendered Table 4.

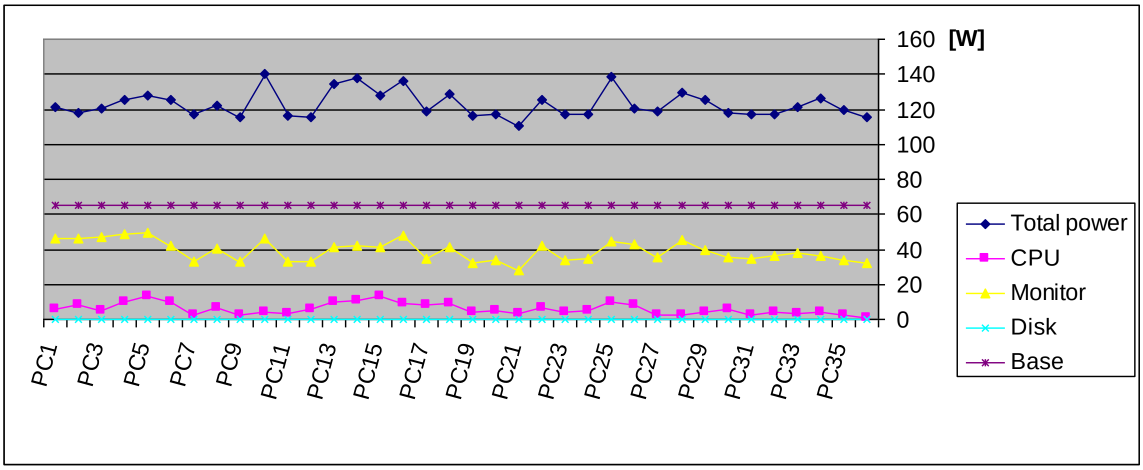


**Fig. 4.** Average hourly consumption of 36 PCs (workstations).

*Table 4*

**Absorbed power by the "equivalent computer"**

| **Total power** | **CPU** | **Monitor** | **Disk** | **Base** |
|---|---|---|---|---|
| 4420,1 W | 216,27 W | 1405,16 W | 7,066 W | 2340 W |

Form the charts above is distinguished the biggest energy consumer - monitors. Filtering again recorded values and calculating the average absorbed power on operating modes of the PC, result values from Table 5.

*Table 5*

**Average energy consumption of a monitor**

| | |
|---|---|
| Typical 17" monitor | 50 W |
| Idle mode | 40 W |
| Sleeping Monitor | 0 W |
| Monitor Turned Off | 0 W |

## 5. EXTRAPOLATIONS

**a)** Turning off the monitor when students are not using the computer will help conserve energy. During the reference period there were such downtime, lasting between 5 and 15 minutes. As the energy is integral of active electrical power on a specified period of time (1), means that, according to (2), 230 Wh are useless consumed in total by the 36 computers.

$$E = \int_{t_1}^{t_2} P dt \quad (1)$$

$$E_l = 36 \cdot \int_{0.08h}^{0.25h} 40W dt = 36 \cdot 6.4Wh = 230Wh \quad (2)$$

Approximating (according to the laboratory schedule) the PCs operating time at 100 hours per month, there could be saved 23000 Wh only by turning off monitors during the idle mode. In financial units, there are 3.06 €/month. This is not a significant amount related to laboratory's electricity bill, but if the previous measure would apply to all laboratories in the faculty building (or to an office building) there would be a serious economy. If not evaluate on financial considerations, this measure of the economy that does not involve any resource, is important and deserves to be adopted.

**b)** If desired the design and dimensioning of an electrical network to supply a computer grid similar to the above, must be defined a simultaneity factor as:

$$k_s = \frac{P_{absorbed}}{P_{installed} \cdot k_u} \quad (3)$$

where $k_u$ is the utilization factor, of value 0.8 for faculties and 0.9 for administrative offices [5]. The absorbed power takes the value from table 4.

Still in design phase, on calculating the maximum allowable current to choose conductor's section, cables and protection gear, should be determined the impact of simultaneous start of the 36 computers (peak current). To avoid potentially power spikes and to reduce the value of the peak current at start-up, it's recommended a phased start-up, possibly together with some sort of primitive flagging system. The number of PCs attempting to establish communication with the network simultaneously may be able to be better managed, and thus reduce network traffic flood problems [6].

**c)** If the particular case study on lab computers would expand by analogy and generalization to a data center, there must be taken into consideration and further energy inputs, respectively coolers [7]. In this case efficiency will be appreciated depending on PUE (Power Usage Effectiveness) value, defined in (4). The ideal value of PUE is 1.6 for data centers and the average allowable value is 2 (from 2 W consumed, only 1 W is useful to the computer).

$$PUE = \frac{total\ \ facility\ \ power}{IT\ equipment\ \ power} \quad (4)$$

IT equipment power refers to servers, storage, computers, printers and network [8].

## 6. CONCLUSIONS

When the financial condition does not allow us to acquire intelligent machines and modern equipment with less consumption, it's our duty to make the machines to work as smart as the user and to spread intelligence across our technology infrastructures.

On a computer grid there are plenty of energy saving measures to be adopted. First, to disable screen saver (as it keeps computer in use and generate energy), to turn off the monitor when computer is not used or enable "power saving" functions. Thus, the absorbed power can be reduced, with an economy from 6.4 W to 40 W. Further technical and organizational measures, such as turning off peripherals (printers, faxes, scanners, PDA devices) if aren't used or as sharing a printer than purchasing multiple personal printers, are nothing more than to ease the process of greening the existing grids.

These proposals for monitoring and reducing energy consumption will not affect the computer's performance per watt (as in computer science, efficiency is used to describe properties of an algorithm relating to how much of various types of resources it consumes, like FLOPS per watt).

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