"COMPUTERS: TURN THEM OFF OR LEAVE THEM ON?"

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Abstract

With the advancement of technology, it is difficult to determine whether it is best to power-off computers during times of inactivity, or leave them on continuously in a low, power save mode. Questions that must be addressed include the "cost" of employees' time during virus patching and start-up, and how the hardware inside of the computer reacts to dramatic temperature changes – this is particularly an issue when turning them off and on often. Another issue to consider is how the fans keep the system cool, which becomes an issue when the computers are left on constantly. There is also the financial and carbon footprint issues that arise whenever energy is involved, and parts need to be manufactured. To address these issues, a cost benefit analysis will be used to compare three projects: the first is to turn off the computers when not in use, the second is to leave the computers on continuously in power save mode, and the third is to maintain the baseline, or status quo – which is ultimately a combination of both aforementioned projects. The Environmental Protection Agency's regional office in Seattle will be the sample used in this analysis. Ultimately, project one, "Turn Off Computers" was the best fit for EPA Region 10.

List of Figures, Tables, and Charts

Charts

List of Acronyms

ACPI	Advanced Configuration and Power Interface
ADT	A division of Tyco International, and a worldwide supplier of electronic security systems, communication systems, and integrated building management systems.
CBA	Cost-benefit Analysis
CPM	Computer Power Management
EPA	Environmental Protection Agency
GSK	Glaxo Smith Kline
IT	Information Technology
KW	Kilowatt- the measure of power equaling 1000 watts.
KWH	Kilowatt Hour- the rate of power consumption equaling 1000 watts for one hour. Power x time= KWH. Ie: 100 watt bulb illuminated for 10 hours = 1 Kwh.
LCD	Liquid Crystal Display
LEED	Leadership in Energy and Environmental Design - A certification program by U.S. Green Building Council.
PC	Personal Computer
R10	Region 10 for EPA – Oregon, Idaho, Washington, and Alaska
UWB	University of Washington Bothell
WOL	Wake on Lan

Computers: Turn them Off or Leave them on?

Statement of the Policy Problem

Today's society is faced with a superfluity of technology, making it difficult to determine the optimality of a computer system's overall performance. Whether it is for a business or personal use, when deciding what type of computer to purchase there are multiple factors that should be considered, such as: overall drive lifetime, energy consumption versus energy conservation, reduction in carbon footprint, and financial savings. Other pertinent factors include: design, disposal, and the cost to replace the hardware pieces or computer altogether. What is difficult to understand is how much of an effect power-on time has on overall computer lifetime, and whether it is better to power-off the computer more often or to leave it on continuously in an energy efficient power management setting.

House Bill 5646 (2006) states that, "It is the sense of Congress that it is in the best interest of the United States for purchasers of computer servers to give high priority to energy efficiency as a factor in determining best value and performance for purchases of computer servers." EPA's goal is to have 40% of computer purchasers actively using their power management settings nationally by 2010, 60% by 2012, and ≥ 80% by 2014. This is due to the recognized importance of power management, and EPA is trying to encourage American industry to develop a collective strategy for securing and funding this research, so that it may be useful to the American public. Although this bill only sets goals for computer servers, it is a step towards implementing standards on all computer equipment subject to power management settings.

Peter Orszag, the Director of the Office of Management and Budget, stated in his public address, "The public is getting a bad return on its tax dollars because government workers are operating with outdated technologies" (Campbell, 2008). It used to be that the technology provided in the federal workplace was current and more effective than what the typical household had to offer. Now that technology is so advanced and less expensive, households have access to incredible technology, leaving the federal government behind. Orszag's argument for better technology in the workplace is that, the American public is receiving slow and inadequate customer service and there is a lack of transparency about how dollars are spent. "…the American people deserve better service from their government, and better return for their tax dollars" (Campbell,2008).

Due to the difference in technology used by the government and the American public, it may vary as to whether it is best to power-off the computers in a government agency because of the inefficiencies of the equipment and hardware components. Outdated equipment will make the hardware more susceptible to drastic temperature changes, which would cause premature wear on the parts. The other alternative is to leave them running continuously, on a less energy efficient power management setting; causing higher energy bills, and a faster depletion of natural resources. "Turning computers off is generally perceived as the 'right thing to do,' people tend to — consciously or subconsciously — exaggerate how often they do it. A Lawrence Berkeley National Lab Report found that only 36% of computers got turned off each night in a sampling of commercial offices" (Campbell, 2008). This proposal takes a the problem of whether it is best to turn off computers when not in use or leave them on continuously and breaks it down by Federal Agency, and then by Regional Office. The pilot Regional Office for this project will be EPA Region 10, specifically; the focal point for rectifying the inefficient technology gap will be the Information Technology (IT) Department.

Policy Considerations

"In the business world, office equipment constitutes the fastest growing portion of electrical loads" (Power Management, 2010). Every day, technology is heavily relied upon for the most common uses: music, phones, clocks, calculators, copiers, fax machines, computers, printers, etc. The main issue with this is that most of the day the equipment is left on while not in use, which means power is being drawn unnecessarily. Effective ways of reducing electrical loads from the equipment, as well as cooling loads include simply unplugging equipment, or the purchase and use of Energy Star labeled office equipment. Replacing old office equipment with Energy Star equipment is also an opportunity that EPA can and should take advantage of. Power-management features increase the lifetime of computers and monitors, because drastic changes between hot and cold temperatures is a leading cause of equipment failure (Energy Star Product Specifications, 2011). When the power-management feature is used, the computer generates less heat due to slower and less dramatic phases of temperature changes, so it may last longer and maintain reliability. An additional advantage to power management settings is that manufacturers have increased the reliability of components, such as hard drives and microprocessors that "cycle" when power management is used (Power Management, 2010).

Policy Scenario:

Project One - Turn Computers Off. The first project option is to turn off the computers while not in use, or "Turn Off". The main goal of this project is to network all computers in EPA Region 10 together, and allow the employees, and the system itself to turn the computers on and off as necessary. One example of when this would be necessary is, weekends when no one is in the office, the computers would be automatically turned off after a certain time, or amount of time left idling. Another example of the benefits of this system include when a computer software patch needs to be uploaded, this can be done without interrupting employee work time, because computers can be patched during times that employees are not in the office. Virus patching and updates are a major setback to employee productivity, and these updates may last anywhere from ten minutes to an hour.

Policy Alternatives

Project Two - Leave Computers On. The second option is to leave on the computers all day and night, even when not in use, but in an energy efficient power-save mode. This would maintain a more constant temperature for the computer and the hardware. Additionally, employees would be able to begin working upon arrival, rather than waiting for the computers to turn on and complete the necessary updates, because the computers would be able to be patched during “non-working” hours (nights and weekends).

Project Three – Baseline. The third and final option is to allow computers to be left on constantly without a way to turn them off systematically. Currently, employees are responsible for turning off their computers when not in use, along with making sure that the power management settings are optimized for the agency. EPA also requires all computers to be left on at least once a week to download security patches during the night. Data will be collected from EPA, primarily through the IT unit. This data includes, how many computers, what types, what type of replacement schedule does EPA have (desktops, laptops), typical computer usage times, and what is the length of warranties on the computers.

Review of Literature

Big Fix Power Management Implementation in the Public School District. Tom Sims (2007) discusses the implementation of a power conservation program for the Miami Dade School district's 100,000 PCs with sufficient flexibility to accommodate differing opening hours and shutting down computers without reducing windows for necessary maintenance.

In 2007, BigFix in collaborated with Miami Dade Schools Information Technology Services (ITS) on implementing a new product, BigFix Power Management. The new solution from BigFix enables administrators to centrally set and implement power conservation programs on enterprise-scale IT infrastructures. Typically, this means that organizations can use BigFix to remotely shut down computers, or some of their subsystems, during non-business hours. This directly reduces power consumption, electric utility costs, and, more indirectly, damage to the environment. "We had been using BigFix for several years for security and system management purposes. Power management looked like a neat way to apply their technology, especially since the monetary and environmental benefits seemed to be direct. We then arranged to try out BigFix Power Management in a proof-of-concept at five schools" (Sims, 2009).

Power Management was installed on 80,000 PCs at 370 locations in the school district, now operate approximately 50% less per day. Installation only took a few days, and followed a proof-of-concept trial at five schools, from which the BigFix-Miami Dade team estimated power savings, electricity cost reductions, and carbon emissions reductions. Miami Dade IT achieves additional savings by coordinating computer down time with air conditioning shut downs. Based on proof-of-concept findings, Miami Dade correctly projected $2.1 million in annual electricity cost reductions on 80,000 PCs. This also translated to the school district saving an estimated

15,558 metric tons of CO2 per year — that's almost 194 pounds of CO2 per user annually (Sims, 2009).

Overall, those computers running BigFix Power Management run an average of 10.3 hours a day compared to 20.75 hours per day previously, the schools are now able to coordinate computer and HVAC electricity systems to save even more. Even with exceptions, 97 percent of the computers running BigFix Power Management are turned off when not in use. Wake-on-LAN features in BigFix Power Management have also proven useful to Miami Dade Schools. Sims comments: "We can wake up computers to service them even when BigFix Power Management turns them off. Not only can we synchronize system maintenance with power conservation, but we realized that the need to maintain computers was one of the reasons we left them on in the first place" (Sims, 2009).

"Glaxo Smith Kline Uses an Often Overlooked Windows Tool for Computer Power /management – And Saves Big: Free solution will reduce annual energy expenses by nearly $1 million". GlaxoSmithKline (GSK), the global healthcare group, sought out new ideas from their staff to put forward their most promising information technology management innovations. GSK business analyst Matt Bartow looked into what default sleep settings were used at GSK and discovered that the settings in use were minimal. Monitors were set to sleep after 20 minutes of inactivity, but no settings were in place to put inactive computers into a low-power sleep mode. Bartow drafted a proposal for implementing a companywide computer power management (CPM) policy and for improving GSK's existing monitor power management policy. He emphasized how the effort would not only save the company money, but significantly reduce its environmental impact.

To do this, Bartow developed preliminary savings estimates in conjunction with the Energy Star "Low Carbon IT" website. These estimates were based on typical commercial Energy Star computer usage patterns observed by researchers at US EPA and Lawrence Berkeley National Laboratory, and confirmed them with input from Energy Star technical support contractors and an external analyst.

In March, 2010, the company tested 550 computers for two weeks. "The company chose to work with a command line utility called powercfg.exe, which is included in Microsoft Windows XP, Service Pack 2" ("Glaxo Smith Kline Uses an Often Overlooked Windows Tool", 2010). The trial was so successful, that by August 2010, the company brought CPM to a total of 92,000 computers. Additionally, GSK patches PCs during normal business hours, so remotely waking up their sleeping computers in order to install periodic Windows security patches and software updates was not a factor in this situation ("Glaxo Smith Kline Uses an Often Overlooked Windows Tool", 2010).

Ultimately, GSK expects to save a lot of money from its CPM efforts. The company estimates it will save $989,317 a year, or $10.75 per computer. Energy Star technical support contractors note that "these figures probably understate actual savings, because GSK's baseline estimate of power consumption (that is, energy use prior to computer power management) was based on end-user responses to survey questions about how frequently they shut down their PCs. "People tend to overstate how often they turn off their PCs, when in reality they frequently forget" ("Glaxo Smith Kline Uses an Often Overlooked Windows Tool", 2010). The company's efforts will save an estimated 5,291 metric tons of CO_2 per year — that's almost 157 pounds of CO_2 per user annually.

Exclusions to the study: Certain computers must be left on 24 hours/day such as laboratory computers that control research equipment or perform overnight data processing, as well as computers that stream video communications throughout the global organization. In addition, there are LCD monitors in common areas such as cafeterias and elevators that were excluded.

"Seven Steps for Greening PCs". One of the main reasons agencies are so energy inefficient is that there are too many limitations on "the management and use of the technology including the lack of training and education of end users to ensure more energy efficient work practices" (Howard, Howard, and Lane, 2009).

ADT recognized that the IT infrastructure was drawing a significant amount of power to run their office equipment, and that often many computers sat idle as employees were working on other projects, in meetings, or on conference calls. A new environmental campaign called Project Greenfoot had recently been launched to help ADT employees reduce their carbon footprint and save energy. Initially the company rolled out a user-dependent power management plan that relied on employees manually powering off their workstations each evening and powering them on again in the morning. Issues with this system included employees choosing to ignore the campaign, or reverted back to old habits due to lengthy system start-up times in the morning.

Criteria used to find a new solution included: solution needed to provide central control of a workstation's power settings—especially the ability to override a user's settings and prevent the user from deactivating the power management software. The methodology used was a review and quantitative analysis of preexisting data from, regarding power consumption, ineffective system software, and mannerisms and behaviors that impact energy inefficiencies (Howard, Howard, and Lane, 2009).

ADT selected Faronics Power Save for a pilot deployment. During the initial deployment of Faronics Power Save, energy savings and cost benefits were recognized early on in the test program. Faronics' solutions helped ADT increase the productivity of existing IT investments and lower IT costs. This proved to ADT that Power Save had a rapid and quantifiable return-on-investment.

Currently, ADT has Power Save installed on 2,700 desktop and laptop computers. One of the key differentiations about Power Save for ADT is its low administration overhead. From March 2009 to July 2009, ADT has saved 181,037 kWh of electricity. If this is added into the savings generated during the pilot phase, this number jumps up to 227,088 kWh along with a continual 36,200 kWh per month. Power Save has enabled ADT to support one of its key strategic objectives: "to reduce its carbon footprint, save energy and become a much greener company"(Howard, Howard, and Lane, 2009). ADT did not provide an estimated monthly cost savings in conjunction with the monthly kWh reduction.

"Harnessing Green IT: Principles and Practices". In this article, Sam Murugesan defines the field of green computing as, "…the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment, such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment" (Murugesan, 2008).

Murugesan discusses the four main green pathways that must be addressed: Green use, green disposal, green design, and green manufacturing. Murugesan goes into further detail about the four points and determines that these solutions may also need to address end user satisfaction, management restructuring, regulatory compliance, and return on investment/financial motivations (Murugesan, 2008). This article is primarily related to the reduction in carbon footprint and energy savings issues which are related to the projects one and two proposed in the cost benefit analysis for EPA. The ideal solution for EPA would not only reduce carbon emissions, but also increase user satisfaction and productivity.

*"***The Green PC Environment"**. Steve Kleynhans from the Gartner organization have identified seven key steps of a program to improve environmental performance throughout the PC life cycle in the article: "Seven Steps for Greening PCs". Step 1: Survey Your Environment, Step 2: Create a Policy, Step 3: Set Realistic Goals for Energy Efficiency and Waste Management, Step 4: Budget for Tools to Reinforce the Policy, Step 5: Establish Reporting and Auditing Mechanisms, Step 6: The Right PC for the Right User, Step 7: Disposal (Kleynhans, 2008).

Power management settings can be considered, "Free tools to manage power settings are available but may not always be effective in all cases. Power management tools can support the enforcement of policies on energy use and reduce energy consumption without compromising security and desktop support. Although power management tools are relatively inexpensive, and often fully recover their costs in energy savings, they should still be budgeted for" (Kleynhans, 2008). This is because implementing a power management system has upfront costs, while it takes time to recover costs through energy savings. This is a factor that EPA must consider because, as a government agency, any additional funding requested must be budgeted for, and the public must be willing to pay for it through policy and taxation.

"Summary of Assumptions for EPA Energy Star Savings Estimates Energy Star Preliminary Draft Computer Specifications for ADT". The final document reviewed shows Energy Star initial savings estimates expected back in 2005. The first part of this document provides the basic assumptions that went into creating the estimates that the specification would not cause the current power management enabling rates in homes (10%) or businesses (6%) to increase or decrease.

In order to create an energy savings estimate, a baseline energy consumption of today's computers must be compared to the expected energy consumption of computers once the Energy Star specification takes effect. To simplify this calculation, the energy consumption of one computer is calculated by multiplying the power, in watts, consumed in an operational mode by the time (hours) spent over the course of a year in that mode. Then, this annual energy consumption per computer, kilowatt hours or kWh, is multiplied by the population of computers that are being measured (Energy Star Product Specifications, 2006). The power and duty cycle assumptions used corresponds with the table used for measuring EPA and UWB's power and duty cycle. Please refer to Table 1 below

Equation: Power (watts) x time (hours in a year) x population = energy consumption

Table 1

Standard and Energy Star Desktops & Laptops Power Modes

			Active Modes	
Power Level Assumptions in Watts	Off Mode Power	Sleep Mode Power	Idle State Power	High Performance State Power
Current Desktop Computer	2.9 W	11.2 W	Commercial: 55.0 W Residential: 70.0 W	Commercial: 80.0 W Residential: 126.0 W
Version 4.0 Energy Star Desktop Computer	2.0 W	5.0 W	Commercial: 42.0 W Residential: 52.0 W	Commercial: 70.0 W Residential: 101.0 W
Current Laptop Computer	2.4 W	7.0 W	21.0 W	30.0 W
Version 4.0 Energy Star Laptop Computer	0.50 W	5.0 W	21.0 W	30.0 W
Current Server	N/A	N/A	172.0 W	246.0 W
Version 4.0 Energy Star Server	N/A	N/A	140.0 W	200.0 W

Methodology

Cost Benefit Analysis (CBA)

A Cost Benefit Analysis is a study of the cost effectiveness by which you weigh the total expected costs against total expected benefits of two or more projects to determine the best option, which could mean the most profitable, most sustainable, most energy efficient, etc. The purpose of a CBA is to measure the efficiency of projects one and two, relative to the baseline (project three). The costs and benefits of the impacts of the alternative options are evaluated in terms of “the American public's willingness to pay for them (benefits) or willingness to pay to avoid them (costs)” (Gupta, 2010). If the EPA does not have the funding budgeted to replace their computers, or implement new technology, the funding will be requested from the public in the form of taxes.

Use of Cost- Benefit Analysis in Environmental Issues

A CBA was chosen to compare three possible projects which will determine whether or not it is best to leave computers on constantly, or to always turn them off when not in use. The three projects are: One - turn off the computers when not in use, two - to leave the computers on continuously in power save mode, and three - baseline– which is ultimately a combination of both aforementioned projects. The Environmental Protection Agency's regional office in Seattle will be the sample used in this analysis. Listed below are all possible tangible, and intangible, direct, and indirect, benefits, and costs for each of the first two projects, and the baseline measurements that EPA currently has in effect are listed in project three.

Analysis

Costs and Benefits for Each Study

Included at the end of this section is an abbreviated version of the costs and benefits to be measured. Please see Table 2 on page 29.

"Turn Off": **Direct tangible benefits of Project 1 include:**

EPA's IT unit will install software on the computers that will utilize the preexisting network to turn the computers off and on when necessary. Monitoring the system will take place as an additional duty for the technician that already runs the security patches. Data will come from EPA's IT unit. How: By implementing a system that is networked and can upload security patches at night, EPA employees will not have to be delayed or slowed down by computers patching during the middle of the day and requesting that the system be restarted.

Funds will be saved due to energy conservation. How: Computers will no longer be left on all night, or on the weekends. The system will be able to automatically power them off, reducing emissions, and conserving energy. Data will be provided by literature resources and by EPA's IT unit.

Longer computer hardware lifetime due to less wear and tear (this still has to be determined). How: Although this hypothesis is still in the initial stages and needs more analysis, it is possible that by having the computers systems powered on for less hours per day, their hardware components will remain intact and healthy for a longer lifespan. Data will be provided by literature from Tomshardware.com and Slashdot.com, along with other literature resources and input from EPA.

Direct intangible benefits:

There will be a realized overall reduction in virus patching application time. Ie: 5 hours of employee time saved per week. How: Once the program is up and running independently, the IT employee(s) will not have to spend nearly the amount of man hours that were required before the computers automatically patched. Data confirming this will come from EPA's IT unit.

Taxpayers' dollars can be reallocated to other projects and other needs of society. How: An automatic system will require less personnel expenses and employee time can be spent on operations, thus increasing the amount of time allowed for other projects etc. Data will be gathered through the Federal reserves on how employee time is reallocated to meet the needs of the government. Another direct intangible benefit is the overall reduction in unnecessary kilowatt usage. How: Less power on time for the computers will equate to less electricity being used. The data will come from a combination of General Electric's white papers, IEE database, and other literature resources.

Energy Conservation: "Technology needs to be able to change behavioral patterns; it can do this by allowing energy users to see graphically the impact their energy use can have in their workplace. Advance real-time energy metering is able to help "people" save energy by their actions. Rather than become wasteful automatic energy saving technologies. Data will be collected through literature resources along with EPA's internal white papers on the subject.

Indirect tangible benefits:

An indirect tangible benefit of project one is product longevity. How: Gartner maintains that the PC manufacturing process accounts for 70 % of the natural resources used in the life cycle of a PC. Therefore, the biggest contribution to green computing usually is to prolong the equipment's lifetime. Another report from Gartner recommends to "… look for product longevity, including upgradability and modularity" (Gartner, 2007). For instance, manufacturing a new PC makes a far bigger ecological footprint than manufacturing a new RAM module to upgrade an existing one, a common upgrade that saves the user from having to purchase a new computer. Lastly, a reduction in office cooling costs (less heat load) is another benefit of project one. How: When cooling in off-hours is already turned completely off, then there is less heat impact on office equipment or need to turn on cooling for workers during off hours.

Indirect intangible benefits:

Indirect intangible benefits include, a reduction in carbon footprint. How: Power on time will be limited to actual computer usage. Data will be calculated by using an average kilowatt hour usage tool. Another benefit is realizing future gain through long term applications. How: Technology will be produced and tested that can be used in other agencies, public and private. This creates long term benefits for society overall. There will be less controversy. How: It supports EPA's mission statement, "To protect human health and to safeguard the natural environment — air, water, and land — upon which life depends" (EPA Mission Statement, 2011). Lastly, there will be fewer funds spent on new equipment. How: The hypothesis is that computers would need to be replaced less frequently due to less power on time. Data is still being collected from the literature sources listed below.

Direct tangible costs include:

The direct, tangible costs involved include purchasing the software, which is already in existence, to create a sustainable system. There will be an **i**ncrease in FTE during creation and implementation stages of product. How: Funding the initial labor costs to setup the system would require EPA to hire/pay for additional personnel hours for installation and troubleshooting of new software.

Direct intangible costs:

The direct intangible costs include, potential loss of jobs due to computer efficiency not requiring human guidance. Time spent troubleshooting issues/bugs with the software installed, and additional kilowatt usage while in implementation stage.

Indirect tangible costs:

Indirect tangible costs include, manual installation of software onto the computers, the purchase of the software necessary to automatically power on and off the computers through the network (ACPI, 2008), and physical wear and tear of hardware.

Indirect intangible costs:

Indirect intangible costs are more difficult to define. A specific cost includes employees concern for privacy due to computers ability to turn on and off automatically.

"Leave On": Direct tangible, benefits of Project Option 2 include:

Direct tangible benefits include, computers will still be able to receive their security patches, and additional funds will be saved to due to more efficient use of employee time. There will be less start-up and shut-down time every day, and potentially, longer computer hardware lifetime due to less wear and tear. Software such as Faronics Power Save Management Systems will manage the power settings. Other benefits of project two include, intelligent computer energy management, non-disruptive to user or IT processes, power consumption and savings reports, ability to override operating system power management, and system is deployed and managed through a central console.

Direct intangible benefits:

Direct intangible benefits include overall reduction in unnecessary kilowatt usage (Smalley, Tim).

Indirect tangible benefits:

Indirect tangible benefits include, employees are able to divert time and attention to other critical job elements. How: The employees will not have to worry about turning off and on their computers, therefore, eliminating one thought process to make room for another. Also, maximum machine efficiency reduces the premature replacement of hardware.

Indirect intangible benefits:

Indirect intangible benefits include, Reduction in carbon footprint, and the potential for future gain. How: Technology will be produced and tested that can be used in other agencies, public and private. This creates long term benefits for society overall. Lastly, there will be less controversy. How: It supports EPA's mission statement, "To protect human health and to safeguard the natural environment — air, water, and land — upon which life depends" (EPA Mission Statement, 2011).

Direct tangible costs include:

Direct tangible costs include, additional FTE would be required to implement this solution. Why: Short term training for employees will require more man hours. Also, the monetary cost of continuous kilowatt usage. Why: Because the computers would be left running 24hrs a day (Lawrence, 2009). Lastly, the potential exponential physical wear and tear of hardware on the components in comparison to turning on and off the computers routinely.

Direct intangible costs:

Direct intangible costs include, continuous usage of energy resources. How: Computers will always be left on, constantly draining power (Murugesan, 2008).

Indirect tangible costs:

Indirect tangible costs include, the premature replacement of hardware due to constant wear and tear. How: fans will be thermocycling continuously so that the computers do not overheat (Feng ,2005).

Indirect intangible costs:

Indirect intangible costs include the depletion of natural resources due to constant energy usage.

"Baseline" Direct tangible, benefits of Project Option 3 include:

Direct tangible benefits include that all “benefits” will remain unchanged, and there will be no added workload for employees and no added workload for IT. Operations would be considered “business as usual”, and no new software would be required.

Direct intangible benefits:

Direct intangible benefits include, computers will still receive their security patches, no added energy usage, and employees will be able to continue work as usual with the same amount of interruptions. Overall, all “benefits” will remain unchanged.

Indirect tangible benefits:

Indirect tangible benefits include, no additional training required for employees and no need for funding the initial labor costs to setup the system. Overall, all “benefits” will remain unchanged.

Indirect intangible benefits:

Indirect intangible benefits include no need for “retraining” the employees on a new system and instead, allowing employees’ current schedules to continue as usual. Overall, all “benefits” will remain unchanged.

Direct tangible costs include:

Direct tangible costs include lengthy start- up times, no additional money is being used on FTE, and otherwise, all “costs” remain unchanged.

Direct intangible costs:

Direct intangible costs include, the existing solutions are disruptive to the workplace, and otherwise, all “costs” remain unchanged.

Indirect tangible costs:

Indirect tangible costs include, patches and updates are not consistently delivered to all computers, data can be lost during system restarts after the uploads, and otherwise, all "costs" remain unchanged.

Indirect intangible costs:

Indirect intangible costs include continued environmental degradation.

Table 2

CBA Measures

Project	Direct Tangible Benefits:	Direct Intangible Benefits:	Indirect: Tangible Benefits:	Indirect Intangible Benefits:	Direct, Tangible Costs:	Direct Intangible Costs:	Indirect Tangible Costs:	Indirect Intangible Costs:
#1 Turn off	**IT unit will install software which will utilize the network to turn the computers off and on when necessary.**	**Energy Conservation. The overall reduction in kwt usage. Reduction in start-up time.**	**Longevity- less wear and tear on the computers.**	**Fewer funds spent on new equipment.**	**Increased FTE during creation and implementation stages of project.**	**Time spent troubleshooting issues/bugs with the software installed**	**Purchase of software necessary to power on and off computers through the network.**	**Employees concern for privacy.**
#2 Leave on	Computers will receive their security patches.	Less start-up and shut-down time required every day.	Employees will be able to immediately begin working.	Future gain. Technology will be produced and used in other agencies.	Cost of continuous kilowatt usage	Physical wear and tear on hardware.	Possible premature replacement of hardware from constant wear & tear.	Depletion of natural resources due to constant energy usage.
#3 Baseline	No added workload for IT employees	Computers still receive maintenance. No change in energy usage.	No additional training for IT employees	No “retraining” employees on a new system.	No additional money is used on FTE	All “costs” remain unchanged.	All “costs” remain unchanged.	No change in environmental impacts

Qualitative Background Discussions

Through qualitative interviews with Joe Shelley, the Assistant Director of IT Services at the UWB's IT department, and Tony Guerrero, the Director of Facilities Services at UWB, I learned of a new policy that UWB's IT unit was implementing on campus to conserve energy and costs accrued by the campus computers. UWB received a grant to LEED certify the buildings on campus, and due to LEED specifications and requirements, a portion of the grant was dedicated to "greening" UWB's computer system. Currently UWB does not turn off their computers… ever. The policy currently in place requires that all computers must be left on 24/7 to receive updates and virus patches. The UWB's "greening" grant will allow UWB to install and implement software that will allow the 2,600 computers to be turned off and on through the network, thus still allowing for updates to be received while energy usage and costs can be cut-down. For a complete list of interview questions asked, please refer to Appendix One.

Myrna Jamisen the Contracting Officers Representative at EPA R10 was vital in attaining information regarding EPA's current practices. From interviewing Mrs. Jamisen, I was able to attain the specific numbers used in my analysis to calculate costs and savings. Data provided about EPA included the total number of laptops, desktops and monitors in use, the amount of hours per day computers are on, the potential reductions of power per mode for each day, and who EPA has contracts with. The population size for EPA is 545. 350 of these are desktops, 295 are laptops, and there are approximately 394.25 monitors in use (the partial monitor is due to the percentage given of 15% of all laptops are used with monitors. This is equivalent to 44.25 monitors.). The best-suited project for both EPA and UWB will be determined by cost savings, energy savings, computer type (PC and Desktop), hardware components, Energy Star rating, and time. Please see the tables 3,4, &5 below.

Table 3

EPA "Turn Off"

Mode / Week	Hours Active, Sleep, Idle, or Off	days/ week	Total hours/ week	% of week
Active	5.5	5	27.5	16%
Idle	1	5	5	3%
Sleep	1.5	5	7.5	4%
Off	16	5	128	76%

Table 4

EPA "Leave On"

Mode / Week	Hours Active, Sleep, Idle, or Off	days/ week	Total hours/ week	% of week
Active	5.5	5	27.5	16%
Idle	1	5	5	3%
Sleep	15	5	75.6	45%
Off	2.5	5	60.48	36%

Table 5

EPA "Baseline"

Mode / Week	Hours Active, Sleep, Idle, or Off	days/ week	Total hours/ week in Mode	% of week
Active	7	5	35.25	21%
Idle	2	5	10	6%
Sleep	4	5	20.25	12%
Off	11	5	102.5	61%

Table 6 - shown below, reflects the power levels used in each mode (off, sleep, and active) for desktops and laptops for standard and energy star computers (Power Management, 2010).

Table 6

Standard and Energy Star Desktops & Laptops Power Modes

Power Level Assumptions in Watts	Off Mode Power	Sleep Mode Power	Active Modes: Idle State Power	Active Modes: High Performance State Power
Current Desktop Computer	2.9 W	11.2 W	Commercial: 55.0 W Residential: 70.0 W	Commercial: 80.0 W Residential: 126.0 W
Version 4.0 Energy Star Desktop Computer	2.0 W	5.0 W	Commercial: 42.0 W Residential: 52.0 W	Commercial: 70.0 W Residential: 101.0 W
Current Laptop Computer	2.4 W	7.0 W	21.0 W	30.0 W
Version 4.0 Energy Star Laptop Computer	0.50 W	5.0 W	21.0 W	30.0 W
Current Server	N/A	N/A	172.0 W	246.0 W
Version 4.0 Energy Star Server	N/A	N/A	140.0 W	200.0 W

Results

Methods, Analysis of Data, and Interpretation of Findings

Environmental Protection Agency. Qualitative and quantitative data for this project was collected from past literature experiences in this field along with related technology fields, past surveys completed by the EPA, and interviews with personnel in the technology field. Data was also collected from EPA's IT department, along with from UW's IT department which is doing a similar project for the university.

After the analysis has been completed, and the project has been accepted by EPA Region 10, the implementation of the software package setup will take approximately one year. A deadline for acceptance of this project is hard to define due to the government potentially facing political constraints in its investment decisions, and ill-defined sources of government revenue. The goal time horizon for acceptance of this project is short-term, 4 to 6 months, considering that technology is constantly changing and being updated, therefore, to keep this project relevant, it must be implemented in the near future.

As previously shown, population size, and hours per day in each power mode (off, sleep, idle, active) were attained from EPA. To calculate these results, each project option was multiplied by power drawn in watts per hour in each mode and the percentage of the day that the computer and monitor spent in that mode. This was translated into kilowatts by dividing the number of watts by 1,000, then multiplying the result by the number of hours that the power is being consumed. The kWh was then multiplied by the rate that Seattle City Light charges to find the total dollars paid and again multiplied by 365 days in a year. Please refer to the break-down of the equations listed below, along with table 7, which reflects Seattle costs per kilowatt.

Equations:

Power drawn (watts) x hour(s) in day spent in each mode= watts per day for each mode

Watts per day for each mode /1000 = KWH per day.

KWH x 5 days in a work = KWH per work week

KWH x Seattle City Light rates= $ paid per day

$ paid per day x 365= Total $ paid per year.

Table 7

Seattle City Light Costs per Kilowatt

	$/kwt	$/kwt after 10 kwt	CO2/kwh
Dollars $	0.0461	0.0956	0.0007

Note: 1kWh=0.0007 metric tons CO2

“Turn Off” Results. Between “Turn Off” standard and Energy Star there is a 21% savings and a 20 metric ton reduction.

Table 8

"Turn Off" Results

	Standard	Energy Star	25% Energy Star	75% Energy Star
Total kw/year	121,860	93,361	114,735	100,486
Total Cost/year	$11,649	$8,925	$10,968	$9,606
Total metric tons CO2/year	85	65	80	70
Savings %	20%	21%	20%	21%

"Leave On" Results. Between "Leave On" standard and Energy Star there is a 13% savings and a 26 metric ton reduction.

Table 9

"Leave On" Results

	Standard	Energy Star	25% Energy Star	75% Energy Star
Total kw/year	140,222	103,427	131,023	112,625
Total Cost/year	$13,405	$9,887	$12,525	$10,766
Total metric tons CO2/year	98	72	92	79
Savings %	8%	13%	9%	11%

"Baseline" Results. Between "Baseline" standard and Energy Star there is a 22.08% difference, just by maintaining the same practices, but changing to 100% Energy Star computers, along with a 24 metric ton reduction.

Table 10

"Baseline" Results

	Standard	Energy Star	25% Energy Star	75% Energy Star
Total kw/year	152,330	118,693	143,920	127,102
Total Cost/year	$14,562	$11,347	$13,758	$12,150
Total metric tons CO2/year	107	83	101	89
Savings %	0%	0%	0%	0%

Overall results for all three projects, standard and Energy Star are compared side by side in Table 11 below. This table also includes results for a combination of 75% standard, and 25% Energy Star computer systems.

Table 11

EPA Overall Results for all Three Projects

	"Turn Off"	"Leave On"	"Baseline"	"Turn Off" 25%	"Leave On" 25%	"Baseline" 25%
KWH/Year	121,860	140,220	152,330	114,735	131,025	143,920
Cost/Year	11,650	13,405	14,562	10,968	12,525	13,760
Metric Tons CO2/Year	85	98	105	80	90	100
KWH/Year; Energy Star	93,360	103,425	118,693	100,485	112,625	127,100
Cost; Energy Star	8,925	9,887	11,345	9,605	10,766	12,150
Metric Tons CO2; Energy Star	65	72	83	70	80	90

The best-suited project was determined using a combination of: Cost savings, energy savings, computer type (laptop and desktop), hardware components, Energy Star rating, and time. Ultimately, “Turn Off” realizes a 22.2% savings for their standard computers, and 23.9% savings for Energy Star computers. “Leave On” realizes an 8.3% savings for standard computers, and a 13.7% savings for Energy Star. The full tables for each project option are listed below in Appendix 5.

University of Washington-Bothell. Additionally, UWB was reviewed. Based on the same equation that was used for EPA, UWB will realize a larger percentage of savings than EPA due to the ratio of desktop to laptop computers. Please see the table 12 below.

Table 12

University of Washington-Bothell Results

	"Turn Off"	"Leave On"	"Baseline"	"Turn Off" 25%	"Leave On" 25%	"Baseline" 25%
KWH/Year	895476	962279	936418	843749	898680	740294
Cost/Year	85607	91993	89521	80661	85913	70771
Metric Tons CO2/Year	626	673	655	590	629	540
KWH/Year; Energy Star	688567	707886	717715	740294	771484	772391
Cost; Energy Star	65826	67673	68613	70771	73753	73840
Metric Tons CO2; Energy Star	482	495	502	518	540	540

Recommendations for Action

EPA recently implemented a “lifecycle policy” for their computers. Previously there was not a replacement schedule, but now, 25% of all computers must be replaced per year. This means that new contracts will replace computers before hardware components are outdated or no longer covered by warranty. EPA will now be donating all computers to local schools in and around Seattle. An additional benefit to this is that now all computer lifetimes coincide with the warranties they come with, making replacing individual hardware components within a computer a non-issue.

Based on the results of the previous analysis and the newly implemented policies, the main recommendations for EPA include: education and training for employees, creating power supply and operational mode minimum efficiency requirements, purchasing only Energy Star computers when replacing old computers, ensuring proper setup of equipment and that power management settings are fully utilized, and finally, purchasing software which will turn on and off computers through the network whenever necessary.

Educate Employees – so that they understand what power management is and why it is important to them. Simple ways to reach them may include signs posted that read: *"Is 'Sleep' the same as 'Off?' No. Sleeping equipment still draws some electricity, so turn it off when not in use for long periods of time."* Also, "*screen savers were created to prevent images from burning onto a monitor's screen, but all they really do is draw additional power because they do not allow computers to use their power-management features properly*". Lastly, *"Energy Star labeled equipment produces less heat by powering down when not in use. Ultimately, this can reduce energy costs of air-conditioning and contributes to a cooler and more comfortable workspace".*

Purchase Energy Star Products - Revise the purchasing or procurement specifications to include Energy Star.

Turn Off Computers - Require EPA employees to turn off their computers when not in use. Remind them that they do not have to wait for the power management settings to go into effect every day.

Enable Power Management Feature - Ensure the power management feature is enabled on all monitors and computers at EPA, particularly upon installation and after service is performed.

Set a Region Wide Policy - Voice it to the employees. Inform employees through regular training and other internal materials, that Energy Star is an organizational policy. E-mail and messages can be sent to employees providing them with Energy Star information as well as updates on the air pollution reductions resulting from their using energy-efficient equipment. Displaying Energy Star posters in copy rooms, lounges, and other areas can also help to remind employees to use the energy-saving features and to turn off their equipment at the end of the day.

Use Free Solution - Require IT to take advantage of Microsoft's free power save options, to maximize power savings without spending more. Power management settings can be set through a logon script using the command line utility powercfg.exe, which is included with Microsoft Windows. It can be used to configure most power options. In Windows, only Local Administrators and Power Users have the rights to change the settings, but employees can still do things such as: create "tasks" or "switches" to turn computers on or off, or get "sleep proxy" and "wake-on-LAN" software.

Power Supply Efficiency Requirements- Computers Using an Internal Power Supply: 80% minimum efficiency at 20%, 50%, and 100% of rated output and Power Factor $\geq$ 0.9 at 100% of rated output. Computers Using an External Power Supply: Must be Energy Star qualified or meet the no-load and active mode efficiency levels provided in the Energy Star Program Requirements for Single Voltage Ac-Ac and Ac-Dc External Power Supplies (Computers for Consumers, 2010).

Operational Mode Efficiency Requirements- Desktop Categories for Idle Criteria: For the purposes of determining Idle state levels, desktops, including integrated computers and desktop-derived servers, must qualify under Categories A, B, or C as defined in Table 13:

Table 13

Operational Mode Efficiency Requirements

Categories	Desktop Categories for Idle Criteria
Category A	All desktop computers that do not meet the definition of either Category B or Category C below will be considered under Category A.
Category B	To qualify under Category B desktops must have: Multi-core processor(s) or greater than 1 discrete processor, and a minimum of 1 gigabyte of system memory.
Category C	To qualify under Category C desktops must have: Multi-core processor(s) or greater than 1 discrete processor, and A GPU with greater than 128 megabytes of dedicated, non-shared memory. Minimum of 2 gigabytes of system memory, TV tuner and/or video capture capability with high definition support, and/or Minimum of 2 hard disk drives.

Discussion

Limitations of the Study

Further Research. Calculating costs and energy consumption for manufacturing hardware – not a factor for EPA due to warranties on computers and the recently implemented "lifecycle policy" which created a replacement schedule for computers of 25% every year; which covers the span of the warranties purchased with the computers (Jamisen, 2011). This would be a factor if the study was expanded and/or generalized to larger population of computers or organizations. Then factoring in carbon footprint of manufacturing individual components for replacement versus replacing the entire computer on a schedule.

With more time and technical tools, original data could have been used, rather than secondary data. With the proper equipment, actual time spent in each mode for every computer day could have been tested. Also, syncing building heating and cooling equipment with computer power on and off times would realize even larger cost and energy savings.

Conclusion

Project 1: "Turn Off", was the most energy, carbon, cost, and time efficient considering all aforementioned aspects, therefore, for all computers at EPA R10, in the long and short run, it is best to turn off the computers while not in use.

<u>Supporting information</u>: It has been determined that sleep features do not wear out hardware by forcing the computer to turn on and off several times a day, because, "Modern computers are designed to handle 40,000 on-off cycles before failure, and you're not likely to approach that number during the average computer's five- to seven-year life span. In fact, IBM and Hewlett Packard encourage their own employees to turn off idle computers, and some studies indicate it would require on-off cycling every five minutes to harm a hard drive" (Computers and Peripherals, 2004). This causes the "Leave On" option to be less attractive, because modern hard drives are not significantly affected by frequent shutdowns (Nordman, 2000).

Although, in Microsoft OS, there are no administrative software tools for centrally managing computer power management features. There are still numerous ways to centrally activate and manage these features today — many of them free. When a computer is in system standby or hibernate mode, it can still receive important software updates such as new antivirus definitions and Windows security patches because there are numerous ways for network administrators to ensure that software updates are applied:

a. Configure client computers to apply software patches and updates as soon as the computer becomes available on the network.

b. Windows Task Scheduler can wake up sleeping computers for updates. Scripts distributed via Active Directory can allow one to centrally manage these "scheduled tasks."

c. With Wake-on-LAN activated, a network administrator can wake up sleeping machines at any time in order to perform on-demand software patches or updates.

d. Purchase software to turn on computers through the network.

"If every home office product purchased in the United States this year had earned the Energy Star, the U.S. would save more than $75 million in annual energy costs, prevent 1 billion pounds of greenhouse gases, equivalent to emissions from 90,000 cars, and save 700 million kWh of electricity" (Computers for Consumers, 2010).As previously stated, "… energy conservation can result in increased financial capital, environmental quality, national security, personal security, and human comfort" (Lawrence, 2009). Individuals along with organizations that are direct consumers of energy choose to conserve energy to reduce energy costs and promote economic security. To increase energy efficiency and maximize profit, emissions must be reduced by either the producer or the consumer. Energy conservation is an important part of lessening climate change and energy shortages. To become the most efficient and effective with our computer power usage, it must be determined whether leaving the computers on, or powering them off is best overall.

APPENDIX 1:

Interview Questions:

1. How many computers does EPA have in Region 10? At UWB?
2. How many laptops, desktops, monitors?
3. How many Energy Star computers?
4. Are you considering more?
5. How frequently does the average person use a PC on a daily basis?
6. Which PC brand does EPA buy?
7. What are main the factors/criteria when buying a new PC?
8. Are warranties a factor?
9. What is EPA's replacement schedule for computers/if there is one?

APPENDIX 2:

Power Level Requirements:

The following tables indicate the required power allowances for the Tier 1 specification. Table 13 gives the baseline requirements. For those products that meet the WOL enabling requirement for either Sleep or Standby, a model must meet the energy level provided in Table 14.

Table 14

Energy Star Program Requirements for Computers

Tier 1 Energy Efficiency Requirements Product Type	Tier 1 Requirements
Desktops, Integrated Computers, Desktop-Derived Servers and Gaming Consoles	Standby (Off Mode): ≤ 2.0 W Sleep Mode: ≤ 4.0 W Idle State: Category A: ≤ 50.0 W Category B: ≤ 65.0 W Category C: ≤ 95.0 W Note: Desktop-derived servers (as defined in section 1. F) are exempt from the Sleep level above.
Notebooks and Tablets	Standby (Off Mode): ≤ 1.0 W Sleep Mode: ≤ 1.7 W Idle State: Category A: ≤ 14.0 W Category B: ≤ 22.0 W
Workstations	TEC Power (P_{TEC}): ≤ 0.35 * [P_{Max} + (# HDDs * 5)] W Note: Where P_{max} is the maximum power drawn by the system as tested per the test procedure in Section 4 of Appendix A, and #HDD is the number of installed hard drives in the system.

Note: WOL additional power allowance is + 0.7 W for Sleep + 0.7 W for Standby

Qualifying Computers with Power Management Capabilities: The following requirements should be followed when determining whether models should be qualified with or without WOL:

Sleep: Computers should be tested and reported as shipped for Sleep. Models sold through enterprise channels, as defined in the Tier 1 Power Management Requirements (Section 3.A.3), should be tested, qualified, and shipped WOL enabled. Products going directly to consumers through normal retail channels are not required to be shipped with WOL enabled from Sleep, and may be tested, qualified, and shipped with WOL either enabled or disabled. Those models sold both through enterprise channels and directly to consumers must test and meet both the levels with and without WOL.

Systems where any additional management services are, at the customer's request, pre-provisioned by the manufacturer, do not need to test the systems with these functions in an active state providing the function is not actually activated until there is specific action by the end user.

APPENDIX 3:

Computer Load Reduction Example:

Typical load reduction (for 10 Energy Star labeled PCs and monitors): 1,000 watts

Replacing 10 PCs with Energy Star labeled models represents a reduction of 3,413 Btu/h no longer lost to the conditioned space. So, at $0.08 per kWh, 8 hr. per day, the heating cost was $0.64 per day. Assuming gas costs $0.80 per therm and contains 100,000 Btu/therm, with a heating efficiency of 75%, the new heating cost is $0.29 per day.

Heating Cost Savings: 54%

APPENDIX 4:

Sleep Modes:

Office equipment with the Energy Star label saves energy and money by powering down and entering “sleep” mode or off mode when not in use. Products that meet the Energy Star specifications use about half as much electricity as conventional equipment. Monitors automatically enter two low-power modes of 15 watts and 8 watts after 15–30 minutes of inactivity. There are 4 basic types of computer power management, or "sleep" features on Windows PCs: "System standby" -Drops monitor and computer power use down to 1–3 watts each. Wakes up in seconds. Saves $25–75 per PC annually. "System hibernates"- Drops monitor and computer power use down to 1–3 watts each. Wakes up in 20+ seconds. Saves work in the event of power loss. Saves $25–75 per PC annually. "Turn off monitor" -Drops monitor power use down to 1–3 W. Wakes in seconds or less. Saves half as much as system standby or hibernate: about $10–40. "Turn off hard disks"-This option saves very little energy

References:

Ames, B. (2006). EPA sets strict rules for Energy Star 4.0. Retrieved from http://www.energystar.gov/ia/products/downloads/Public_Law109-431.pdf

Advanced Configuration and Power Interface. (2008). ACPI. Retrieved from http://www.acpi.info/adopt.htm.

Boudreau, M., Chen, A., & Huber, M. (2008). Green IS: Building sustainable business practices. Retrieved from http://globaltext.terry.uga.edu/userfiles/pdf/Green.pdf.

Bray, M. (2006). Review of Computer Energy Consumption and Potential Savings. Retrieved from http://www.dssw.co.uk/research/computer_energy_consumption.pdf.

Campbell, P. (2008). Green IT - How Qld is leading the national green IT agenda. ACS Green IT Taskforce. Retrieved from http://www.acs.org.au/greenit/Presentations/Paul%20Campbell%20-%20Green%20IT%20SIG%20- %20Qld%20leading%20the%20agenda%20.pdf.

Chin, M. (2008). Recommended Hard Drives. Life Cycle Analysis and Eco PC Review, Retrieved from http://www.ecopcreview.com/LCA_and_ECPR

Deloitte Technology Predictions. (2008).The common sense of lean and green IT. Retrieved from http://www.deloitte.co.uk/TMTPredictions/technology/Green-and-lean-it-data-centre-efficiency.cfm.

Energy Star (2011). Energy Star Product Specifications. Retrieved from www.energystar.gov/productdevelopment.

Energy Star (2011). Low carbon IT. Retrieved from www.energystar.gov/ lowcarbonit.

Energy Star. (2011). Power Management. Retrieved from http://www.energystar.gov/index.cfm?c=power_mgt. pr_power_mgt_powerconfig.

Energy Star. (2009). Faronics Corporation. Retrieved from http://www.energystar.gov/ia/products/power_mgt/downloads/CaseStudy_ADT.pdf.

Energy Star. (2009). Energy Star Program Requirements for Computers. Retrieved from http://www.energystar.gov/ia/partners/product_specs/program_reqs/Computer_Spec_Final.pdf.

Energy Star. (2011). Energy Star Office Equipment Savings Calculator. Estimate your own CPM savings here: Retrieved from www.energystar.gov/lowcarbonit.

Energy Star. (2010). Computers for Consumers. Retrieved from http://www.energystar.gov/index.cfm?fuseaction=find_a_product.ShowProductGroup&pgw_code=CO

Energy Star. (2005). Summary of Assumptions for EPA Energy Star Savings Estimates. Energy Star Preliminary Draft Computer Specification (Version 4.0). Retrieved from http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Assumptions_Prelim_Draft_Comp_Spec.pdf

Energy Star . (2010). "Glaxo Smith Kline Uses an Often Overlooked Windows Tool for Computer Power /management – And Saves Big: Free solution will reduce annual energy expenses by nearly $1 million". http://www.energystar.gov/ia/products/power_mgt/downloads/GlaxoSmithKline_Case_Study.pdf

Feng , W. (2005). The Importance of Being Low Power in High Performance Computing. CT Watch Quarterly volume 1. Retrieved from http://www.ctwatch.org/quarterly/articles/2005/08/the-importance-of-being-low-power-in-high-performance-computing/.

Gartner, S. (2007). 10 Key Elements of a "Green IT" Strategy: Retrieved from www.onsitelasrmedic.com/pdf/10_key_elements_greenIT.pdf

Gupta, Dipak (2010). Analyzing Public Policy: Concepts, Tools, and Techniques. Pages 345-369.

How Dell Does IT: Energy Efficiency. (2008). Dell Cuts energy costs by up to 40% with a new power management plan. Retrieved from http://www.dell.com/content/topics/global.aspx/casestudies/en/emea/eu/fy2008_q3_id688?c=us&l=en&s=gen

Howard, A. Howard, S. Lane, M. (2009). The Energy Inefficiency of Office Computing and Potential Emerging Technology Solutions. Issues in Informing Science and Information Technology Volume 6.

Ieee engineering computing database. (2010). "Switch off your computer and save money" "IEEE Spectrum: Energy-Efficient Ethernet". Spectrum.ieee.org. Retrieved from http://spectrum.ieee.org/computing/networks/energyefficient-ethernet.

Infoworld. (2010). EPA Energy Star. http://www.infoworld.com/art icle/06/10/26/HNepaenergystar_1.html.

Jones, E. (2007). EPA Announces New Computer Efficiency Requirements. U.S. EPA. Retrieved from http://yosemite.epa.gov/opa/admpress.nsf/a8f952395381d3968525701c005e65b5/113b0c0647fee41585257210006474f1!OpenDocument.

Kleynhans, Steve. (2008). The Green PC Environment. Gartner Advises Companies to Stay Green. Green Tecnology World, Retrieved from http://green.tmcnet.com/topics/green/articles/24925-gartner-advises-companies-stay-green.htm

Lawrence, A. (2009). Market Insight Service Analyst: Leaving it on? (2007). "TCO takes the initiative in comparative product testing". Retrieved from http://www.boivie.se/index.php?page=2&lang=eng.

Lawrence Berkeley Laboratory. (2010). "After-hours Power Status of Office Equipment and Inventory of Miscellaneous Plug-Load Equipment." Retrieved from http://enduse.lbl.gov/info/53729-abstract.html.

Microsoft. (2010). Windows 7 Processor Power Management, and Windows Vista Power Management Changes. Retrieved from http://www.microsoft.com/whdc/system/pnppwr/powermgmt/ProcPowerMgmtWin7.mspx.

Murugesan, San. (2008). Harnessing Green IT: Principles and Practices. IEEE IT Professional. Pp. 24-33.

Nordman, B. (2000). Lawrence Berkeley National Laboratory. "User Guide to Power Management for PCs and Monitors". Retrieved from http://eetd.lbl.gov/EA/Reports/39466/ 2000

PC Energy Report. (2009). Alliance to Save Energy: United States. United Kingdom. Germany. Retrieved from http://www.climatesaverscomputing.org/docs/1E_PC_Energy_Report_2009_US.pdf.

Rocky Mountain Institute. (2004). Home Energy Brief #7. Computers and Peripherals. Retrieved from http://www.p2pays.org/ref/32/31146.pdf.

Sims, T. (2009). Miami-Dade County Public Schools. Big Fix Power Management Implementation in the Public School District. Retrieved from http://www.netlib.org/linpack/

Tom's Hardware. (2006). Conventional Hard Drive Obsoletism? Samsung's 32 GB Flash Drive Previewed. Retrieved from http://www.tomshardware.com/reviews/conventional-hard-drive-obsoletism,1324.html.

To Study and Promote the Use of Energy Efficient Computer Servers in the United States, H.R. 5646, Public Law 109–431 of 2006, 120 STAT. 2921, House Reports: No. 109–538. (2006).

Tables, and graphs of EPA and UWB:

EPA

Table 15

EPA "Turn Off"

Unit	Power drawn while off	Time off % of day per week	Power drawn in sleep	Time sleep %	Power drawn in idle	Time idle %	Power drawn in active	Time active %	Kw/day	Kw/year	Quantity
Desktop	2.9 W	0.76	11.2 W	0.04	55 W	0.03	80 W	0.16	0.41 kw	150	350
Monitor	2 W	0.76	4 W	0.04	0 W	0.03	80 W	0.16	0.35 kw	127	394.25
Laptop	2.4 W	0.76	7 W	0.04	21 W	0.03	30 W	0.16	0.18 kw	66	295
Energy star desktop	2 W	0.76	5 W	0.04	42 W	0.03	70 W	0.16	0.34 kw	124	350
Energy star monitor	1 W	0.76	2 W	0.04	0 W	0.03	57 W	0.16	0.24 kw	87	394.25
Energy star laptop	0.5 W	0.76	5 W	0.04	21 W	0.03	30 W	0.16	0.14 kw	53	295
	Total kw/year Energy star		93,361			Total kw/year Standard		121,860	114,735		
	Total Cost/year Energy star		$8,925			Total Cost/year Standard		$11,649	$10,968		
	Total metric tons CO2/year		65			Total metric tons CO2/yr		85	80		
	Metric ton reduction		20								
						Percent savings		23.39%			

Table 16

EPA "Leave On"

Unit	Power drawn while off	Time off % of day per week	Power drawn in sleep	Time sleep %	Power drawn in idle	Time idle %	Power drawn in active	Time active %	Kw/day	Kw/year	Quantity
Desktop	2.9 W	0.36	11.2 W	0.45	55 W	0.03	80 W	0.16	0.49 W	180	350
Monitor	2 W	0.36	4 W	0.45	0 W	0.03	80 W	0.16	0.37 W	134	394.25
Laptop	2.4 W	0.36	7 W	0.45	21 W	0.03	30 W	0.16	0.23 W	83	295
Energy star desktop	2 W	0.36	5 W	0.45	42 W	0.03	70W	0.16	0.37 W	135	350
Energy star monitor	1 W	0.36	2 W	0.45	0 W	0.03	57 W	0.16	0.25 W	91	394.25
Energy star laptop	0.5 W	0.36	5 W	0.45	21 W	0.03	30 W	0.16	0.19 W	69	295
	Total kw/year Energy star		103,427			Total kw/year		140,222	131,023		
	Total Cost/year Energy star		$9,887			Total Cost/year		$13,405	$12,525		
	Total metric tons CO2/year		72			Total metric tons CO2/year		98	92		
	Metric ton reduction		26								
						Percent savings		26.24%			

Table 17

EPA "Baseline"

Unit	Power drawn while off	Time off % of day per week	Power drawn in sleep	Time sleep %	Power drawn in idle	Time idle %	Power drawn in active	Time active %	Kw/day	Kw/year	Quantity
Desktop	2.9 W	0.61	11.2 W	0.12	55 W	0.06	80 W	0.21	0.55 W	202	350
Monitor	2 W	0.61	4 W	0.12	0 W	0.06	80 W	0.21	0.44 W	161	350
Laptop	2.4 W	0.61	7 W	0.12	21 W	0.06	30 W	0.21	0.24 W	86	295
Energy star desktop	2 W	0.61	5 W	0.12	42 W	0.06	70 W	0.21	0.45 W	166	350
Energy star monitor	1 W	0.61	2 W	0.12	0 W	0.06	57 W	0.21	0.31 W	111	350
Energy star laptop	0.5 W	0.61	5 W	0.12	21 W	0.06	30	0.21	0.20 W	74	295
	Total kw/year Energy star		118693		Total kw/year		152330	143920			
	Total Cost/year Energy star		$11,347		Total Cost/year		$14,562	$13,758			
	Total metric tons CO2/year		83		Total metric tons CO2/year		107	101			
	Metric ton reduction		24		Percent savings		22.08%				

Table 18

EPA Projects 1,2,&3 Compared

	"Turn Off"	"Leave On"	"Baseline"
KWH/Year	121,860	140,222	152,330
Cost/Year	$11,649	$13,405	$14,562
Metric Tons CO_2/Year	85	98	107
KWH/Year; Energy star	93,361	103,427	118,693
Cost; Energy star	$8,925	$9,887	$11,347
Metric Tons CO2; Energy star	65	72	83
	"Turn Off" 25%	"Leave On" 25%	"Baseline" 25%
KWH/Year	114,735	131,023	143,920
Cost/Year	$10,968	$12,525	$13,758
Metric Tons CO_2/Year	80	92	101
	"Turn Off" 75%	"Leave On" 75%	"Baseline" 75%
KWH/Year	100,486	112,625	127,102
Cost/Year	$9,606	$10,766	$12,150
Metric Tons CO_2/Year	70	79	89
	Project 1-3	Project 2-3	
Regular	22.2%	8.3%	
Energy star	23.9%	13.7%	

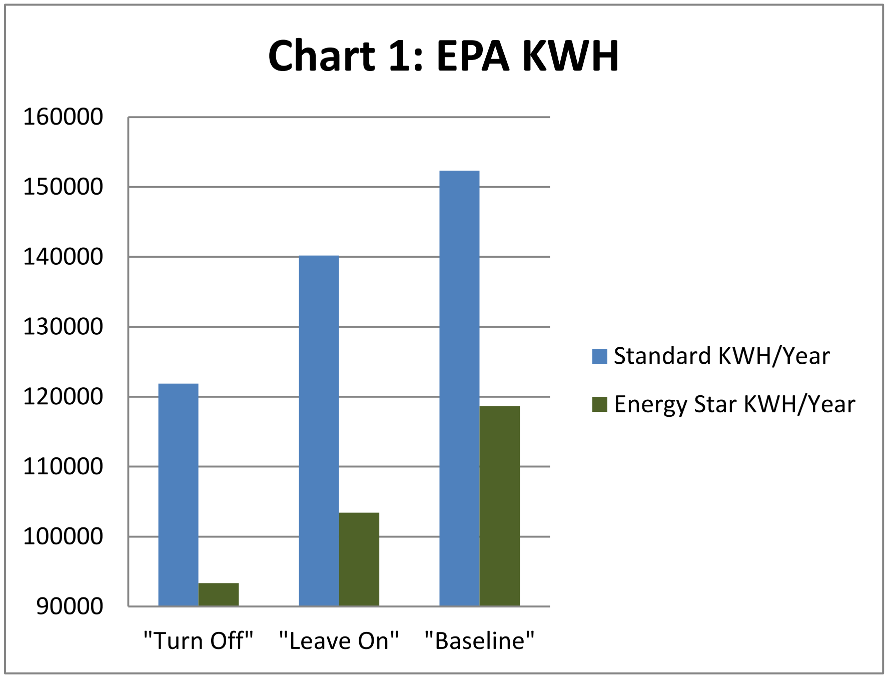
Chart 1: EPA KWH
160000
150000
140000
130000
120000
110000
100000
90000
"Turn Off"
"Leave On"
"Baseline"
Standard KWH/Year
Energy Star KWH/Year

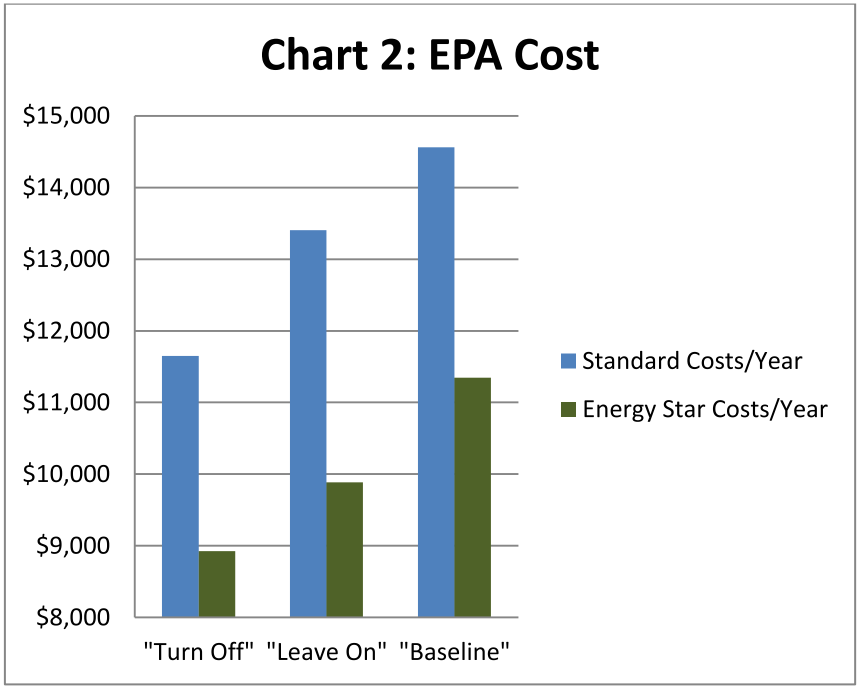
Chart 2: EPA Cost
$15,000
$14,000
$13,000
$12,000
$11,000
$10,000
$9,000
$8,000
"Turn Off"
"Leave On"
"Baseline"
Standard Costs/Year
Energy Star Costs/Year

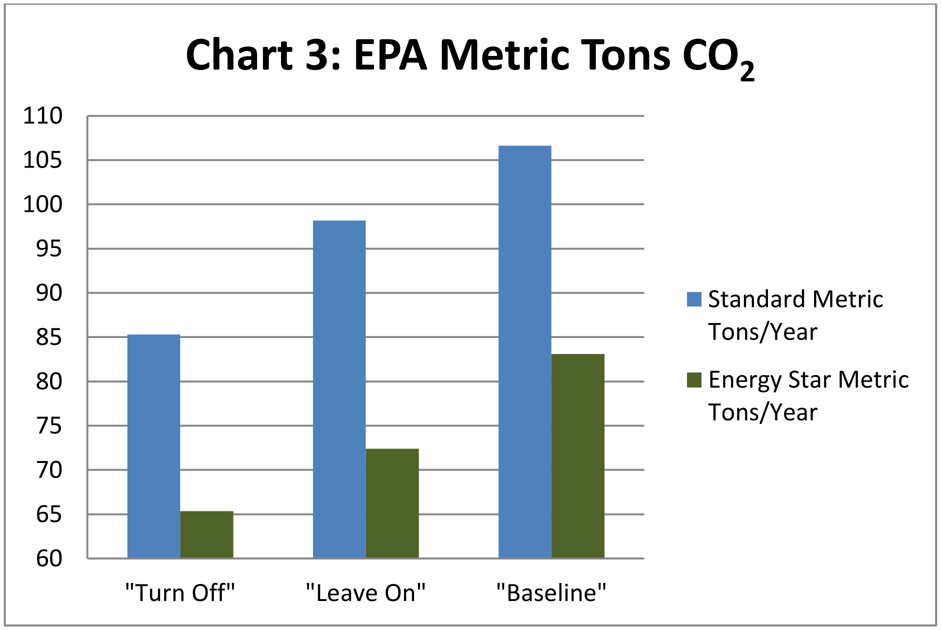
Chart 3: EPA Metric Tons CO_2
110
105
100
95
90
85
80
75
70
65
60
"Turn Off"
"Leave On"
"Baseline"
Standard Metric Tons/Year
Energy Star Metric Tons/Year

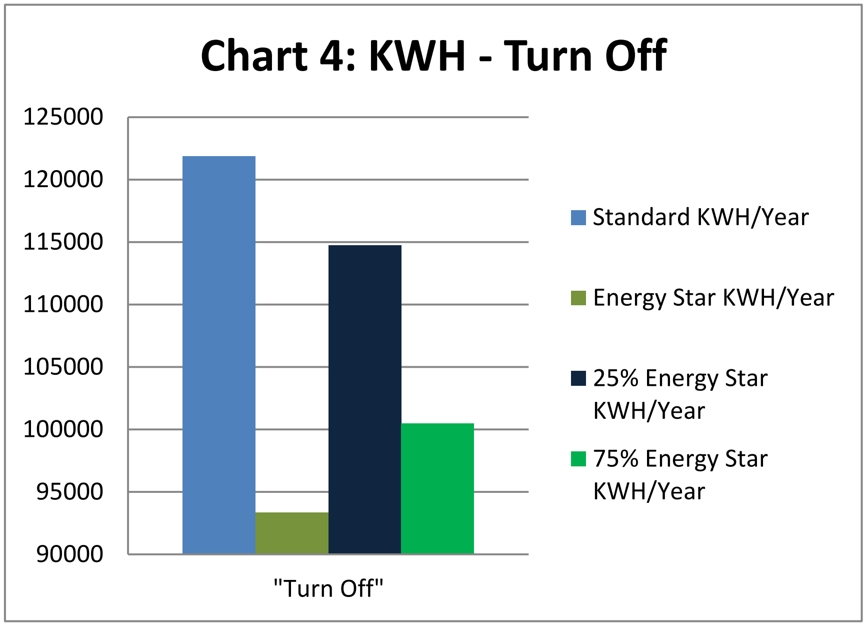
Chart 4: KWH - Turn Off
125000
120000
115000
110000
105000
100000
95000
90000
"Turn Off"
Standard KWH/Year
Energy Star KWH/Year
25% Energy Star KWH/Year
75% Energy Star KWH/Year

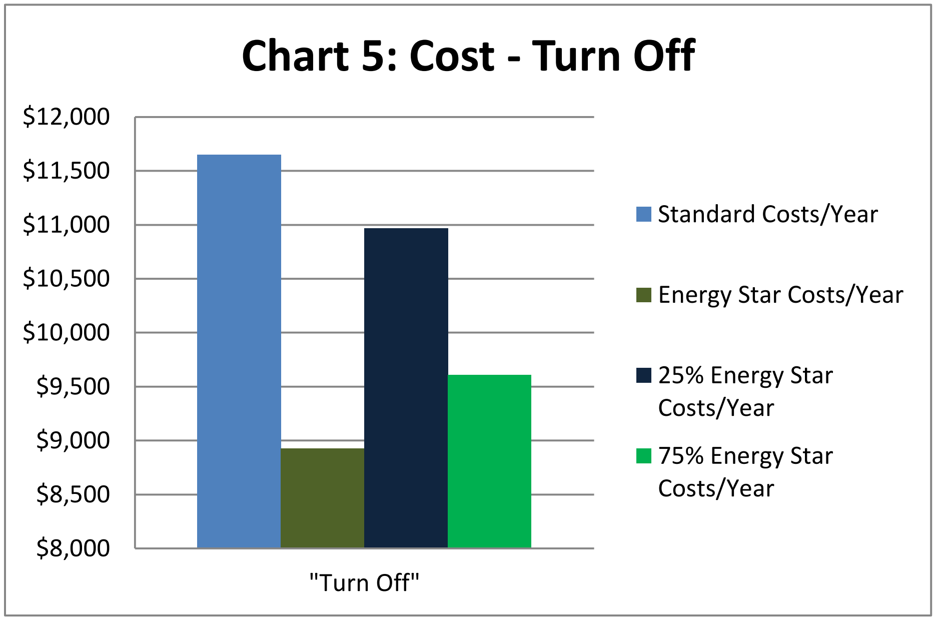
Chart 5: Cost - Turn Off
$12,000
$11,500
$11,000
$10,500
$10,000
$9,500
$9,000
$8,500
$8,000
"Turn Off"
Standard Costs/Year
Energy Star Costs/Year
25% Energy Star Costs/Year
75% Energy Star Costs/Year

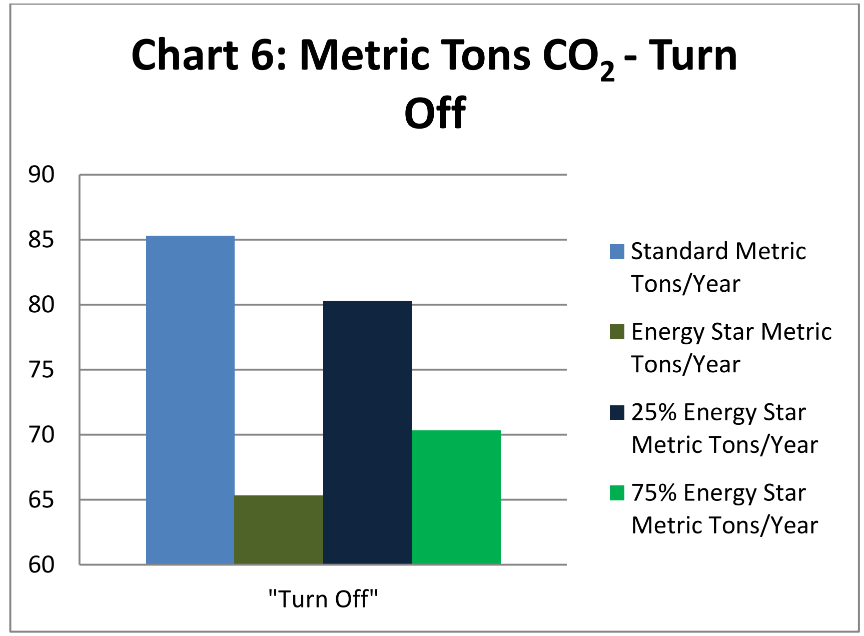
Chart 6: Metric Tons CO_2 - Turn Off
90
85
80
75
70
65
60
"Turn Off"
Standard Metric Tons/Year
Energy Star Metric Tons/Year
25% Energy Star Metric Tons/Year
75% Energy Star Metric Tons/Year

UWB

Table 19

UWB "Turn Off"

	Time sleep	w/idle	Time idle	w/active	Time active	kw/day	kw/year	quantity
Desktop	0.06	55	0.03	80	0.21	0.50	184	2,600
Monitor	0.06	0	0.03	80	0.21	0.44	160	2,600
Energy star desktop	0.06	42	0.03	70	0.21	0.42	154	2,600
Energy star monitor	0.06	0	0.03	57	0.21	0.30	111	2,600
	Total kw/year Energy star		688,567	Total kw/year		895,476	843,749	740,295
	Total Cost/year Energy star		$65,827	Total Cost/year		$85,607	$80,662	$70,772
	Total metric tons CO2/year		482	Total metric tons CO2/year		627	591	518
	Metric ton reduction		145	Percent savings		23.11%		

Table 20

UWB "Leave On"

	Time sleep	w/idle	Time idle	w/active	Time active	kw/day	kw/year	quantity
Desktop	0.42	55	0.01	80	0.21	0.56	203	2,600
Monitor	0.42	0	0.01	80	0.21	0.46	167	2,600
Energy star desktop	0.42	42	0.01	70	0.21	0.43	158	2,600
Energy star monitor	0.42	0	0.01	57	0.21	0.31	114	2,600
	Total kw/year Energy star		707,886	Total kw/year		962,279	898,681	771,484
	Total Cost/year Energy star		$67,673	Total Cost/year		$91,993	$85,913	$73,753
	Total metric tons CO2/year		496	Total metric tons CO2/year		674	629	540
	Metric ton reduction		178	Percent savings		26.44%		

Table 21

UWB "Baseline"

	Time sleep	w/idle	Time idle	w/active	Time active	kw/day	kw/year	quantity
Desktop	0.09	55	0.06	80	0.21	0.55	200	2,600
Monitor	0.09	0	0.06	80	0.21	0.44	160	2,600
Energy star desktop	0.09	42	0.06	70	0.21	0.45	165	2,600
Energy star monitor	0.09	0	0.06	57	0.21	0.30	111	2,600
	Total kw/year Energy star		717,715	Total kw/year		936,419	881,743	772,391
	Total Cost/year Energy star		$68,613	Total Cost/year		$89,521	$84,294	$73,840
	Total metric tons CO2/year		502	Total metric tons CO2/year		655	617	541
	Metric ton reduction		153	Percent savings		23.36%		

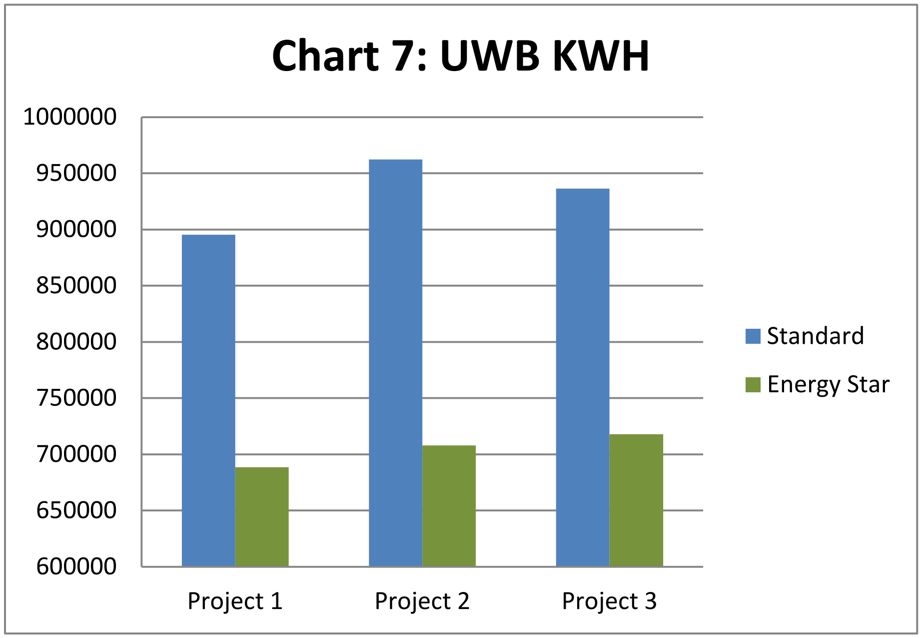
Chart 7: UWB KWH
1000000
950000
900000
850000
800000
750000
700000
650000
600000
Project 1
Project 2
Project 3
Standard
Energy Star

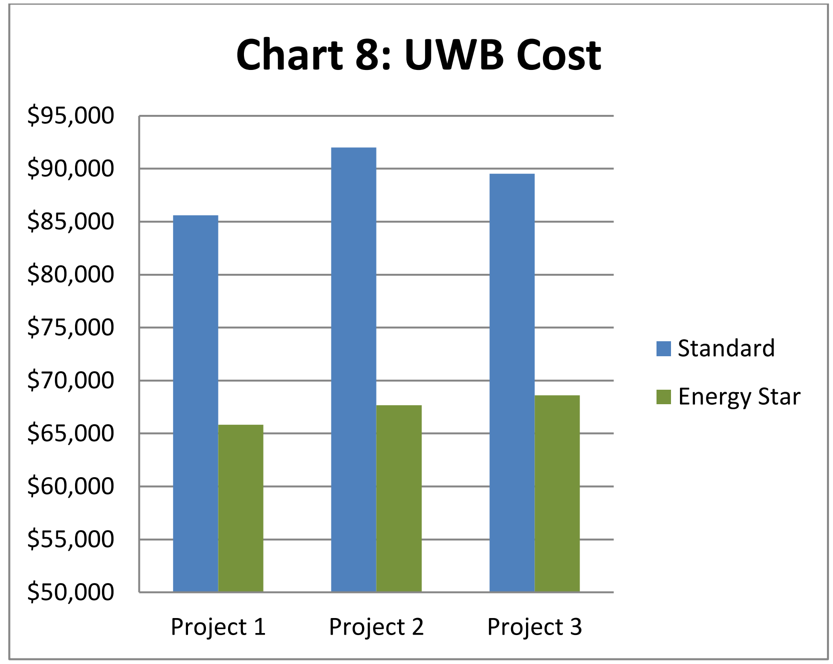
Chart 8: UWB Cost
$95,000
$90,000
$85,000
$80,000
$75,000
$70,000
$65,000
$60,000
$55,000
$50,000
Project 1
Project 2
Project 3
Standard
Energy Star

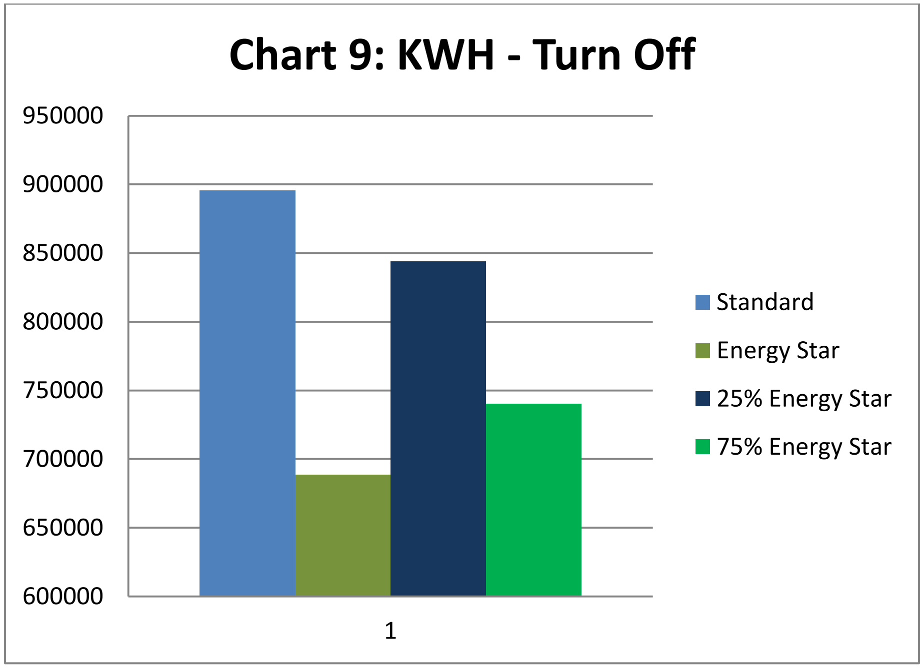
Chart 9: KWH - Turn Off
950000
900000
850000
800000
750000
700000
650000
600000
1
Standard
Energy Star
25% Energy Star
75% Energy Star

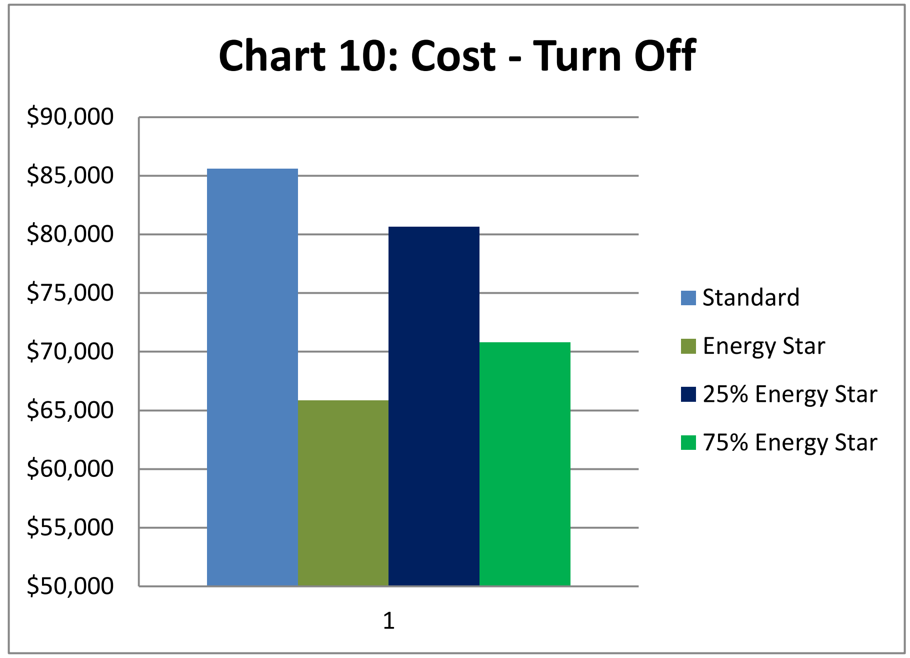
Chart 10: Cost - Turn Off
$90,000
$85,000
$80,000
$75,000
$70,000
$65,000
$60,000
$55,000
$50,000
1
Standard
Energy Star
25% Energy Star
75% Energy Star

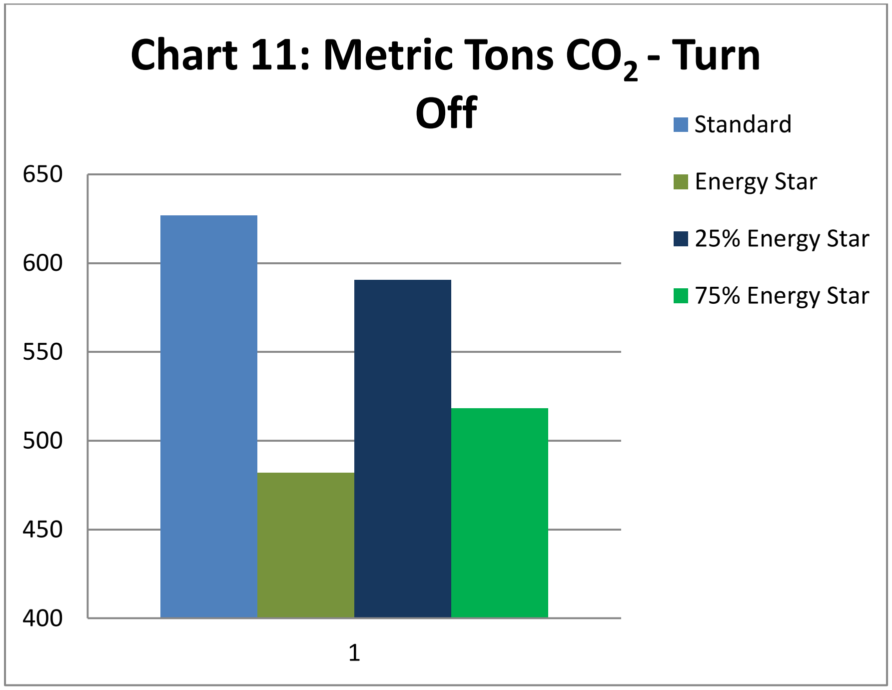
Chart 11: Metric Tons CO_2 - Turn Off
Standard
Energy Star
25% Energy Star
75% Energy Star
650
600
550
500
450
400
1

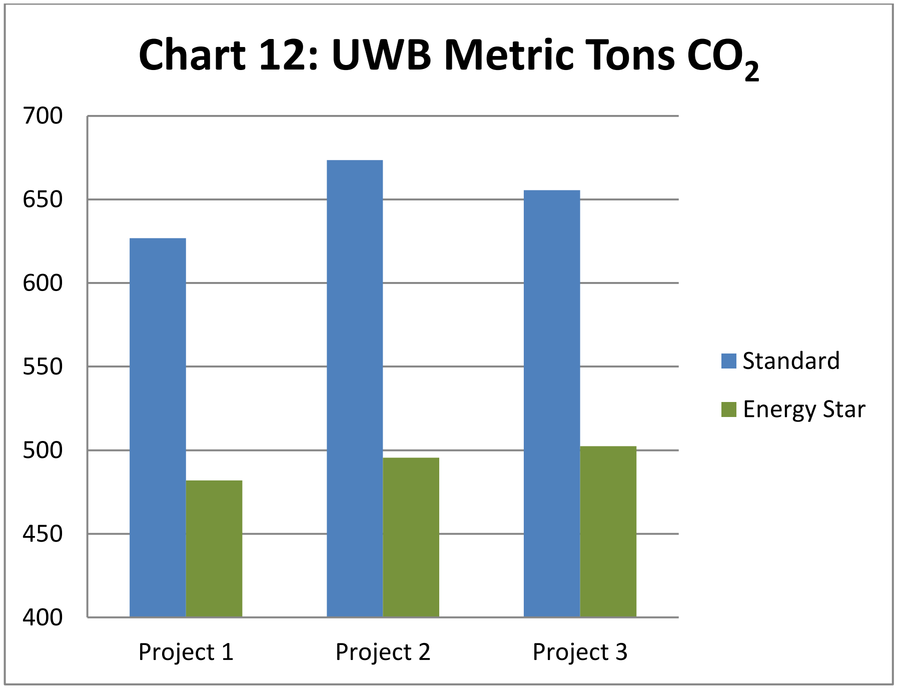
Chart 12: UWB Metric Tons CO_2
700
650
600
550
500
450
400
Project 1
Project 2
Project 3
Standard
Energy Star