Jere Koret

Energy consumption of workstations and external devices in school of business and information technology

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Jere Koret
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Abstract

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The purpose of this thesis was to measure energy consumption of workstations and external devices in School of Business and Information Technology and search for possible solutions to reduce electricity consumption.

The commissionaire for the thesis was Oulu University of Applied Sciences School of Business and Information Management unit. The reason for the study is that School of Business and Information Management has a environmental plan which is based on ISO standard 14001 and this thesis is part of that by trying to discover possible new solutions to reduce electricity consumption.

ISO (International Organization for Standardization) standard 14000-group consists of such as environmental auditions, product life cycle evaluations and various eco-labelled standards. Present ISO 14001-standard was approved in November 2004.

Purpose of this thesis was to help the school in this plan and seek information and solutions and/or alternative options which would bring down the energy consumption of our schools computers and external devices as low as possible and at the same time think all the solutions in aspect of ”environmental friendliness”.

Foundations for the thesis have been acquired from various articles and books concerning electricity consumption, recycling, production of electric components and literature about Green IT in general. Research methods consist mainly of data gathered using energy meter by using an ETECH PM300 energy meter device in between the electrical socket and measured device. Main results of this thesis have been energy consumption of individual workstations and energy consumption of variable external devices.

Results and conclusions were not so black and white. Finding the right solution might be extremely difficult since new hardware setup might not be so energy efficient and vice versa. What comes to further measures central air conditioning, lighting and servers should be evaluated.

Keywords: Sustainable development, energy consumption

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1 INTRODUCTION

Continuous growth of energy consumption has not only raised the costs of electricity bills but also interest of people towards energy saving and thinking green in general. Couple of years ago even component manufacturers were not really interested into consumption of their products. Performance was everything.

Within few years everything has turned upside down in component markets. Manufacturers even compete how mingy their products are in energy consumption. Green IT has become topical issue and it catches a lot more attention than a decade ago.

School of Business and Information Technology is involved in the ISO standard 14001 environmental management system and the purpose of this thesis is to be part of this plan.

The environmental policy says: "The School of Business and Information Management develops its operations according to the environmental policy of the Oulu University of Applied Sciences, and follows the environmental legislation, orders of the authorities and the policies of the city of Oulu. The most important environmental objective is to increase awareness of environmental issues among the staff, students, local business and working life. Other essential environmental objectives include decreasing energy consumption, use of paper and amount of waste. In all acquisitions energy consumption, durability and recyclability are taken into account according to the instructions of the Oulu Region Joint Authority for Education." (OUAS, Environmental Policy 2011. Date of retrieval 7.6.2012.)

Purpose of this thesis was to research the energy consumption of computers and various additional devices in school of business and information management and search solutions to cut back energy consumption in aspect of green IT and also to find out if the results could give some hints how to reduce energy consumption. Statistics of energy consumption are read with ETECH PM300 energy meter.

2 BASICS OF GREEN IT

2.1 WHY SHOULD I BOTHER?

Many ask themselves "why should I bother?" especially when saving procedures requires some effort. In reality green thinking only takes initiativeness and very little effort like shutting down the workstation when it's not needed.

Changing small things may seem pointless on daily basis but when days turn into months and eventually into years the results are beginning to show up. According to Velte J. Velte T. and Elsenpeter (2008, 13) measuring carbon footprint isn't just tap on a shoulder within the company. Reducing carbon footprint also reduces costs and improves company's efficiencies along getting public recognition for taking steps towards greener less consuming future.

2.2 GETTING INTO BASICS

When acquiring workstations it would be priority to know the purpose of the device and if possible the best result is gained by picking every component separately. Assembled computer setup may have compatibility problems between components therefore it would be highly advisable to do some research in advance from desired components to avoid major incompatibility problems.

Because of competition or lack of it there is not much of choices on processors. However there is much difference in energy consumption how operating system is profiled energy wise and how processor is configured in BIOS.

Despite high acquisition prices of Solid-state drives (SSD) they consume a lot less power than normal 3,5" SATA drive and because of SSD does not contain any moving parts inside they produce less heat and tend to last longer than 3,5" drives as well.

Latest motherboards include built-in display card which does its purpose if computer is not used on anything which requires additional display card such as 3D graphic tools and games. Otherwise additional display card just doubles the amount of energy consumption and heats up central unit. Heat strains computers cooling system which increases energy consumption.

Also list of used materials should be investigated if possible since the use of toxic materials in components may vary radically between different manufacturers. Particularly products should be

monitored for lead-free solders and if mercury has been used in making of TFT-display terminals. TFT-screens should also include long-life lamps. Possible batteries should rechargeable or at least interchangeable and recyclable.

When selecting devices and electronics they should be compliant with the EPEAT (Electronic Product Environmental Assessment Tool) ranking system. "EPEAT was developed by the Green Electronics Council in Portland, Oregon to help institutional purchasers evaluate, compare, and select desktop computers, notebook computers, and monitors based on their environmental attributes. Electronics can be awarded a gold, silver, or bronze certification, based on how well they meet 51 criteria, including ease of disassembly, chemical content, end-of-life design, and others. Products must meet at least 23 of the criteria for the bronze-level certification." (Velte J. Velte T. & Elsenpeter 2008, 55.)

*FIGURE 1. epeat criteria rating symbols (*EPEAT, date of retrieval 25.5.2012)

3 ENERGY CONSUMPTION MEASUREMENTS

Measurements were made with ETECH PM300 energy meter. Meter itself turned out to be very simple and easy but yet effective tool for the measurements although meter set some challenges and limitations as well. Problems and limitations were mainly related to the physical connectivity of the meter. Some devices had fixed electricity wiring which could not be removed from the wall. This resulted in leaving bigger devices such as central air conditioning system out from the measurements.

FIGURE 2. Etech pm300 energy meter. Front and side figure of used ETECH PM300 energy meter

Due to difficult implementation work spaces for the staff members were left out form the measurements. However most of the staff and office members have same kind of configurations than ones that are used in classrooms so in theory I have measured those configurations as well.

Audio devices in classrooms were left out too because measurements would have required the removal of installed stands. To get some view from consumption of audio devices I decided to add and measure normal home receiver. Servers were left out for obvious reasons since attachment of energy meter would have caused shutdown.

4 RESULTS

Division in processors were roughly half single core and half dual core processors. Most of the configurations had only one hard disk drive. There were total of 445 work stations in 21 classrooms. In every classroom there were set of audio devices and video projector. Configurations that were left out from the measurements are within the staff members rooms. Most of staff members rooms have 2 PC workstations and or laptops in around 90 workers / configurations in total.

4.1 COMPUTERS

There weren't notable difference between the configurations in energy consumption. However seems that newer configuration doesn't always mean bigger consumption. For the sake of contrast 3 additional high tier PC configurations were added into measurements. 2 configurations were overclocked and tested with 2 different power supply units and with SSD-drive and normal 3,5" SATA drive. One configuration was tested with relatively big power supply unit, SSD-drive and a bit older more energy consuming processor model.

Table 1 includes configurations that School of Business and Information Management had at the time. All configurations were running with Windows XP operating system. Table 1 clearly shows that the amount of cores does not really affect to the amount of wattages but the amount of hertzes. 3,5" HDD consumes around 20 to 40w each.

TABLE 1. Configurations in School of Business and Information Management

CPU / Cores	CPU GHz	RAM	Hard drive(s)
AMD 64bit x 2	2,6GHz (3800+)	3 GB	80 GB + 160 GB
Intel Core 2	1,8GHz (6300)	2 GB	160 GB
Intel Pentium 4 x 1	3,2GHz	3 GB	80 GB
Intel Pentium 4 x 1	2,6GHz	2 GB	40 GB
Intel Celeron x 1	2,0GHz	768MB	40 GB
	Consumption when		
Configuration	**Turned OFF**	**Startup**	**Turned ON (on desktop)**
AMD 64bit x 2	9W	135W	100-118W
Intel Core 2	8W	80W	65W
Intel Pentium 4 x 1	11W	140W	100W
Intel Pentium 4 x 1	4W	70W	50W
Intel Celeron x 1	11W	80W	70W

Table 1 above contains test environment built power PC configurations meant for heavy graphics and gaming. All configurations were running 64-bit Windows 7. Heavy strain testing phase was executed using Battlefield 3 computer game. The idea of these measurements were to bring aspect of high-end PCs energy consumption.

Configurations in tables 2A and 2B were ran overclocked with identical motherboards and identical graphics cards. i7 had only one 3,5" HDD and i5 configuration had two 3,5" HDDs. Both were tested with old very low quality power supply units. Outcome with older power supply units were that both of the configurations consumed around 10W when turned off and around 140W when turned on and measured on desktop use. More radical difference in consumption between configurations was when they were set under heavy strain. Both configurations consumed over 200W but the difference was around 70W. In tables GFX stands for graphics card and PSU stands for power supply unit.

TABLE 2A. Test environment power pc configurations with low quality power supply

CPU / Cores	CPU GHz / Overclocked	GFX Card	RAM	Hard drive(s)	PSU
Intel i5 2500k Quad (Sandy Bridge)	3,3GHz @ 4,33GHz	Radeon HD6870	8GB	2 x 3,5" SATA (250GB + 500GB)	550W
Intel i7 2600k Quad (2nd Gen Sandy Bridge)	3,4GHz @ 4,6GHz	Radeon HD6870	8GB	1 x 3,5" SATA (500 GB)	630W

TABLE 2B. Consumption results of configurations in table 2a

Configuration	Turned OFF	Turned ON	Heavy strain
Intel i5 2500k Quad (Sandy Bridge)	11W	130W	230W
Intel i7 2600k Quad (2nd Gen Sandy Bridge)	13W	140W	298W

Table 3 configurations were slightly changed. In i5 configuration old 3,5" 250GB HDD was switched to 120GB OCZ Agility 3 SSD-drive.

TABLE 3A. Test environment power pc configurations with high quality 80+ bronze certificate power supply unit

CPU / Cores	CPU GHz / Overclocked	GFX Card	RAM	Hard drive(s)	PSU
Intel i5 2500k Quad (Sandy Bridge)	3,3GHz @ 4,33GHz	Radeon HD6870	8GB	SSD + 3,5" SATA (120GB + 500GB)	650W
Intel i7 2600k Quad (2nd Gen Sandy Bridge)	3,4GHz @ 4,6GHz	Radeon HD6870	8GB	1 x 3,5" SATA (500 GB)	650W

TABLE 3B. Consumption results of configurations in table 3a

Configuration	Turned OFF	Turned ON	Heavy strain
Intel i5 2500k Quad (Sandy Bridge)	11W	90W	220W
Intel i7 2600k Quad (2nd Gen Sandy Bridge)	13W	111W	232W

Brand new identical XFX 650W pro series power supply unit as displayed in figure 3 was installed into both configurations. See notable drop on energy consumption under heavy strain compared to configurations in table 2b.

FIGURE 3. Xfx 650W 80+ bronze certificate power supply unit

Configuration in table 4 with first i7 generation processor, with a bit more efficient graphics card compared to tables 2,3 and 4. SSD-drive is the same 120GB OCZ Agility 3 than in previous i5

configuration. Configuration is powered by high quality 700W Be Quiet! power supply unit. Graphics card is a bit more efficient than in newer i7 configuration however the difference between consumption is immense 98W.

TABLE 4A. Test environment power pc configuration with high wattage 80+ bronze certificate power supply unit

CPU / Cores	CPU GHz	GFX Card	RAM	Hard drive(s)	PSU
Intel i7-950 Quad (1st Gen Bloomfield)	3,07GHz (Default)	GeForce GTX 570	12GB	SSD + 3,5" SATA (120GB + 750GB)	700W

TABLE 4B. Consumption results of configurations in table 4a

Configuration	Turned OFF	Turned ON	Heavy strain
Intel i7-950 Quad (1st Gen Bloomfield)	14W	177W	330W

Tables 5A and 5B configurations measurement was done with everything set to save consumption within windows power options and in BIOS (see figure 4).

TABLE 5A. Test environment power pc configuration with default cpu clock rates and all power save options enabled

CPU / Cores	CPU GHz	GFX Card	RAM	Hard drive(s)	PSU
Intel i7 2600k Quad (2nd Gen Sandy Bridge)	3,4GHz (Default)	Radeon HD6870	8GB	1 x 3,5" SATA (500 GB)	650W

TABLE 5B. Consumption results of configurations in table 5a

Configuration	Turned OFF	Turned ON	Heavy strain
Intel i7 2600k Quad (2nd Gen Sandy Bridge)	13W	114W	134W

Hertzes were downed to defaults, cooling system was set to automatic and system performance profile was set to power saving. Wattages in heavy strain dropped 98W compared to everything set to high performance. In desktop use everything worked like a charm but under heavy strain configuration had hard times keeping frame rates up and had notable performance issues in general.

FIGURE 4. Asus p8z68-v/gen3 motherboard bios main screen in asus ez mode.

Power settings can be changed and forced from BIOS to work under Windows operating system.

4.2 DISPLAY- AND EXTERNAL DEVICES

Consumption in display terminals was twice the bigger in newer than older models but newer screens were 5" or even larger than older ones but newer display terminals consumed a bit less when switched off. Remarkable observation as seen on table 6, regarding to displays was that consumption in sleep-mode was exactly the same when display was completely switched off.

TABLE 6. Display devices in School of Business and information Management

	Consumption when		
Display Device	**ON**	**OFF**	**Sleep**
HP / HPL1906	40W	6W	6W
ViewSonic VA1703WB 17"	28W	6W	6W
BenQ G2200WT	44W	4W	4W
Compaq 1501	24W	4W	4W
Fujitsu-Siemens	29W	9W	9W

All display devices in table 6 are flat screen panels. BenQ model G2200WT was the newest model measured which was high definition TFT-LCD with 16:9 aspect ratio. All other models mentioned were old TFT-LCD with aspect ratio of 4:3.

TABLE 7. Brand new led display used with test environment configurations

	Consumption when		
Display Device	ON	OFF	Sleep
Asus 24" VE247H (LED Display)	25W	0W	0W

Brand new 24 inch full high definition display used with test environment configurations. When comparing table 6 and 7 we can find out that newer displays have smaller consumption in all cases whether they are set off, sleep or on.

TABLE 8. Test environment laptop

CPU / Cores	CPU GHz	RAM	Hard drive
Intel Dual-core	2,2	4GB	500GB
Consumption when			
Turned OFF	Startup	Turned ON	Heavy Strain
5W	35W	25W	50W

There are not many laptops in active use within the staff of School of Business and Information Management but I still decided to measure laptop in test environment (see table 8). Choosing a model to measure I decided not to pick up any brand new model but an average laptop that is more likely to be found in use within the staff members or students. Measured laptop had 64-bit Windows 7 installed. Measurement results were like expected. Laptop consumed 5W when turned off and only 25W when on normal desktop use. This is the same amount than display device used in test environment with desktop computers (see table 7). Heavy strain was tested with playing high definition video and during this test laptop managed to consume no more than 50W.

Table 9 includes printer models that could be found in almost every class room. Energy saving settings in printers were set to 1 hour. Other available options were 1 and 15 minutes though there were very little to none difference in energy consumption between ready state and power save state. Measured models looked pretty much the same visually but they were not the same and what comes the measurements results were either. Ready- and power state modes consumed around the same but when printer was on duty difference was immense. 4250N model consumed momentarily over 1000W more than 4200N model.

TABLE 9. Printers in School of Business and Information Management

	Consumption when		
Printers	Ready State	Printing	Powersave
HP LaserJet 4200N	27W	580W	24W
HP LaserJet 4250N	27W	600-1900W	23W

4.3 OTHER DEVICES

Tested projector is almost identical to the model that is installed on almost every classroom. The reason why actual model could not be measured was that every projector is connected to burglar alarm. Table 10 shows the consumption of the identical video projector model. Projectors energy consumption is around the same than desktop computers when set under heavy strain and because of this it would be very important to inform people to shut down projector when it is not used.

TABLE 10. Video projectors in School of Business and Information Management

	Consumption when	
Video Projector	OFF	ON
Hitachi CP-X275	25W	200W

Since schools own audio devices could not be measured I decided to measure normal home receiver in test environment to get a view how much audio devices consume (see table 11). Result was the receiver consumed far more than expected even in standby mode. Since some of the schools audio devices are always turned on, possible solutions for shutdown could be discovered.

TABLE 11. Test environment audio device

	Consumption when	
Device (Receiver/Tune-amplifier)	Standby	ON
Harman/Kardon AVR-230	68W	78W

4.4 CONCLUSIONS FROM MEASUREMENTS

General observations from actual measurements. Hardware consumption is not so much tied to its age but hertzes within the processor, not how many cores processor has. Old TFT displays consumed a lot more than brand new Asus 24" LED display. This was almost double less than BenQ G2200WT display was the latest model used in schools configurations. Asus display device used in test environment didn't consume any electricity whether in off or sleep-state unlike displays used in schools configurations that had exactly the same amount of consumption whether they were turned off or driven into sleep-state.

Printers and video projectors used as much electricity in power save mode as brand new display in test environment when it was turned on. Since none of schools audio equipment couldn't be measured I decided to measure normal receiver in comparison to get a view now much they could consume. Receiver turned out to be surprisingly energy hungry even on ready state. Some of the audio devices located in classrooms are always turned on so I decided to leave off state out of the test environment measurements. In future proper instructions to users should be given what comes to the use of schools audio devices and possible solution to turn off audio devices completely.

Certificate marked power supply unit was able to produce energy more effectively without producing unnecessary waste energy. Shift between SSD-drives and normal 3,5" SATA drives were around 30W for the benefit of SSD-drive configurations.

Displays with LED technology have dramatically dropped energy consumption but yet providing more inches on screens with sharper and clearer image. Consumption in configurations has even decreased in new from older configurations if we look at the power / wattage ratio.

5 GREEN IT; SOLUTIONS TOWARDS BETTER FUTURE

5.1 SOLUTIONS WITH EXISTING EQUIPMENTS

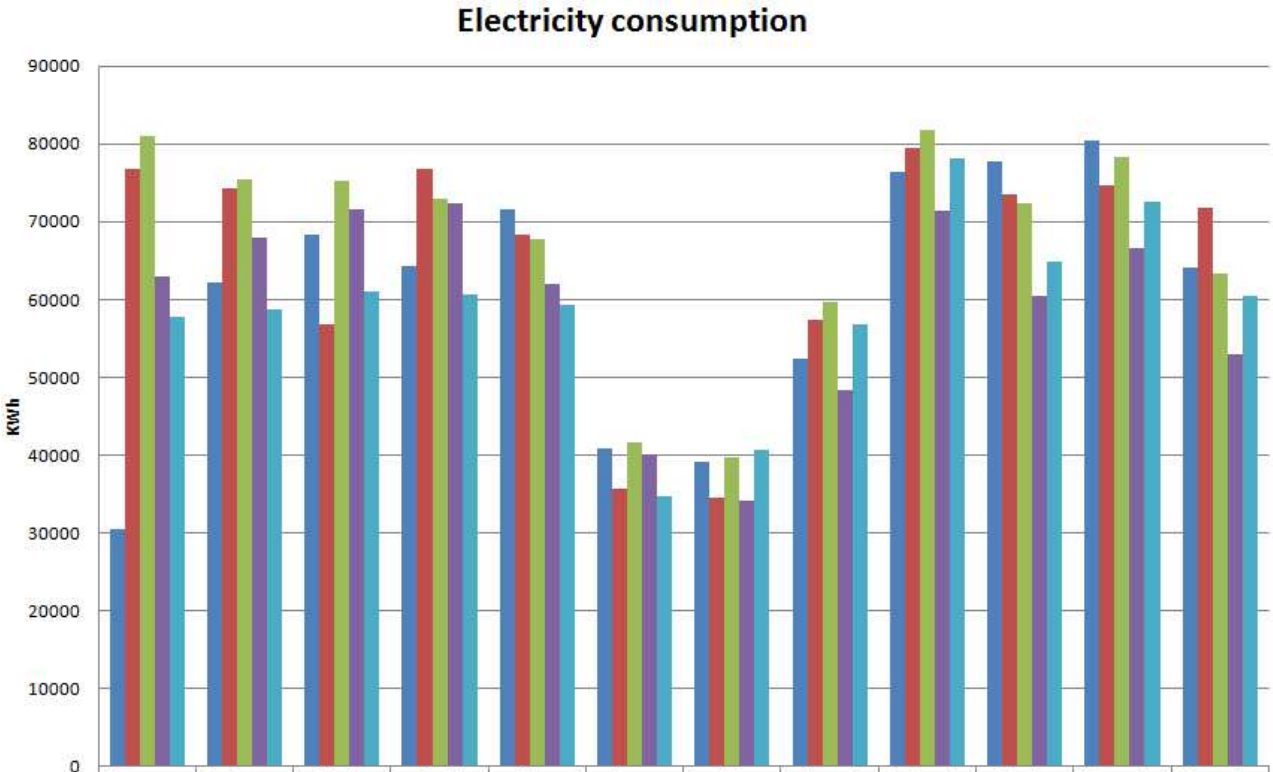
Looking at the annual electricity consumption charts (see figure 6 and table 11) the amount of consumption has clearly decreased in 2011 between January and June, drop of around -15% compared to year 2010. However according to the chart during period July and October 2011 consumption has skyrocketed. The reason for this could be the absence of automatic shutdown system for workstations. Although consumption may be impossible to calculate 100% accurate since utilization ratio may vary.

Since staff members computers cannot be affected with automatic shutdown system, polite energy consumption guides should be instructed to all staff members. Since best way to cut down electricity is to shut down devices, students could be taught to close their workstations after lessons. This could be done by informing new and existing students in this matter and setting up a wallpaper to all computers that says "please shut down computer after the lesson" or so. This wallpaper could be designed very neat looking by arranging a competition within the students. This wallpaper could be "Ernie dog" themed as displayed in figure 5, for example to match with the schools environmental guide.

*FIGURE 5. Ernie dog the symbol of environmental instructor in School of Business and Information Management (*OAMK environmental guide, date of retrieval 7.6.2012)

"You can't teach old dog new tricks" phrase might be true, that's why most important it would be to teach schools environmental policy to the new students before they learn old habits or import their own.

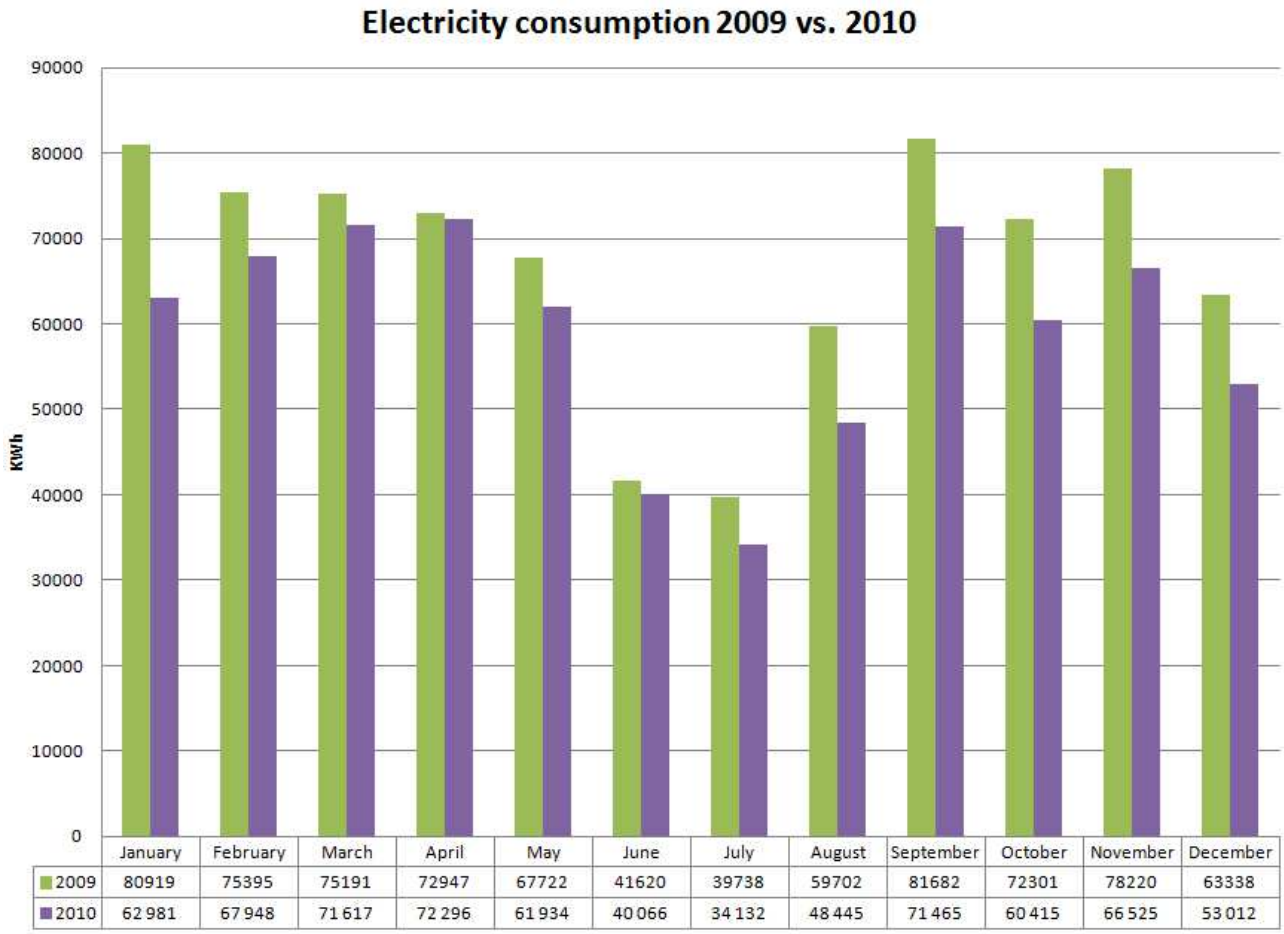
What comes to hardware and measurement results it would be very advisable to change all old TFT displays to new LED flat screens since with consumption of one old TFT, two LED screens can be used instead.



	January	February	March	April	May	June	July	August	September	October	November	December
2007	30486	62269	68283	64261	71537	40939	39200	52407	76313	77762	80401	64138
2008	76697	74276	56738	76831	68247	35713	34453	57369	79442	73531	74605	71836
2009	80919	75395	75191	72947	67722	41620	39738	59702	81682	72301	78220	63338
2010	62 981	67 948	71 617	72 296	61 934	40 066	34 132	48 445	71 465	60 415	66 525	53 012
2011	57 828	58 664	60 995	60 633	59 284	34 742	40 676	56 750	78 045	64 799	72 463	60490

*FIGURE 6. Electricity consumption chart in School of Business and Information Management (*Facility info, date of retrieval 5.3.2012).

During 2010 School of Business and Information Management developed an automatic shutdown system for Windows XP operating system which forces workstation to shut down after being idle for 30 minutes.



	January	February	March	April	May	June	July	August	September	October	November	December
2009	80919	75395	75191	72947	67722	41620	39738	59702	81682	72301	78220	63338
2010	62981	67948	71617	72296	61934	40066	34132	48445	71465	60415	66525	53012

FIGURE 7. Intense drop in electricity consumption between 2009 and 2010 in School of Business and Information Management

That might be one reason for 12% consumption decrease in 2010 (see table 12) In summer 2011 all workstations were updated to use Windows 7 operating system. This operation broke automatic shutdown system until December 2011 when it was fixed to operate again.

Overall consumption has risen from 2011 maybe because there are more starting groups and students than in previous years. However amount of exact electricity consumption is very hard to monitor, because the amount of people within the school unit is constantly changing. The more there are people the bigger consumption is. Weather should also be noted in consumption charts since cold winter lifts up electricity consumption. Also possible renovations during the summer might increase consumption as well.

TABLE 12. Electricity consumption chart in School of Business and Information Management

	2006	2007	2008	2009	2010	2011
January	0	30486	76697	80919	62 981	57 828
February	5640	62269	74276	75395	67 948	58 664
March	19480	68283	56738	75191	71 617	60 995
April	11100	64261	76831	72947	72 296	60 633
May	9340	71537	68247	67722	61 934	59 284
June	27240	40939	35713	41620	40 066	34 742
July	67740	39200	34453	39738	34 132	40 676
August	72620	52407	57369	59702	48 445	56 750
September	79340	76313	79442	81682	71 465	78 045
October	71760	77762	73531	72301	60 415	64 799
November	66960	80401	74605	78220	66 525	72 463
December	56060	64138	71836	63338	53 012	60490
Total		**727996**	**779738**	**808775**	**710836**	**705369**
Change in previous year			**7 %**	**4 %**	**-12 %**	**-1 %**

Automatization can be brought to certain level without affecting negatively into work efficiency and usability. Therefore, for example every workstation should be closed manually when user ceases working. Even though automatic shutdown would operate after 30 minutes of idle time. Although this is not more than 30 minutes but if this 30 minutes is multiplied with all computers within the classroom, 30 minutes turns into hours of idle time per one workstation which certainly will affect annual level of consumption.

Configuring power settings in Windows 7 operating system will make moderate to significant differences in energy consumption. Note that the more consumption is cut down the more is taken out from performance.

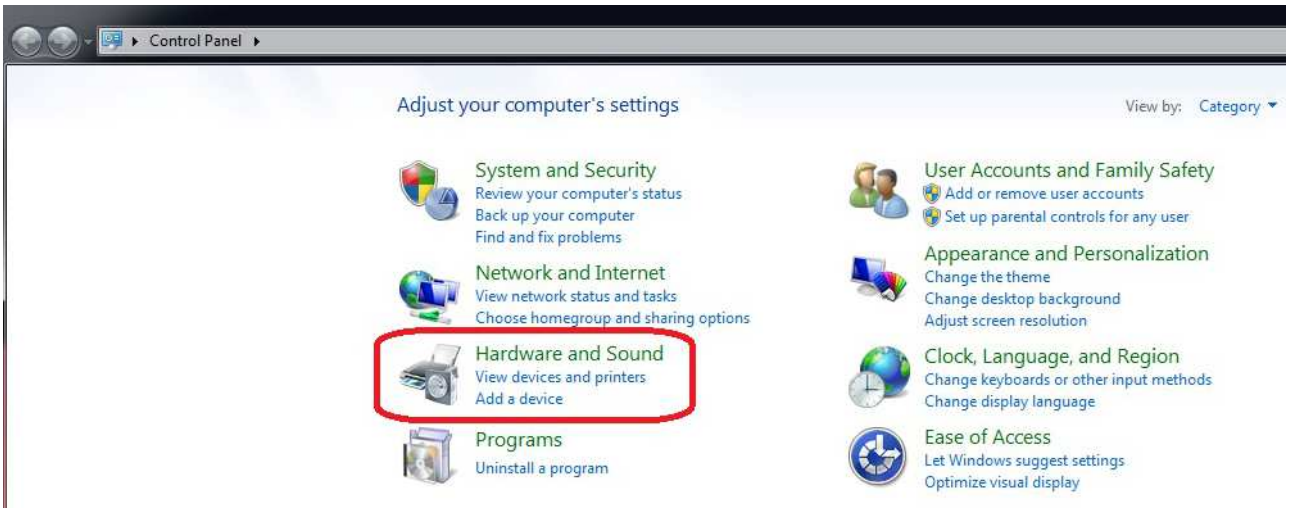


FIGURE 8. How to access Windows power options. Power plan settings can be accessed from control panels Hardware and Sound menu (see figure 8).

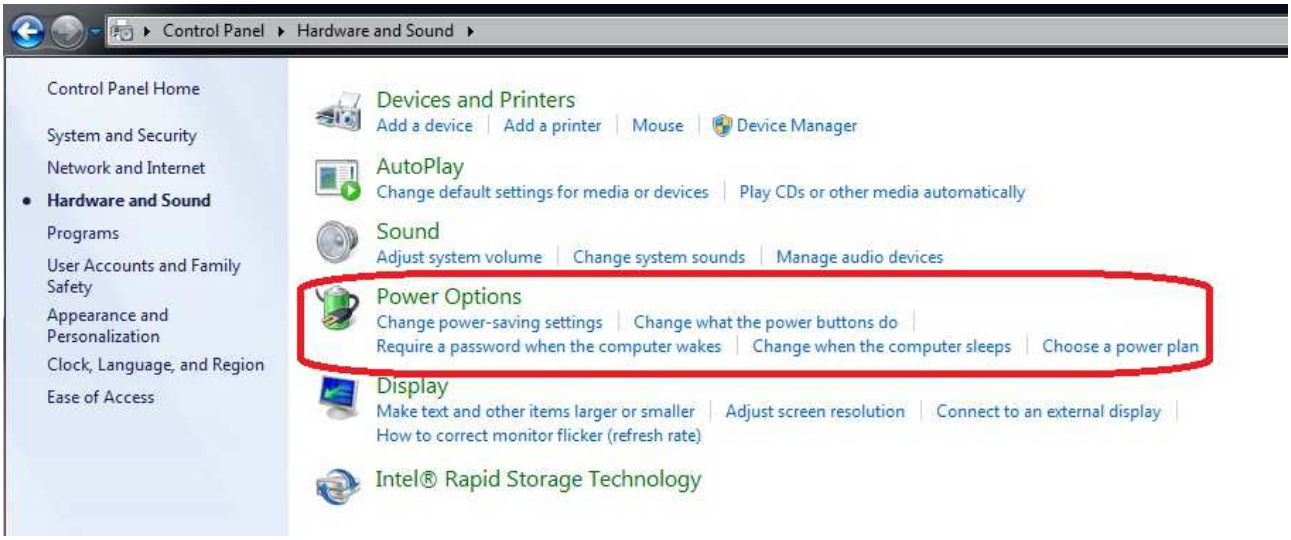


FIGURE 9. Power options are located in Windows hardware and sound settings.

How to access power options (see figure 9).

In Power Options menu there are 3 premade profile settings that each can be manually changed as user desires (see figure 10). Profile has 2 simple timer settings for the display and computer. Advanced settings includes such as behavior for hard disks, sleep mode and processor power (figure 11).

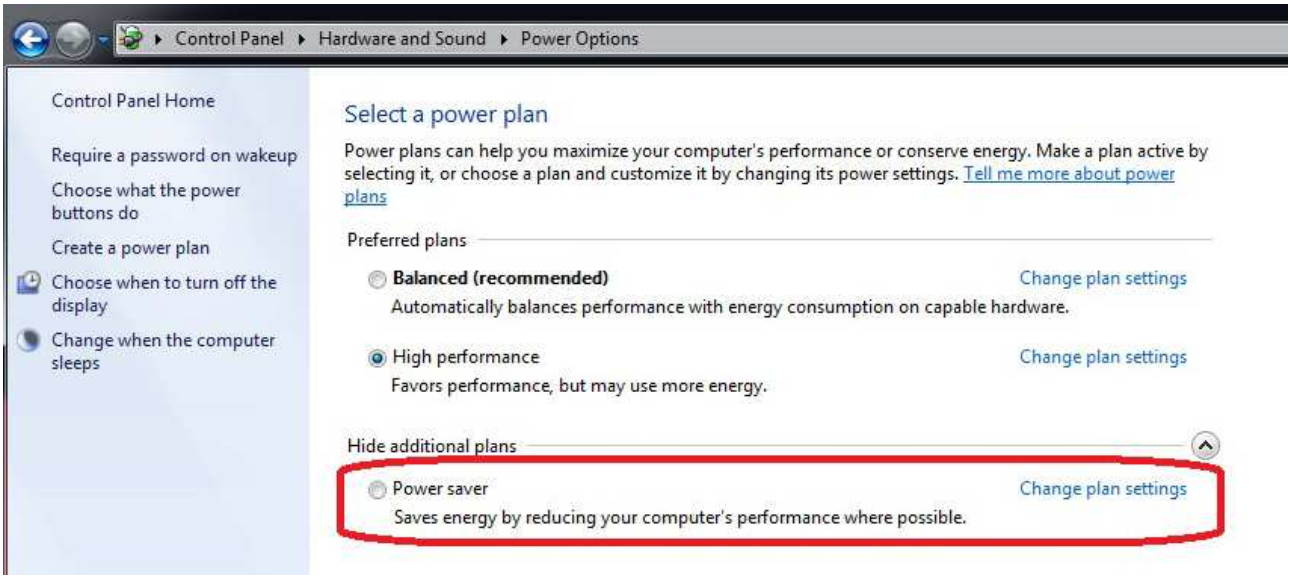


FIGURE 10. Profile selection within Power options.

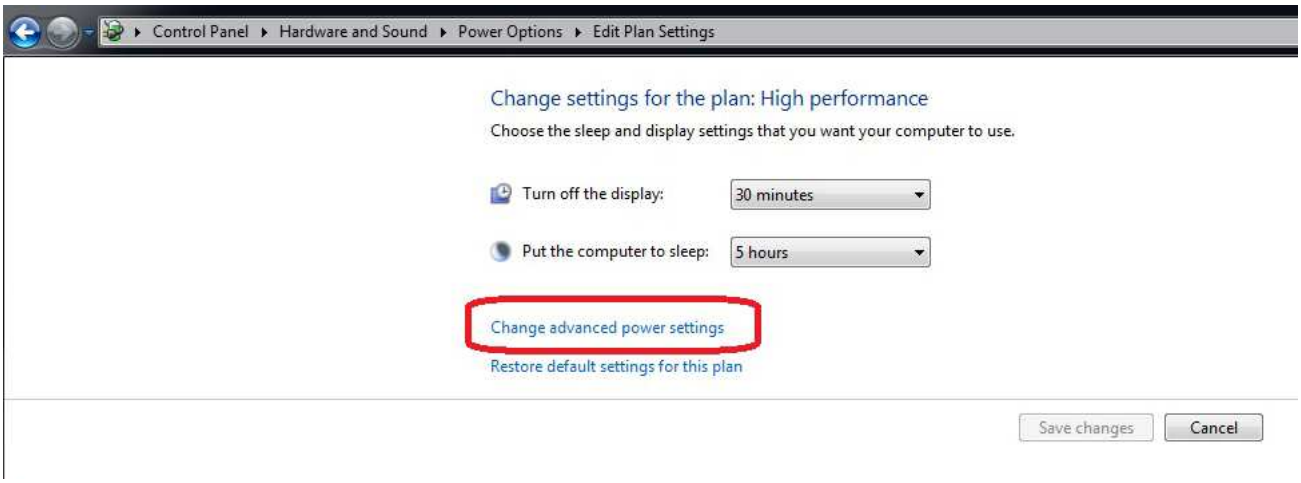


FIGURE 11. Simple options for power saving plans.

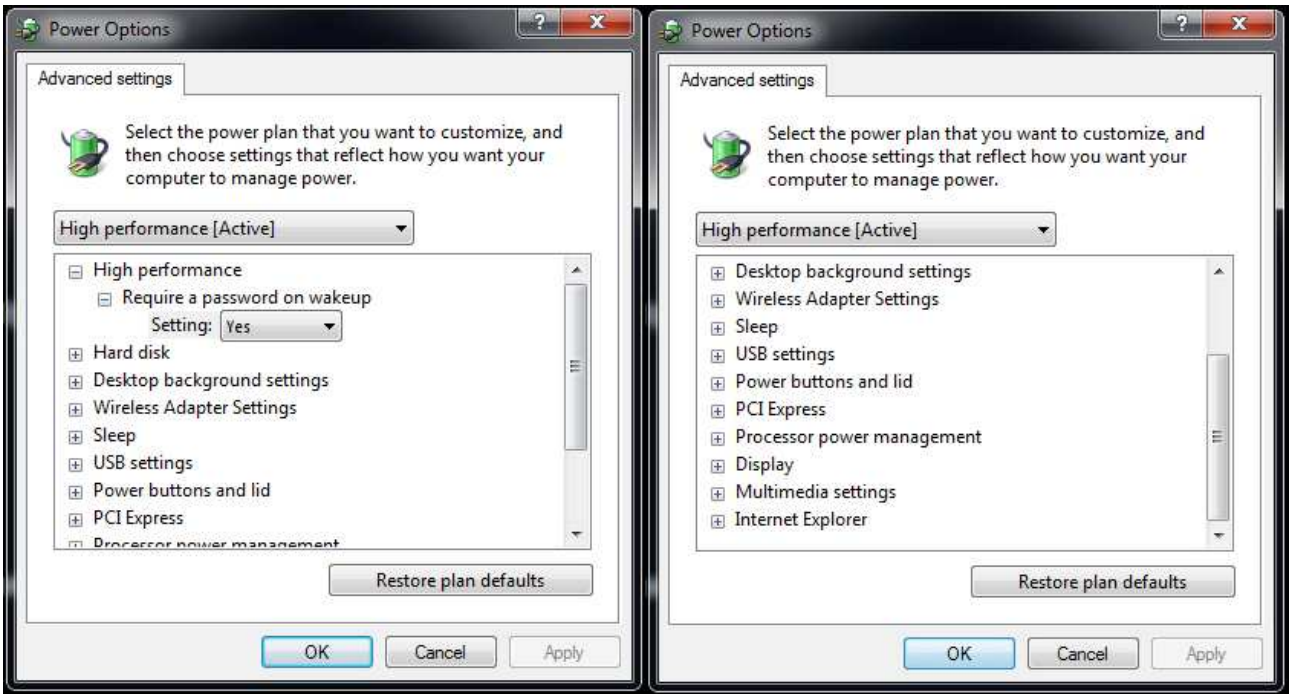


FIGURE 12. Advanced power plan options. Advanced options for power plans. Modified settings can be restored as defaults with just a push of a button (see figure 12)

Despite all power save configurations the absolute minimum consumption of configuration remains about the same, just maximum energy consumption will be decreased. Cutting power consumption has also setbacks such as cutting calculation abilities of processor.

5.2 WHEN TO CHANGE NEW HARDWARE?

It is impossible to set a specific pattern for hardware life-cycle, mainly because demand for updating or changing computer is so individual and connected to the use of equipment and for what purpose the configuration is meant to be.

"Rule of thumb" for changing configuration is somewhere between 2 and 4 years. Life-cycle can be extended slightly if configuration is possible to upkeep with upgrades instead of changing whole computer. Unnecessary change of hardware should be avoided due to hazardous waste which is set off from old components.

According to Velte J., Velte T. & Elsenpeter (2008, 164,165) hardware lifecycle is based on three factors:

"**Useful life** This expresses the equipment's lifetime, in which eventually the equipment wears out and it is not feasible to repair it anymore.

Technological life A system may become impractical to maintain even though it can still be repaired and maintained. For example, it might not be possible to find the right type of memory chips for the system because they are no longer made. Another way to look at this is obsolescence.

Economic life A system might still be functional, but it costs too much to use. It might also be that newer systems can be purchased that have lower operating costs so that the payback period of making that purchase is short."

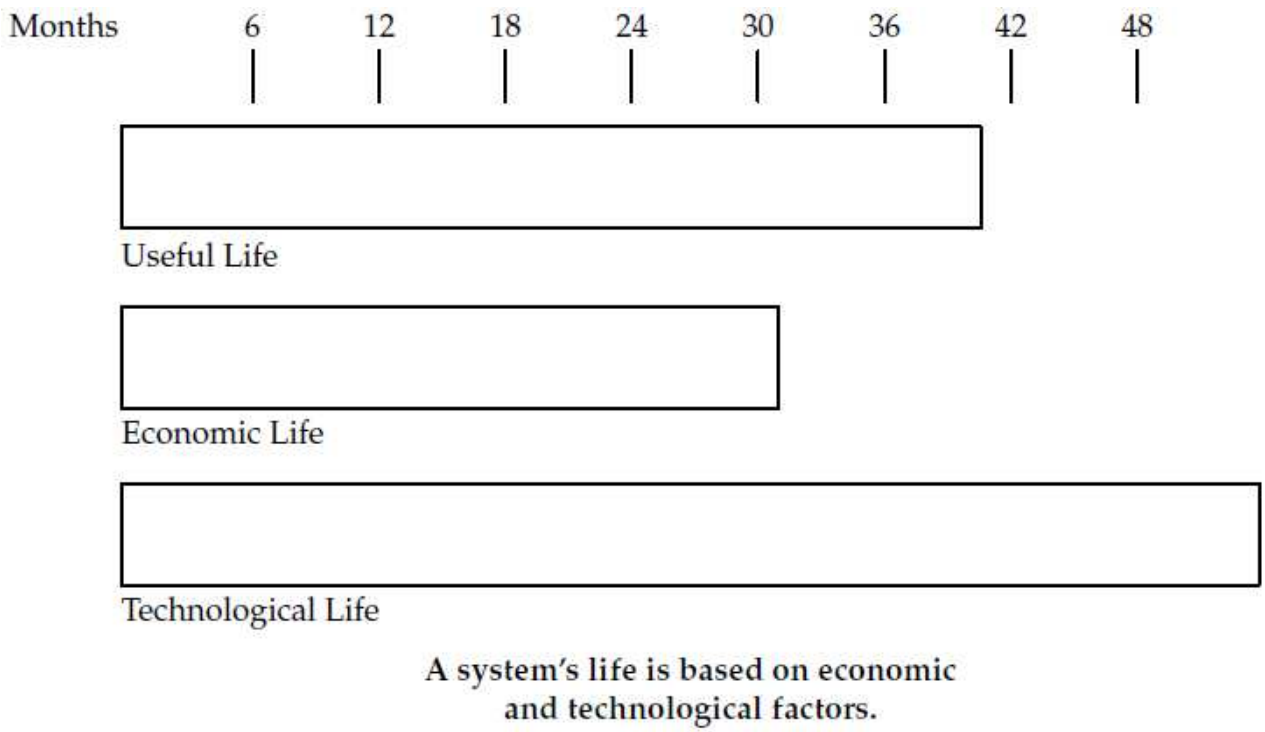


FIGURE 13. Hardware lifecycle chart. (Velte J., Velte T. & Elsenpeter, 2008, 136).

According to Velte J., Velte T. & Elsenpeter (2008, 136) it's impossible to predict lifetime of hardware and or configuration, but it can be estimated by taking reviewing these previously mentioned factors.

Thanks to new technology total consumption in configurations has decreased and new generation power supply units produce less spare wattages. According to Al Gore and International Energy Agency (2009, 245) roughly one extra dollar investment in electrical equipment saves more than two dollars in electrical supply.

All schools electronical equipment are acquired via Oulu Region Joint Authority for Education (Oulun seudun koulutuskuntayhtymä, OSEKK) and OSEKK is using EPEAT to get and recycle all equipment. EPEAT takes care that all equipment acquired via EPEAT meet the EPEAT standards in all levels from used materials to shipping phase and packaging. "EPEAT®-registered products meet strict environmental criteria. From fewer toxins in manufacturing to efficient operation and easier recycling" (EPEAT, date of retrieval 31.5.2012)

5.3 SCHOOLS INSTRUCTIONS ON ELECTRICITY AND ENERGY CONSUMPTION

Good basic instructions can be found from Oulu UAS environmental "environmental Ernie" guide (page 5). This guide can be found at large through intranet of School of Business and Information Management. This guide should be handed to all students especially starting students to get them used to schools environmental plan. Self evident is that staff should set students an example in environmental behavior. According to Ernie's instructions (2011, 5) for electricity and energy consumption are:

"DO NOT LEAVE EQUIPMENT SWITCHED ON UNNECESSARILY

Switch off your computer (or at least the screen) for the lunch break or longer meetings. It pays to switch off the screen even for a short while. The screen’s proportion of the computer’s electricity consumption can be up to 70 per cent.

Activate the energy-saving settings for your computer, printer, photocopier and other office equipment. The equipment consumes energy even in the standby mode, so be sure to switch it off for nights and weekends. A regular screensaver does not save electricity, just the screen. An image or animation used as a screensaver may even increase the consumption. The average energy consumption of laptops is just one-tenth of that of desktop computers with a CRT screen. The average consumption of LCD screens is 50–70 per cent lower than that of CRT screens.

When you need to print or copy something, do it in one go if possible. Favor energy-efficient equipment (for example, products with the Energy Star label). USE LIGHTING ONLY WHEN NECESSARY

Utilize natural light, use spotlights rather than ceiling lights. Switching off lights always pays when the room is unoccupied for more than ten minutes. Fluorescent lamps are not damaged when switched on and off. Replace incandescent bulbs with energy-saving bulbs. The electricity consumption of fluorescent bulbs is only a quarter of that of incandescent bulbs. They will also last eight times longer."

Velte J., Velte T. & Elsenpeter says (2008, 310) that SMART goals is a efficient concept to use in order to achieve green goals. These goals could be schools guidelines within modes of action. SMART is an acronym for:

FIGURE 14. Smart goal chart. (Velte J., Velte T & Elsenpeter, 2008, 310)

Specific: A goal that should be precise and put in terms people can relate to.

Measurable: Concrete criteria for measuring progress toward a goal

Attainable: Identify your goals and thinking of ways to achieve them.

Realistic: Keeping goals so that they are actually achievable

Timely: Time lining goals and checkpoints to keep plan in progress

5.4 VIRTUAL PC LABS

Due to complex and vast concept of virtualization I decided to give it less attention in this thesis. Students are using virtual PC labs at least in Linux and database courses. In future virtual PC utilization should be taken more effectively into consideration in schools courses. Although virtualization is an effective way to focus tasks on one computer and thus save power but usability deteriorates and virtualization itself requires more effective computer so perform those multiple tasks. In any case needless virtualization should be avoided since it makes even the most simple tasks more difficult to perform.

6 CONCLUSIONS

Measurements gave good indicative results from total energy consumption in School of Business and Information Management. Technology is advancing positively what comes to hardware and energy consumption and maybe within 5 years we'll see something remarkable for example in processor or power supply unit designs that will make present configurations look like electricity gluttons.

During the making process of this thesis I have learned quite a lot, things like how crucial air ventilation and cooling is for electric devices, how much differences there are in power supply units and how even small things like how product is packaged makes a mark in long run.

Still some further actions should be performed in order to obtain the final survey. Spreading information from green thinking to students and staff, pointing the facts out that small things will eventually snowball into big things when everything is added together. Environmental guide should be more easily accessible from schools intranet, now it is hidden within all the information and people barely knows that it exists, if at all. Throughout schools intranet needs to be made clearer, not just the sake of environmental guide.

Consumption of servers should be measured with software and check if physical placements of servers are done correctly to maintain proper air ventilation thus avoiding excess heat formation of server cabinet.

The use of classrooms in the evenings, weekends and summer studies should be organized so that classes would be on the same floor and in the same wing. This would allow reduction of lighting and air conditioning on floors which do not have any activity. According to plumbing specialist there is not even reason to use air conditioning, if the space is empty. People make air condition work properly, in empty room air will only be refreshed in ceiling areas.

Particularly unnecessary lighting should be main concern in future since lighting takes major part out of total consumption. Rooms should take advantage of natural lighting whenever possible and in future possible motion controlled light switches should be taken into consideration.

Since northern Finland's springs and summers are very bright and considering use of solar power with solar cell panels and / or making use of wind power somehow to cover up some of the electricity expenses during the year.

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