Life Cycle Management of Computers and Servers: Curbing Energy and Environmental Impacts by Managing from Cradle to Grave

Kent Dunn, Verdiem Corporation
Robin Hawley, Ecos Consulting
Mark Monroe, Sun Microsystems

ABSTRACT

Historical approaches to reducing energy consumption and environmental impacts from IT equipment, specifically networked computers and servers, have been both tentative and disparate. Recently, efforts to improve efficiency in computer hardware have become more visible due to ENERGY STAR® activities and to market driven programs such as 80 PLUS®, which labels computers and servers that use highly energy-efficient certified power supplies. Concurrently, advances have been made in network power management technology, and commercially available tools now exist that allow organizations to easily measure and manage energy consumption across large numbers of computers. Additionally, as regulations have tightened around the disposal of electronic waste (e-waste), responsible end-of-life reclamation organizations have been formed to provide eco-friendly disposal options.

These strategies are highly complementary and represent a powerful 'life cycle management' (LCM) model: procure efficient computers; use active power management during their lifespan; and dispose of them properly when they are retired. Because these strategies have been promoted independently, they have unfortunately often been viewed as mutually exclusive rather than as complimentary components of a comprehensive LCM strategy.

The reality is that these strategies should be inextricably linked. When combined they represent a holistic approach that maximizes active life energy savings of computers and ensures environmental savings by facilitating proper disposal of the product. This paper will include empirical and anecdotal data to demonstrate how hardware and software efficiencies can combine to show significant energy savings, how responsibility for these activities should be shared by manufacturers of IT equipment, consumers and regulators, and how the promotion of a LCM model can elevate awareness and create dynamic global market opportunities.

IT Equipment Poses Bigger Environmental Problems than We Think

Which of these industries are responsible for more CO2 emissions - the aviation industry or the information technology (IT) industry? According to new estimates just released from Gartner, a group of IT industry analysts, the answer is surprising…they are about the same[1]. This type of realization is throwing fuel on the already hotly burning topic of how to curb the insatiable energy hunger of IT devices.

For several years, the IT industry has been responding to pressures such as volatile energy markets, globalization and expanding environmental regulations. To combat these pressures and to continue to remain competitive in the marketplace, many manufacturers have sought to locate plants in regions with inexpensive power, low labor rates and limited environmental regulations to defend against these very real threats to the bottom line. As a result, consumers have benefited from IT products with low price points and high levels of

performance. However, until recently, energy and environmental concerns were often overlooked in the engineering of IT products, and consumers have been incurring an ever increasing energy and environmental burden as their IT infrastructures have grown.

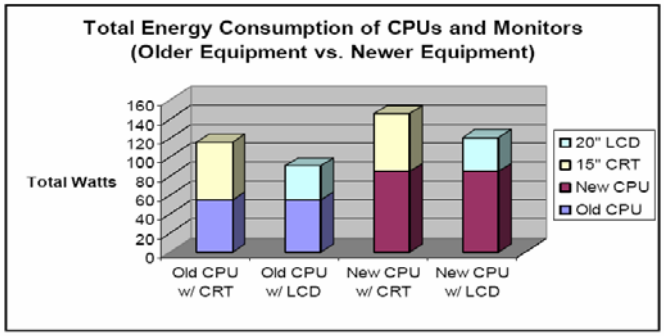
Now, for the first time, a market climate is evolving between manufacturers, consumers and regulators that is motivating great change in the industry and is bringing sharp focus to energy efficiency and end-of-life disposal. The convergence of high energy rates, consumer awareness, changing standards by organizations such as ENERGY STAR[2], a resurgence in utility demand side management initiatives and the presence of innovative market transformation programs has created a rapidly growing demand for 'green' IT products, and manufacturers are moving quickly to fill this market demand.

The net result is that the evolving market is now delivering consumers an opportunity to bring a cohesive, forward thinking management approach to their purchase, operation and disposal of computers. Manufacturers, driven by the need to address the ever present issue of heat build-up inside a computer, are responding to utility-funded incentive programs and evolving standards programs such as ENERGY STAR and Electronic Product Environmental Assessment Tool (EPEAT). Concurrently, advances have been made in enterprise-quality network power management technology, and commercially available tools now exist that allow organizations of all kinds to easily measure and manage energy consumption across large numbers of computers. Additionally, as regulations have tightened around the disposal of e-waste, end-of-life reclamation opportunities have emerged to provide eco-friendly disposal options that are alleviating some of the environmental issues associated with electronic waste.

The Myth of Computer Energy Efficiency

The reasons for the rapid growth in computer energy consumption over the past decade are both intuitive and surprisingly counterintuitive. The intuitive reason is simply related to the rapid proliferation of desktop personal computers (PCs) in commercial and institutional settings, where there is at least a one to one ratio between workers and computers. In fact, many institutions now have more PCs than employees. The counterintuitive reason is that new machines, despite conventional wisdom, are NOT less energy intensive than their predecessors. Instead, the reality is that despite improvements in the efficiency of power supplies, processors and chipsets, **PCs are consuming more energy than ever before**.

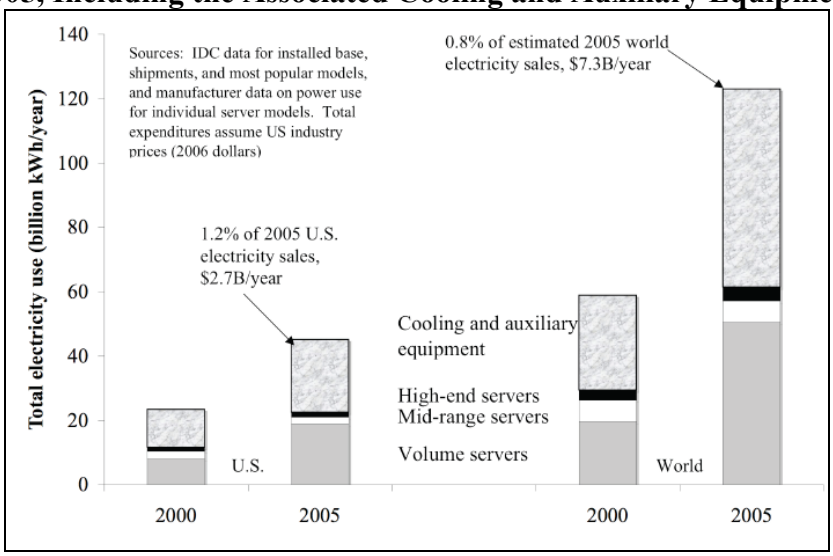
Figure 1. Energy Consumption of Older vs. Newer Computers



The rise in computer energy consumption is even more dramatic when looking at the electricity used by servers and other Internet infrastructure. A recent study by Lawrence

Berkeley National Labs showed that aggregate electricity use by servers double in the U.S. and the world in the five years between 2000 and 2005.

Figure 2. Total Electricity Use for Servers in the U.S. and the World in 2000 and 2005, Including the Associated Cooling and Auxiliary Equipment



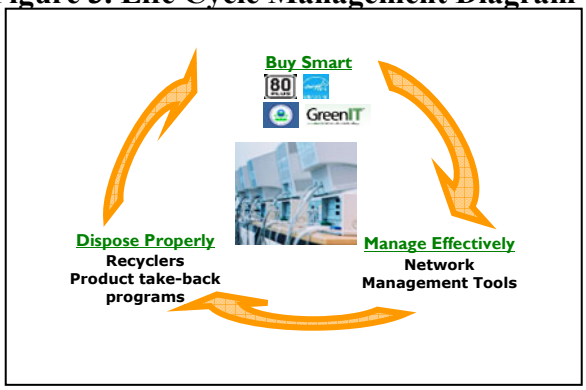
The equation is troubling indeed: more PCs and servers consuming more energy add up to unprecedented energy consumption and cost - and most consumers that operate large computer networks, while noting that their energy costs are rising dramatically, are still unaware that the PC explosion could be at the heart of the problem.

Defining 'Life Cycle Management'

The United Nations Environmental Program (UNEP) defines Life Cycle Management as "an integrated concept for managing the total life cycle of products and services towards more sustainable consumption and production patterns."[3] From a manufacturer's perspective, LCM means designing products for efficient management throughout their lifecycle. From a consumer perspective, LCM is the forward-thinking practice of procuring products that meet or exceed efficiency standards, managing products in ways that allow for maximum energy efficiency while the product is in its active life, and ensuring that products are properly disposed at the end of their active life. This holistic process ensures that procurement and use of the product reduces its energy and environmental footprint to the greatest degree possible.

Until recently, an effective computer and server LCM plan was virtually impossible. Efficient products, particularly ones labeled as such, were small in number. Measurement and management software development was still in its early stages of development. And electronics recycling and product take-back programs had not evolved to a level that could absorb the incredible market demand. But the market has undergone dramatic changes in recent years, and progressive consumers now have all the tools they need to procure and manage their IT products for maximum efficiency.

Figure 3. Life Cycle Management Diagram



When considered separately, each of the three pillars of LCM represents a sound management approach with demonstrable efficiencies and associated cost savings. When considered together, as depicted in Figure 3 above, these three pillars present an incredibly compelling management opportunity. As indicated in Table 1 below, even when the cost of recycling a computer is factored into the equation, the savings from buying more efficient models and managing them appropriately during their active life is more than enough to create a cash flow positive scenario for most organizations.

Table 1. Potential Life Cycle Management Savings

	Energy Saved Per Year	Cross Effect HVAC Savings (at 20% of load)	Total kWh Saved Per Year	$$ Saved Per Year (@ $.10/kWh)	Environmental Value Per PC
Buy Efficient Computers (ENERGY STAR, 80 PLUS)	85 kWh	17 kWh	102 kWh	$10.20	148 lbs. of CO2 emissions per year[4]
Manage Computers (Verdiem's Surveyor)	200 kWh	40 kWh	240 kWh	$24.00	348 lbs of CO2 emissions per year[4]
Recycle Computers	N/A	N/A	N/A	<$13.00>*	Proper recycling and disposal of potentially toxic assets maintains regulatory compliance and supports corporate responsibility
TOTAL SAVINGS	**285 kWh**	**57 kWh**	**342 kWh**	**$21.20**	

Step 1: Efficient Product Design & Green Procurement

LCM starts at the manufacturer level, and manufacturers are influenced most by consumer demand and prevailing procurement practices. Until recently, the market was not demanding high levels of efficiency from IT equipment, so it is no surprise that energy efficiency has not always been at the forefront of product development agendas. For many years, the primary design mandate was to create faster, more powerful machines at lower and lower price points. Environmental considerations, while important, often took a back seat to bottom-line competitive concerns. But changing markets are enabling a wave of change amongst manufacturers. Energy prices are rising rapidly, private and federal labeling programs such as 80 PLUS, EPEAT and ENERGY STAR are evolving, and customers are increasingly demanding more

efficiency from their IT products. Additionally, organizations are anticipating the potential for mandatory carbon caps or cap-and-trade programs in the near future. The net result is an inevitable transformation of the market, and manufacturers are increasingly aware that environmental concerns must be incorporated as an essential component of the design process and an integral part of their marketing message.

Market Driven Programs Drive Industry Change

Transforming the electronics market has long been an objective of government organizations, electric utilities and energy efficiency organizations. However, creating progressive market driven programs for the IT industry was a task easier said than done. In 2004, a breakthrough occurred. Ecos Consulting, through a grant by the Natural Resources Defense Council (NRDC) and the California Energy Commission (CEC), conducted a research project that indicated that by simply improving the energy efficiency of power supplies – the common denominator in all electronic products – significant energy savings could be achieved without prohibitive cost incursions for manufacturers. Ecos and its other partners in this research effort discovered that improving power supply efficiencies allowed savings to be garnered in all phases of a computer's operation, including all active and low power states. Most power supplies sold on the market at the time of the research were remarkably inefficient, wasting 10 - 70 percent of the total energy consumed by the finished product.[5]

In response to this landmark study, in 2005 the 80 PLUS program was created by Ecos and a new standard for what constitutes an energy-efficient power supply was set. By partnering with electric utilities and market transformation organizations, 80 PLUS established a unique pool of market-based incentives to encourage manufacturers to begin using power supplies that meet the new standard. The 80 PLUS specification stipulates that a power supply must be at least 80 percent efficient or greater at various load thresholds and be power factor corrected to at least 0.9. Compared to prior models typically available on the market, an 80 PLUS certified unit saves 85 kWh per year in a computer and 301 kWh per year in a desktop derived server.

Perhaps the most remarkable thing about the 80 PLUS program is that it is driven by market forces, and makes partners of the unlikely duo of electric utilities and computer manufacturers. Funding for 80 PLUS comes from a group of progressive electric utilities and market transformation organizations, who have contributed more than $5 million in incentives to motivate the computer industry to embrace efficient power supplies. 80 PLUS differs from many utility funded incentive programs in that it offers incentives directly to manufacturers rather than to consumers. This incentive program, combined with the promise of changing ENERGY STAR specifications, has created market conditions that are enabling progressive manufacturers to step out in front of their competitors in an effort to differentiate themselves as a vendor of 'green' products. With the recent inclusion of Hewlett Packard (HP) as an 80 PLUS industry partner, the program has shown that mainstream manufacturers are hungry to embrace the green mantle. Because of this, private and public sector organizations now have a great opportunity to buy more efficient computers by simply specifying 80 PLUS certified power supplies in their procurement specifications.

Manufacturers Tackle Efficiency Independently

Manufacturers have been aggressively pursuing their own efficiency projects independent of market driven programs. In particular, there has been tremendous focus on advancing both the speed and efficiency of chipsets and processors. These pursuits, while beneficial to consumers on many fronts, have not necessarily been based in energy efficiency altruism. Rather, manufacturers have been faced with a vexing problem: more powerful and speedy processors have typically meant ever increasing volumes of heat generated inside a computer chassis - and heat is enemy #1 of computer components. As a result, chip makers such as AMD and Intel have made great strides in efficiency while still providing ever more powerful processing capacity. New…"chips will have wires as thin as 45 nanometers, a scale at which 2,000 transistors will fit in the width of a human hair". This type of compaction is enabling manufacturers to add additional computing technology, but is forcing them to further address heat and energy concerns[6]. Perhaps most importantly, the efforts of chip makers are having a spillover effect on other parts of the computer manufacturing industry. Their embrace of the green marketing message has had an enormous impact on procurement behavior and is reinforcing the notion that providing Green IT can be a great business strategy for both component makers and original equipment manufacturers (OEMs) alike.

Evolving Eco-Label Standards Are Changing the Market

ENERGY STAR has been actively influencing computer energy consumption for more than a decade. Although the original ENERGY STAR specification for computers did not seek to establish hardware efficiency requirements for computers, it did require that computers bearing the label have the ability to shift into, and theoretically out of, low power states. Having said that, there was no mandate for manufacturers to enable power management policies in the computers they sold, and no requirement that users enable policies themselves. So despite the fact that computers began to reach the market that were capable of operating in an energy efficient manner, the reality is that few actually did.

This year, ENERGY STAR strengthened its position on computer energy efficiency by passing a new specification for computers, dubbed Version 4.0. The new spec, in force as of July 2007, tackles both hardware efficiencies and power management efficiencies. It sets idle mode consumption limits and mandates that 80 PLUS power supplies be integrated into machines bearing the ENERGY STAR label. These new features are solidifying the market for both efficient power supplies and more efficient chip sets, both of which are generally necessary to achieve the specification requirements.

Further, "the new specification also seeks to decrease the practice of disabling computer power-management features by requiring manufacturers to educate users about the proper operation of power management and its benefits." However, the new specification still does not address network power management in a way that will bring the activity into the mainstream of IT activities, the need for which will be discussed in detail in the following section.

Step 2: Network Power Management – The Key to Active Life Energy Savings

For many years, it has been clear that the bulk of PC energy waste occurs during the active life of a computer. In 1997, a paper titled "User Guide to Power Management for PCs and

Monitors"[7] was commissioned by the Federal Energy Management Program and US Environmental Protection Agency (USEPA). The findings were stark, and indicated that the lack of PC power management could cost U.S. businesses $1.75 billion by the year 2004. The study further indicated that much of this energy would be wasted due the fact that most of the time PCs are 'on' when they are not actively in use—and that the bulk of systems are needlessly left running at night and on weekends. Due the proliferation of PCs in the modern marketplace, the scope of this problem is now much larger than the initial research might have indicated. In fact, the Commercial Energy Business Consumption Survey (CEBCS) [8] indicates that the numbers of PCs in commercial settings has skyrocketed by 35 percent in recent years.

Data from the International Data Corporation[9] indicates that more than 93 million PCs were sold into the US marketplace between 2001 and 2003, with those numbers expected to increase significantly throughout the decade. Of those, ESource estimates that 71 million[10] are in operation in office settings in the U.S. Despite the fact that nearly all modern PCs have the capability to shift to a low power state when not in use, the vast majority of these devices do not do so. In fact, it is estimated that more than 40 percent of the monitors in the commercial marketplace never utilize low power states, and Lawrence Berkeley National Laboratory (LBNL) field surveys indicate that as little as 6 percent of computers in non-residential settings have power management enabled[11]. Further, a disturbing trend has developed in that IT departments are increasingly mandating that PCs NEVER be shut down so that they are accessible 24/7. For a typical commercial or institutional energy consumer, this presents an incredible opportunity to save enormous amounts of energy and operational cost each year simply by properly managing these devices.

Solving this problem and harvesting the savings, while once a daunting task, is now possible due to the advent of new and innovative technologies that provide dynamic management of PC power states while simultaneously measuring and reporting energy consumption**.** More importantly, these innovations provide a crucial bridge that allows organizations to bring balance to the often competing needs of maintaining network productivity and minimizing impact to end-users while simultaneously reducing energy and operational costs. Indeed, what was once thought to be an immeasurable and unmanageable source of energy consumption is now the next great opportunity for energy savings.

Why Hasn't Power Management Been Better Utilized?

Why power management functionality is largely unused has been the topic of much research in the past decade. To be sure, it is attributable to a number of factors, all of which point to a fundamental lack of historic balance between what have emerged as competing goals of energy efficiency and basic network management. Early versions of power management often resulted in impacts to both users and to network productivity, conflicts that were primarily caused because computer hardware was often unable to 'wake up' from a low power state-a consequence that is largely unacceptable for sophisticated IT infrastructures.

As a result, many organizations institutionalized policies against using power management, producing a generation of knowledge workers who thought that the power management of networked computers wasn't possible. Despite the fact that newer equipment has resolved these conflicts, the old negative views of power management persist, and studies continue to show that the vast majority of computers in the commercial marketplace have their power management functionality disabled.

In addition, many modern IT departments have institutionalized bans against power management for another reason altogether: because they want PCs to be on and available at all times in the event that virus updates, system maintenance or other network management activities have to be conducted. Due to the lack of a dynamic central management system, the result of all of these postures is an enormous waste of energy and operational dollars.

Network Level Power Management is the Key

Network energy management solutions are the most comprehensive and cost-effective means of solving the problem of wasted energy in networked computers. This type of solution elevates power management control to a central level and provides network managers the ability to achieve energy savings while maintaining their ability to ensure network stability and manageability, allowing computers to be managed with organizational consistency in much the same way that lights or heating, ventilation and air conditioning (HVAC) systems are governed by energy management systems. Network energy management solutions can vary greatly in their features and abilities, but a comprehensive solution will have the minimum capabilities in the following table, which are the key management elements that allow organizations to strike balance between energy efficiency, user productivity and network stability:

Table 2. Essential Features of Network Power Management[12]

Eight Essential Features of A Comprehensive Network Power Management Solution
1. The ability to accurately measure PC-based energy consumption. "You can't manage what you don't measure"
2. The ability to generate cost, energy consumption and savings reports
3. The ability to create distinct "groups" of users that can each have unique and customized energy profiles
4. The ability to enable different energy policies for different times of day or days of week
5. The ability to execute automated 'shutdowns' of either individual computers or groups of computers
6. The ability to provide a user override function at the discretion of the network manager
7. The ability to intelligently abandon shutdown commands to protect critical applications
8. The ability to 'wake' computers from 'off' or 'low power' states to facilitate network management activities

How Much Can Be Saved with Network Power Management?

On average, computers in real world environments consume around 600 kWh per year[13]. Of that amount, more than 2/3 can be wasted because machines are 'on' when they could either be in a lower power state or 'off'. The real question is, 'how much energy can be saved without impacts to the end user or to network productivity'? The answer to that question varies somewhat from network to network, but on average a solution that utilizes the 'Eight Essential Features' identified above is capable of transparently saving around 200 kWh per year[14], savings numbers originally established by the Bonneville Power Administration's review of Verdiem's "Surveyor Network Energy Manager". For every 5,000 computers, that adds up 1 million kWh of savings per year. At average energy rates of $.10 per kWh, that is $100,000 of savings for doing nothing more than insuring that computers aren't needlessly using energy when not in use!

You Can't Manage What You Don't Measure

It has often been said that you can't manage what you don't measure. In 2001, the Northwest Energy Efficiency Alliance was approached with the opportunity to provide development funding to Verdiem Corporation, at the time a young start-up seeking strategic funding upon which to build its business. The Alliance was immediately intrigued by the opportunity, and agreed to provide funding pending one technical stipulation: that Verdiem integrate measurement and verification (M&V) into the product as a core piece of its functionality[15]. This requirement simultaneously demonstrated the desire of utilities to achieve greater efficiencies in IT equipment, while also pointing out their fundamental concerns of measurement, equipment transience, and savings persistence. Only after it was demonstrated that IT equipment could be accurately measured, tracked and managed for the long term did the Alliance agree to support the initiative. Since then, more than 25 utilities throughout the U.S. and Canada have followed suit with incentives for computer power management products, and have been instrumental in driving the market to this innovative savings opportunity.

Computer Manufacturers Take Power Management to the Mainstream

While power management software is far from a commodity offering, it is becoming available through an ever increasing number of channels. Even computer manufacturers, who are notoriously cautious about changes to their product platforms, are seeking to develop entire lines of 'green' computers that might include components such as efficient power supplies, processors, chip sets and even flat panel monitors. But as most manufacturers embrace these same components, many continue to pursue opportunities to differentiate themselves from the competition. As such, network power management tools are increasingly being viewed as a way for manufacturers to provide a significant 'value add' to their customers, providing tools that extend well beyond current standards and allow customers to proactively address energy management demands.

Step 3: Environmentally Friendly Disposal of Computers and Servers

Now consider what happens at the end of the useful life of a desktop computer, which represents the last important component of life cycle management. New capabilities require upgraded performance, which in most cases means replacement of an otherwise operational computer. On line streaming video, distance collaboration, content-rich electronic mail, even the new Windows Vista operating system causes business people and individual consumers to replace their existing systems every three to seven years. Sometimes the need is driven by a desire to keep employees at peak productivity by using the fastest technology available, but new applications, security weaknesses, availability concerns, and the need to maintain support contracts also drive the continuous replacement of the global computing infrastructure.

How Big Is the Problem?

A recent report by IT industry analyst Gartner Group stated that 133,000 PCs are discarded each day by U.S. businesses and homes.[16] The Federal Electronics Challenge (FEC) estimates that the U.S. government alone accounts for 10,000 computers per week are deemed

excess or surplus. Further, only 10 to 15 percent of electronics are currently recycled, according to industry analysts. The implication is that more than 40 million computers each year are headed for landfills, a potential for over 1 million tons of e-waste annually. Additionally, computers manufactured in recent years can contain a number of toxic substances. A list of some of the most dangerous materials found in computers is shown in the table below.

Table 3. Hazardous Materials Commonly Found in Modern Computers

Hazardous Materials in PCs			
Substance	**Covered by RoHS**	**Substance**	**Covered by RoHS**
Mercury	Yes	PBB	Yes
Lead	Yes	PBDE	Yes
Cadmium	Yes	PVC	Yes
Chromium VI	Yes	Other Brominated Compounds	Yes

Why Aren't Businesses Acting on Their Own?

There are several reasons that many businesses have not disposed of their electronic waste in the past. The economic impact of finding and engaging a recycler is one reason. While there are a number of e-waste recycling businesses starting up, it can be a trick to find a reputable one. There are anecdotal stories of obsolete computers being harvested for valuable materials and then dumped in landfills or on the sides of roads. Basel Action Network (BAN), an activist group opposing international trade in toxic refuse, tracks what ultimately happens to e-waste that is recycled. Among the e-waste that is recycled, says BAN, 50 to 80 percent is exported overseas to dismantling shops where poor workers are exposed to hazardous fumes and chemicals while trying to extract valuable metals and components.

Researchers for Greenpeace International have detected high levels of toxic metals in soil and water samples collected around electronics-dismantling workshops in China and India.[17]

Another reason for companies resisting recycling is the difficulty of designing and executing a process inside the company that can handle the waste. Replacement and collection of older electronic gear is often handled by the Information Technology (IT) group, while disposal and recycling is handled by facilities management. In some companies, it is common to see piles of old computers, monitors, printers, and other electronic office equipment stacked along the walls of back hallways and warehouses. A school district in Colorado that recently replaced several thousand desktop computers ended up placing the old equipment in an unused gymnasium until a recycler could be found. Most people are aware that they should not just send used equipment to the landfill, but the connection to recyclers has not been propagated through the entire organization on what to do with the used gear. Also, there can be cost associated with recycling. Some of the major system manufacturers charge customers between $13 and $34 per box to recycle. An annual stream of 5,000 computers to be recycled quickly becomes a net-negative cash flow of nearly $200,000.

Forced into Action

The problem is big enough that government has gotten involved. The best known legislation globally is probably the Waste Electrical and Electronic Equipment, or WEEE,

Directive in the European Community, which has as its primary purpose "the prevention of waste electrical and electronic equipment, and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste."[16] This directive requires all manufacturers of computers to develop "take back" programs for their equipment. The take back programs must be free of charge to the consumers of the computers, and must be set up so that 65 percent of the components, materials and substances in the computers must be reused or recycled.

Federal legislation has not been written yet in the U.S. There are voluntary programs like the Federal Electronics Challenge (FEC) that urge users of the $62 billion per year federal IT programs to extend the replacement cycles of computers to 4 years (versus the traditional 3-year cycle), to dispose of waste electronics in a responsible way. FEC recommends that federal computer resources be recycled through the Recycling of Electronics and Asset Disposition (READ) services contract, and through the UNICOR electronics recycling program, a wholly-government-owned program run through the Federal Bureau of Prisons that takes computers and electronics into 8 locations around the U.S. and recycles them.[18] In addition, USEPA, both at the national and regional level, offers advice and contacts for electronics recycling via its web pages.

State Governments Acting More Quickly

While the federal government in the United States has not reacted legislatively to the threat of e-waste, many states are not waiting around. As of June of 2003, 23 states had legislation in the works, ranging from funding reports, to control of computer monitor disposal practices, to full blown electronic waste recycling purchase of certain video display devices. The fees are deposited into a special account to be paid to qualified e-waste collectors and recyclers to cover their costs of managing these devices when they are discarded. In addition, Maine, Maryland, and Washington state have passed laws on electronics recycling. The table below offers a quick comparison of these bills.

Table 4. State Laws on Electronics Recycling

Comparison of State Laws on Electronics Recycling March 24, 2006

Components	California	Maine	Maryland	Washington
Which products:	TVs and Monitors 4" or more diagonally. Includes CRTs and flat panels. Laptops, but NOT CPUs or other products.	TVs and Monitors 4" or more diagonally. Includes CRTs and flat panels. Laptops, and CPUs only if attached to monitors.	Monitors, computers (CPUs), laptops	TVs and Monitors 4" or more diagonally, (both CRTs and flat panels), laptops, and desktop computers (CPUs).
What type of owner is targeted:	All owners in California	Households only	Not Specified	Households, charities, small businesses, small governments and schools
Who pays for collection, transportation, recycling?	Consumers pay via fee at purchase	Producers (for transport and recycling and some collection) and municipalities (for some collection)	Counties pay for everything. They can apply for local grants from the state program	Producers

Producer Programs

With all the focus on environment, many of the producers of computer equipment have introduced recycling and take back programs as well. Sun, HP, IBM, Dell, Gateway, Sony, and others have references to their take back programs on their web sites. In some cases, the programs are open to anyone who wants to return any kind of computing device, though there may be a requirement to purchase replacement equipment from the vendor providing the program. Costs vary, with a typical fee being $10-$60. The programs have been very successful. Dell reported recycling 80 million pounds of computer equipment in 2005, and HP reported over 50 million pounds of computer and printer equipment and cartridges at each of its recycling plants in Nashville, TN and Roseville, CA.[19]

Conclusions

LCM of computers is a model whose time has come. Manufacturers are increasingly building more efficient products and designing for their energy and environmental management. Consumers are increasingly specifying green computers in their procurement specifications. The electric utility industry has shed its fear of consumer electronics and is funding innovative market based programs such as 80 PLUS. And labeling agencies such as ENERGY STAR and EPEAT have strengthened specifications to further motivate transformation in the industry.

There is still, however, an enormous amount of progress that must be made before LCM becomes an ingrained part of the PC marketplace. From a manufacturing perspective, a move towards LCM has to date been largely motivated by external factors such as pending ENERGY STAR changes and increasing customer requests. Similarly, consumers have been primarily motivated by external factors as well, including rising energy costs and tightening regulations around electronics disposal. While it is encouraging to see response to these factors, it is clear that the market is still largely in a 'reactive' condition rather than a 'proactive' condition.

The central question that has yet to be answered is whether manufacturers and consumers will begin to internalize the components of LCM in the future and embrace its tenets proactively rather than reactively. Will manufacturers build more efficient products even if they are more costly, and will IT consumers be willing to pay a bit more in order to achieve greater energy and environmental efficiencies. Beyond that, if the answer is 'no' to those questions, will regulatory agencies and labeling organizations such as ENERGY STAR continue to have the political will to push efficiencies to higher levels and demand more of the marketplace?

This much is certain: with the ever-increasing number of computers being manufactured each year and the rapid growth in servers and server farms, energy and environmental concerns surrounding the IT sector will continue to become more visible. In the future, it will continue to be critical for manufacturers, consumers, government agencies and utility organizations to work together to minimize the impacts of consumer electronics, and to give IT consumers the options they need in order to make responsible and beneficial purchasing and management decisions.

References

Murray, James. 2007. "IT as Polluting as Airline Industry." *Green Business News.* April 26.

US Environmental Protection Agency/ENERGY STAR. 2007. ENERGY STAR 4.0 Specifications. http://www.energystar.gov/index.cfm?c=revisions.computer_spec.

Koomey, Jonathan. 2007. *Estimating Total Power Consumption by Servers in the U.S. and the World.* Available at http://enterprise.amd.com/Downloads/svrpwrusecompletefinal.pdf

United Nations Environmental Program, Life Cycle Initiative pages. "Life Cycle Initiative Background."http://jp1.estis.net/builder/includes/page.asp?site=lcinit&page_id=AC5F8210-CF6F-4226-A5B7-F053F4BBED5C

US Department of Energy, Energy Information Administration. *Instruction for Forms EIA-1605, Voluntary Reporting of Greenhouse Gases (calculated at 1.45 lbs per kWh)*

Calwell, Chris and Reeder, Travis. 2001. *Power Supplies: A Hidden Opportunity for Energy Savings.*

Markoff, John. 2007. "Intel Plans Faster Chips that Also Save Power." *The New York Times*, www.nytimes.com. March 29.

Nordman, Piette, Kinney and Webber. 1997. *User Guide to Power Management of PCs and Monitors.*

Department of Energy. http://www.eia.doe.gov/emeu/cbecs/pc_copier/table_4.html.

Quantec LLC. 2004. *Market Progress Evaluation Report 2: Surveyor Software.* Prepared for the Northwest Energy Efficiency Alliance.

Greenburg, Dan. 2004. *Network Power Management Software: Saving Energy By Remote Control.* A report for ESource members. November.

Nordman, etal. 1997. *User Guide to Power Management of PCs and Monitors.*

Verdiem Corporation. 2007. *Energy Industry Guidebook.*

Arthur D. Little Inc, for the US Department of Energy. 2002. *Energy Consumption by Office and Telecommunication Equipment*. http://www.eere.energy.gov/buildings/info/documents/pdfs/office_telecom-vol1_final.pdf

Bonneville Power Administration, Regional Technical Forum Savings Assessment for Power Management. http://www.bpa.gov/Energy/N/projects/cr_discount/

Personal Interview with Phil Degans. Northwest Energy Efficiency Alliance. 2002.

Chea, Terrance. 2007. "Ramping Up Against E-Waste." *The Associated Press, Published in the Denver Post.* March 4.

Chea, Terrance. 2007. "Tech Firms Go Green As E-Waste Mounts." *The Associated Press, Published in www.wrkn.com*. March 4.

"Directive 2002/96/EC of the European Parliament and of the Council of 27 January, 2003 on Waste Electrical and Electronic Equipment (WEEE) – Joint Declaration of the European Parliament, the Council and the Commission Relating to Article 9." Available at http://eur-ex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0096:EN:HTML

Unicor Online | Recycling. http://www.unicor.gov/recycling/process/index.cfm

Chea, Terrance. 2007. "Tech Firms Go Green As E-Waste Mounts." *The Associated Press, Published in www.wrkn.com*. March 4.