If We're Only Snoozing, We're Losing: Opportunities to Save Energy by Improving the Active Mode Efficiency of Consumer Electronics and Office Equipment

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ABSTRACT

With appliances, HVAC, and lighting, the vast majority of energy savings has always come from higher efficiency in the functional or "active" mode. Yet with consumer electronics and office equipment ("electronics"), the primary focus of federal efficiency efforts and utility programs to date has been on standby and sleep mode energy use. In effect, these programs currently call a product "efficient" if it draws a small amount of power when not in active use, *regardless of how much energy it consumes to perform its intended function.*

Now that state and federal standards have "locked in" substantial efficiency improvements in the building shell, HVAC, and appliances, plug loads like electronics represent an ever-growing share of total residential and commercial energy use. Most of these devices now consume more energy in active mode than in their various low power modes. Most contain ac-dc power supplies, which by themselves can waste 10 to 70% of the total energy consumed by the finished product, even though more efficient designs are available in the market. In total, the nation's 3.1 billion power supplies waste about 3 to 4% of the entire U.S. electricity bill in the process of converting high voltage ac to low voltage dc.

This paper will highlight opportunities to improve the active mode efficiency and reduce the overall energy use of computers, monitors, televisions, battery chargers, and other major plug loads. Key strategies include:

- Developing standardized test methods
- Gathering consumer usage data
- Creating active mode efficiency metrics and duty cycle-based benchmarks
- Establishing power supply labeling and standards programs
- Labeling electronics with standardized, quantitative information about performance and energy use

Introduction

Although mandatory efficiency standards have obvious benefits associated with limiting the total energy consumption of particular products, they also serve as a broad foundation for other vital means of saving energy. For example, with appliances like refrigerators, washing machines, and dishwashers, mandatory standards could not be adopted until rigorous test procedures, standard loading conditions and operating modes, and annual duty cycles were established to allow comprehensive and fair comparisons of total annual energy use. In effect, analysts needed to know how much energy a clothes washer requires to clean a standardized load of soiled clothing and how many such loads are typically washed per year to estimate total annual energy use.[1]

All subsequent efforts to highlight differences in appliance energy use – Energy Guide labels, consumer guides, magazine articles, utility incentive and marketing programs, government procurement efforts, and ENERGY STAR® labels – have depended on that standardized energy use information for their success. Knowing total annual energy use is essential to estimating annual operating cost, determining payback times for improved efficiency, and making lifecycle cost comparisons.

Perhaps most importantly, improvements in appliance functionality and increases in appliance size have not eroded energy savings from efficiency improvements. The average size and performance of refrigerators has continued to rise, even though today's refrigerators use about 75% less electricity than they did in the late 1970s. Consumers can look at the Energy Guide label on a large ENERGY STAR side-by-side refrigerator with ice and water dispensers and understand that it may still use more energy than a conventional, smaller refrigerator, because total energy use is reported in both cases.

What about products for which no federally mandated test procedures, duty cycles, and annual energy use estimates were ever developed? ENERGY STAR achieved substantial early success with computers, televisions, VCRs, printers, and monitors. With each of these product categories, there were easy opportunities to reduce energy use during the long periods of time the products sit idle, or are otherwise not in active use. Many of them were consuming nearly constant amounts of power at all times, whether or not they were actually performing their intended function. But having achieved those early and obvious savings, labeling programs and the utility efforts linked to them have not shifted rapidly enough to consideration of other modes of operation and total energy use, particularly in electronic products.[2]

The Growing Importance of Electronics

There are a number of key indicators that illustrate the growing importance of electronics as an opportunity for energy savings:

Sheer Numbers

Electronics already represent a substantial percentage of total U.S. residential electricity use – about 7%, according to a 1996 DOE estimate (Calwell 2004). With the rapidly growing sales (Figure 1) of new categories of electronics like cellular phones, portable CD and MP3 players, battery chargers, satellite receivers, digital video recorders, and digital cameras, it seems likely that electronics now represent about 10 to 12% of total residential electricity use and a growing share of commercial electricity use. If electronics collectively represent as much electricity use as residential lighting and are growing faster, why not devote equal effort and resources to making them more efficient? Utilities would gain larger and more widely varied opportunities to encourage reductions in energy use and peak demand.

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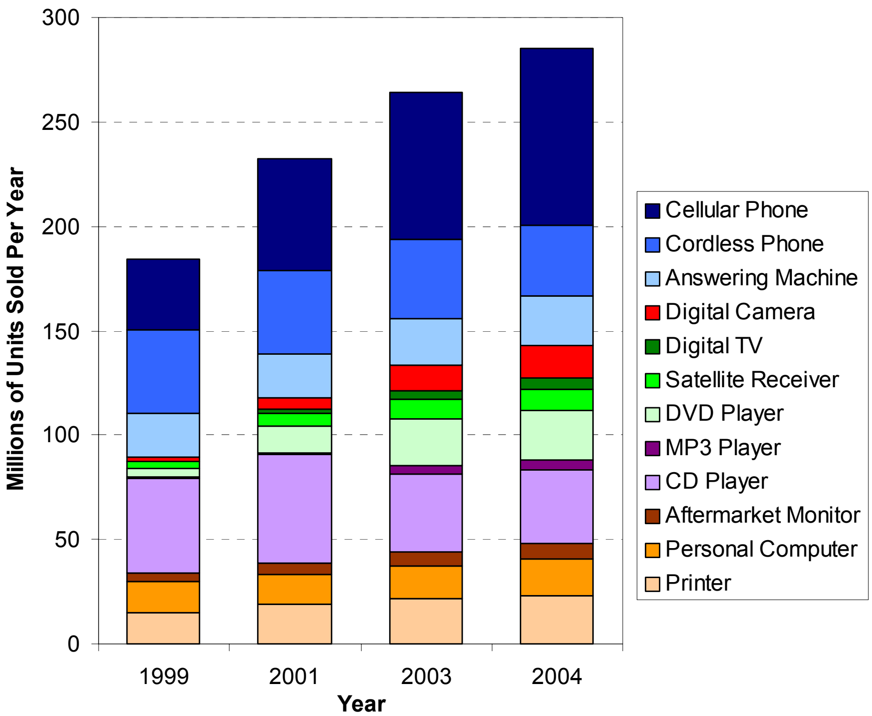
[1] Consideration of standby energy use has also become important in recent years as the products have added electronic features, but the vast majority of clothes washer energy use is associated with washing clothes.

[2] The terms "electronics" or "electronic products" are employed here to refer to the entire group of devices more commonly known as "consumer electronics and office equipment."

High Active Mode Energy Consumption

In order to address the growing energy consumption of electronics, it is vital to follow the example set by appliance standards and include consideration of electronic products' active mode energy use. Across a range of audio, video, information technology, and telecommunications products, we estimate that active mode accounts for the majority of total energy use. Only a small number of products spend the majority of *time* in active mode, but power use can often be 5 to 15 times greater in active mode than in standby or sleep modes. For example (Figure 2), a CRT (cathode ray tube) television consumes about 7 to 9 times as much power operating as it does in standby mode, even when standby power use is fairly high (12 watts).

Figure 1. Growth in U.S. Sales of Selected Electronic Products from 1999 to 2004

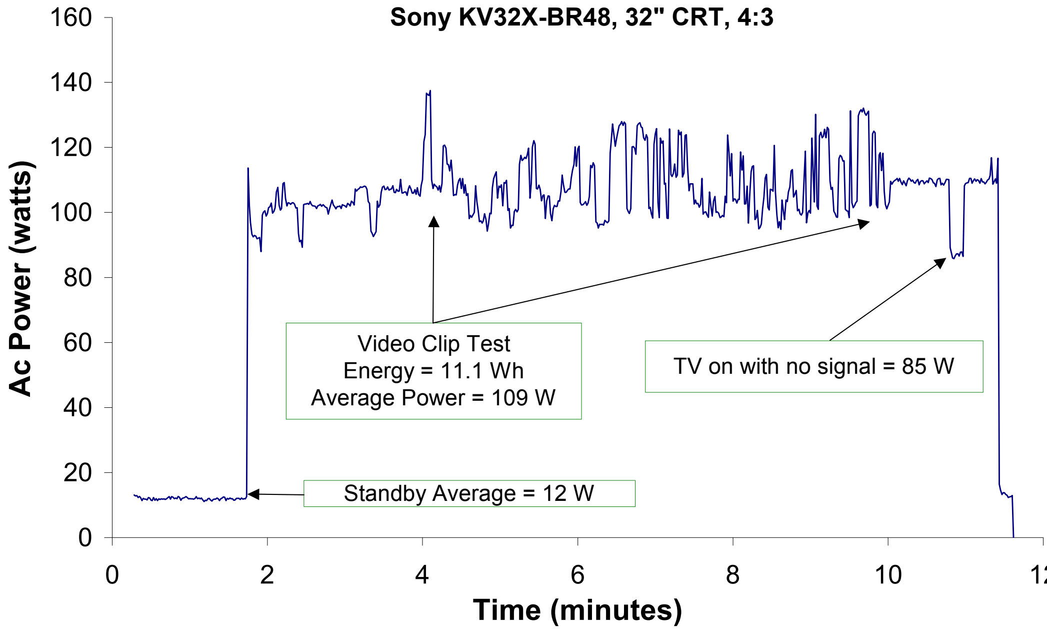


Source: Consumer Electronics Association 2004

Minimal Use of Sleep-Enabled Modes

Another reason for considering all modes of operation in electronics efficiency efforts is that many of the anticipated energy savings from user-enabled sleep or idle modes are not being realized. Current ENERGY STAR specifications that focus on reducing the energy consumption of a product only when it is in its low power modes depend on the user's ability and willingness to initiate low power settings. Even when computers, copiers, and printers are shipped with such sleep modes enabled, those settings are often changed by users or network administrators to maximize convenience or facilitate antivirus and backup functions over networks. A 2004 LBNL survey indicates that 64% of desktop computers in commercial buildings were left on after regular workday hours, and only 6% of those left on were in low power modes. This means that a total of 60% of computers in commercial buildings in this survey were in active mode when not in use at night (Roberson et al. 2004).

Figure 2. Sample Energy Usage of a Television Set



Source: Foster et al. 2004

Similarly, Arshad Mansoor of EPRI-PEAC has observed (Mansoor 2003) that many types of computer audio or desktop speaker systems employ an amplified subwoofer on the floor that remains on even when the user has switched off the smaller speakers on the desk. One particular Yamaha unit he measured could be consuming 16.7 watts of standby power continuously or 1.1 watts continuously, depending on the setting of a poorly labeled switch on the rear of the unit. A better amplifier design would not only improve efficiency when the product is operating, but would allow users to more easily enable low power modes.

Consumer Confusion

Labeling and incentive programs that focus only on differences in energy consumption when products are not in active mode are likely to confuse consumers about which choices can have the greatest impact on their energy bill. Indeed, consumers now routinely purchase labeled plasma televisions, CRT monitors, and desktop computers with far greater total annual energy use than their LCD (liquid crystal display) and laptop counterparts, many of which bear no efficiency label. Buyers believe their purchases are saving energy, not realizing that the labeling criteria only compare energy use in sleep and/or standby modes and that those modes may account for a small fraction of *total* annual energy use. Unfortunately, efficiency in one mode of operation is not a reliable predictor of efficiency in other modes or overall.

Limited Future Low Power Mode Energy Savings

The values allowed for sleep and standy power consumption area already quite low. Therefore, any additional reductions will be associated with diminishing returns. This is evidenced in the recent attempt to revise the ENERGY STAR computer monitor specification. Without addressing active mode power use, ENERGY STAR would not have gained enough energy savings through revisions to sleep and standby power levels alone to justify the effort. Even with the significant active mode savings that LCD monitors offer relative to CRTs, it will be challenging to reduce total U.S. monitor energy consumption, given the rising number of monitors in use and consumer preferences for ever-larger screens sizes. Total energy use of TVs and computers also continues to rise as the devices become more numerous and more powerful.

Strategies for Addressing Active Power

We have developed a multifaceted research approach that uses market analysis and technical assessment to recommend energy efficiency policy actions. Key elements of this approach include:

- Identifying and analyzing simple baseline components (such as power supplies) common to many electronic products that can easily be made more efficient without changing the design of the entire electronic product
- Performing market and technical research to assess the most promising ways to save energy with a particular product, including quantifying the overall energy savings impact of moving toward more efficient products
- Developing a test procedure to measure the efficiency of a product in active mode and measuring a range of products according to the test procedure
- Devising an efficiency metric that compares the product performance to its energy consumption or power use
- Establishing duty cycles based on consumer usage data
- Recommending an efficiency labeling requirement and implementing programs that encourage the introduction of efficient products into the marketplace

The Baseline Component – Power Supplies

Nearly all electronic products contain ac-dc power supplies that convert high voltage ac from the wall outlet into low voltage dc necessary to power digital circuitry, battery chargers, and dc motors. The technology associated with this conversion process is similar, regardless of the type of electronic product (television, cell phone, etc.) that is being powered. As a result, improving the efficiency of power supplies is a key strategy when working to improve the efficiency of consumer electronics in general.

Most of the power supplies that are sold with today's products are relatively inefficient. These power supplies can waste 10 to 70% of the total energy consumed by the finished product (Calwell 2001). In total, the nation's 3.1 billion power supplies waste about 3 to 4% of the entire U.S. electricity bill in the process of converting high voltage ac to low voltage dc (Ecos Consulting 2004). Designs already exist in the market that can bring power supply efficiencies to the range of 75 to 93%.

Power supplies can be internal to the product they are powering, as with televisions, or external, as with cellular and cordless phones. These external "adapters" are perhaps the most familiar type of power supply to consumers, and represent the most obvious opportunity for energy savings. They can be replaced outright in existing devices, or more efficient ones can be specified when new devices are sold, without having to redesign the entire product. Replacing these external power supplies is an easy first step in improving the efficiency of a product in all of its operating modes.

Efficient power supplies offer key advantages to consumers beyond energy savings. Improving external power supply efficiency yields smaller and lighter designs that increase portability and convenience for consumers, reduce packaging and shipping costs for manufacturers, and take up less shelf space in retail stores (Figure 3). Improving internal power supply efficiency reduces the production of waste heat and the need for noisy cooling fans in devices like computers. For example, a highly efficient desktop computer power supply can reduce heat output by as much as 100 watts, while operating far more quietly and paying for its additional cost in a matter of months through lower energy bills.[3]

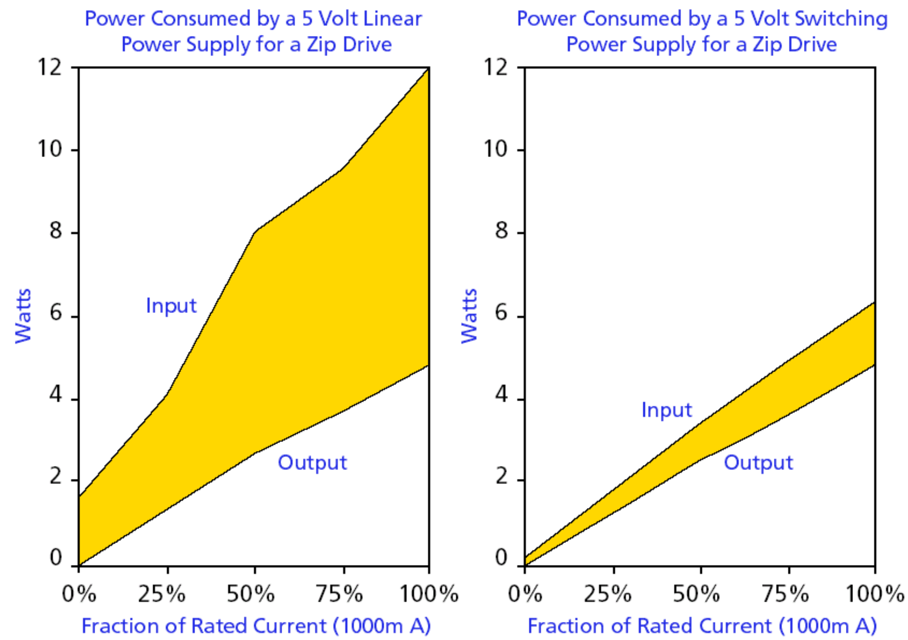
Figure 3. Comparing the Size of an Efficient (Middle) and Two Inefficient External Power Supplies

Source: Ecos Consulting 2004

Figure 4 gives an example of two external power supplies, a less efficient linear design, and a more efficient switching design. These power supplies power the same product, but have radically different efficiencies. The shaded areas represent the net power consumption of each power supply – the amount of ac input power that is converted to heat instead of becoming useful dc output power – across a range of load conditions. Both units are designed to produce a similar amount of dc output power. But at 100% load, the linear design draws nearly twice the ac power of the switching design (12 watts vs. 6.3 watts). At 0% load, it draws more than eight times the ac power (1.7 watts vs. 0.2 watts).

[3] This represents the amount of heat that can be produced when the power supply is operating at full load. During normal use, desktop computers nearly always operate at less than 60% of full power supply load.

Figure 4. Comparing the Efficiency of Two External Power Supplies



Source: Ecos Consulting 2004

Figure 5. Impact of Internal Power Supply Efficiency in a Desktop Computer

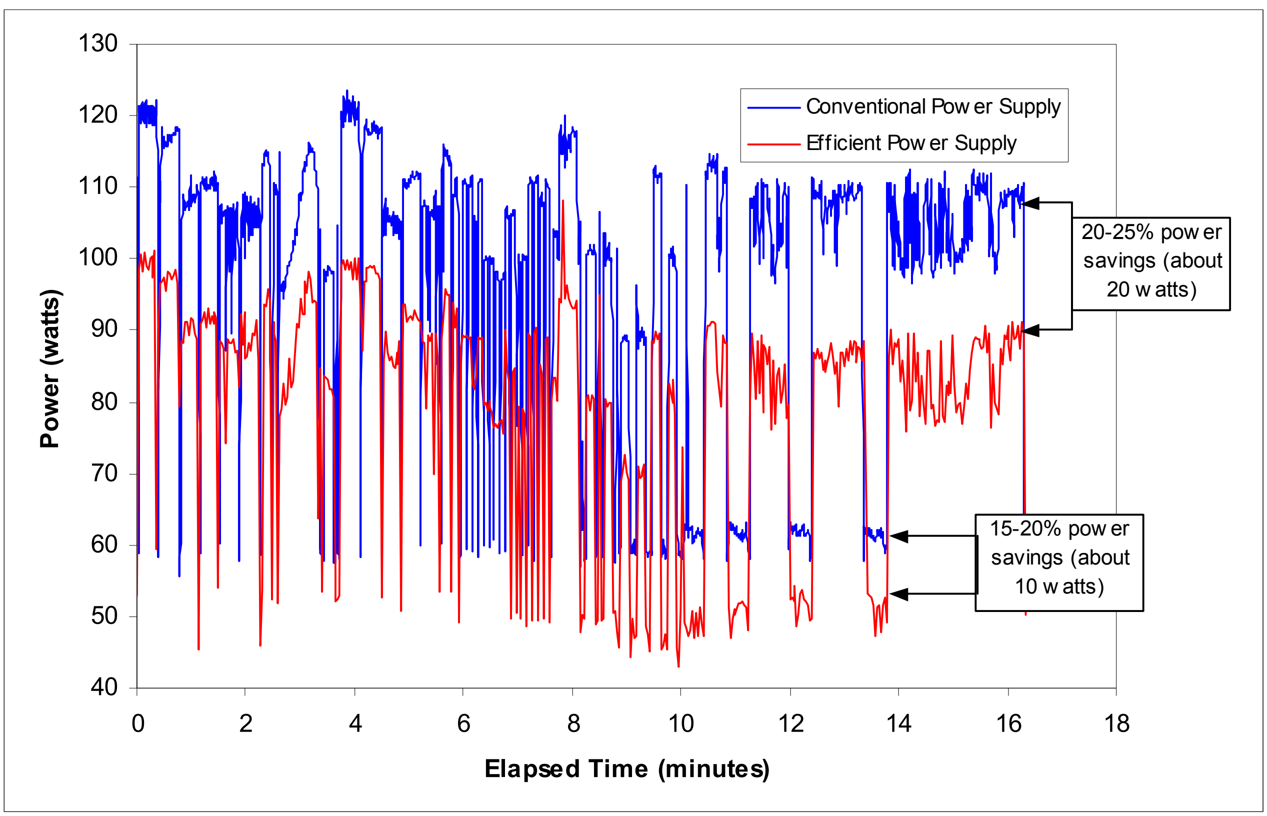


Figure 5 shows the efficiency improvements that can be achieved in a desktop computer simply by replacing the standard power supply with a more efficient power supply. The power use of a 2.66 GHz Pentium 4 HP desktop computer during a PCMark 2004 benchmark test sequence was recorded with two different power supplies installed. The blue line is the power use of the conventional power supply (roughly 55 to 70% efficient) that was sold with the computer. The red line is the power use while the computer is performing the exact same sequence of tasks, but instead with an efficient power supply (roughly 80 to 88% efficient) installed. The resulting energy savings is about 20% - or about 85 kWh per year.

Power supplies form factor is important. When addressing the efficiency of consumer electronics, it is sometimes possible to initially focus on the efficiency of the power supply, especially when the power supply is a commodity with its own housing, as is the case with the external power supply. Additionally, LCD televisions and computer monitors, as well as desktop computers, typically utilize stand-alone internal power supplies (or functionally similar external power supplies) that can easily be interchanged without having to redesign the entire product. The desktop computer power supply, in particular, is a good candidate for energy savings in the short term, with utility incentive programs like 80+ (www.80plus.org) encouraging computer manufacturers to install highly efficient power supplies in new desktop computers.

Other times, as with CRT televisions and computer monitors, the power supplies are often integrated with the other control circuitry of the product, making it difficult to isolate each power supply and measure its efficiency. Because electronics like CRT televisions utilize internal power supplies that differ radically from one product model to another, they must be addressed with specific end-use test methods, efficiency metrics, and policy actions. The focus then shifts to devising a way of measuring and quantifying the efficiency of an entire product, such as a television, and creating policy actions that would improve their efficiency.

Where Are the Biggest Savings Opportunities?

Our research suggests that electronics with the largest savings opportunities are desktop computers, direct view televisions, and computer monitors. Table 1 demonstrates the magnitude.

Table 1. Ecos Consumer Electronic Product Annual Energy Consumption Estimates

Product	Number in Use Nationally	Average Active Mode Energy per Unit (kWh/yr)	Average Sleep Mode Energy per Unit (kWh/yr)	Average Standby Mode Energy per Unit (kWh/yr)	Total Average Annual Energy Use per Unit (kWh/yr)	Total Annual Energy Used Nationally (TWh/yr)
Desktop Computer	205,000,000	308.2	25.7	5.9	339.8	69.7
Direct View Television	227,778,849	116.3	0.0	33.0	149.2	34.0
Computer Monitor	118,600,000	134.8	7.4	16.8	159.0	18.9

External power supplies do not present as great an opportunity for energy savings as products powered by internal power supplies. However, external power supplies are easier to address through policy actions like labeling and standards, which can apply to a range of applications simultaneously. For example, specifications requiring higher external power supply efficiency are relatively easy for cellular phone manufacturers to meet, since they can in turn specify greater efficiency from one or more of their many power supply vendors without changing any aspect of the cellular phone design itself.[4] In addition, roughly 900 million external power supplies are sold worldwide annually, and roughly a third of that, or approximately 300 million, are sold in North America. For these reasons, external power supplies were identified as one of the near-term opportunities for improving the efficiency of electronics.

Test Methods, Efficiency Metrics, and Consumer Usage Data

Test method and measurement. Because appliance standards and their formal test procedures do not exist for electronics, it is necessary to develop standard ways of measuring the energy consumption of a product under conditions resembling actual usage. One approach is to wait for industry bodies like IEEE (Institute of Electrical and Electronics Engineers) or ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers) to develop such methods, but that process can require many years. ENERGY STAR, FEMP (Federal Energy Management Program), and IEC (International Electrotechnical Commission) have established standardized test methods for standby (and in some cases, sleep) power measurement over the last decade. ENERGY STAR's first two test procedures for active power in electronics were developed over one-year periods between 2002 and 2004 for computer monitors and external power supplies. Others are likely to follow in the years to come, as product specifications come up for review and modification. In the near future, IEC may be able to further refine the ENERGY STAR power supply test procedure as part of their process of formal international standards consideration.[5]

In the process of developing a test method, the following actions are important to consider:

- Account for all operational modes of a product in order to capture the full picture of energy consumption
- Specify conditions necessary to ensure repeatable energy measurement across test laboratories
- Engage industry throughout the development and revision process

Figure 2 above illustrates the power use of a CRT television in various modes of operation. The power consumption of the television in standby mode is stable (within the precision limits of the meter) and easy to measure. However, while the television is displaying a moving picture and sound, the power use varies as much as 40%, depending on the type of image that is being displayed. These active mode variations represent the greatest challenge when developing standard test procedures, and are common to most electronic products. One way to address this issue in the case of televisions is to subject every television to a standard set of images and sounds while simultaneously recording the energy that the television consumes

[4] Improving power supply efficiency is the first step to improving the efficiency of externally powered products, but does not eliminate the inefficiencies associated with the design of the product itself. In later research and policy development stages, efficiencies of the product design related to the delivered performance can be addressed to further improve the efficiency.

[5] See www.efficientpowersupplies.org for the current draft of "Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc Power Supplies," authored by Chris Calwell, Suzanne Foster, and Travis Reeder of Ecos Consulting and Arshad Mansoor of EPRI-PEAC.

during that period. In our research, we employed a video clip approach, whereby we selected a standard three-minute DVD segment and measured the TV's energy use while the DVD is played. This approach, annotated in Figure 2, is quite different from testing the power of the television when there is no visual or audio input (109 W vs. 85 W).

NRDC and Ecos are investigating a similar approach for computers, employing benchmarking software to deliver a standard set of instructions to the CPU while simultaneously measuring the computer's energy usage over the same period of time. Figure 5, above, illustrates one such test. A status summary of relevant test methods is given in Table 2.

Table 2. Technical Considerations - Test Methods and Performance Metrics

Product	Performance Measure	Energy Consumption Test Method Status	Efficiency Metric
External Power Supplies	Dc output power	ENERGY STAR endorsed test method developed by Ecos and partners, available at www.efficientpowersupplies.org	dc output power/ ac input power (expressed as a percentage)
Computer Monitors	Displayed pixels	ENERGY STAR endorsed test method	pixels /ac input power
Computers	Near term: power supply efficiency Long term: software benchmark score	Draft internal power supply test method developed by EPRI-PEAC. Available at www.efficientpowersupplies.org Scoping study on laptop computers completed by Ecos for NRDC in 2003 addressed power supply efficiency and benchmarking software opportunities. Ecos and EPRI-PEAC investigating server test methods for LBNL in 2004. NRDC and Ecos plan to conduct desktop software benchmark test method research in 2004.	Near term: dc output power / ac input power Long term: benchmark score / ac energy consumed during benchmark
Direct View Televisions	Screen area and pixels	Official DOE test method exists, but is antiquated and not used by industry. IEC test procedure more current. Draft internal power supply test method developed by partner EPRI-PEAC. Available at www.efficientpowersupplies.org NRDC and Ecos plan to develop a draft, whole-product test method in 2004.	(screen area * resolution) / ac energy used while displaying a reference video clip for a particular period of time
Battery Chargers	Dc energy output from battery	Draft test method developed by Ecos and partners. Available at www.efficientpowersupplies.org	dc energy output from battery / ac energy input to charger

Once a viable test approach is established, a database of energy consumption data can be compiled. The purpose is to determine the range of energy consumption for products with similar functionality. This can be done in a laboratory or field setting, depending on the complexity of the test procedure and the cost of procuring a large number of samples for testing. Early television results, for example, suggest wide variations in kWh consumption among plasma, CRT, and LCD-based televisions with similar screen sizes and resolutions, though the research to refine the test procedure and efficiency metrics is ongoing.

Efficiency metric. Efficiency in general is defined as the functional performance of the product divided by the energy or power required to deliver that performance. Not only does the energy consumption of consumer electronic products vary substantially from model to model, but also their performance differs from model to model. This efficiency ratio allows products that deliver more performance to consume more energy. Electronics technology is constantly changing, so metrics must be developed that are independent of the technology used to create the performance. For example, it is well known that LCD computer monitors are generally more efficient than CRT monitors, but a metric should encourage functional improvements in efficiency, however they can be achieved, rather than stipulating the use of LCD technology. Summaries of adopted and potential performance metrics are listed in Table 2 below, along with test method issues.

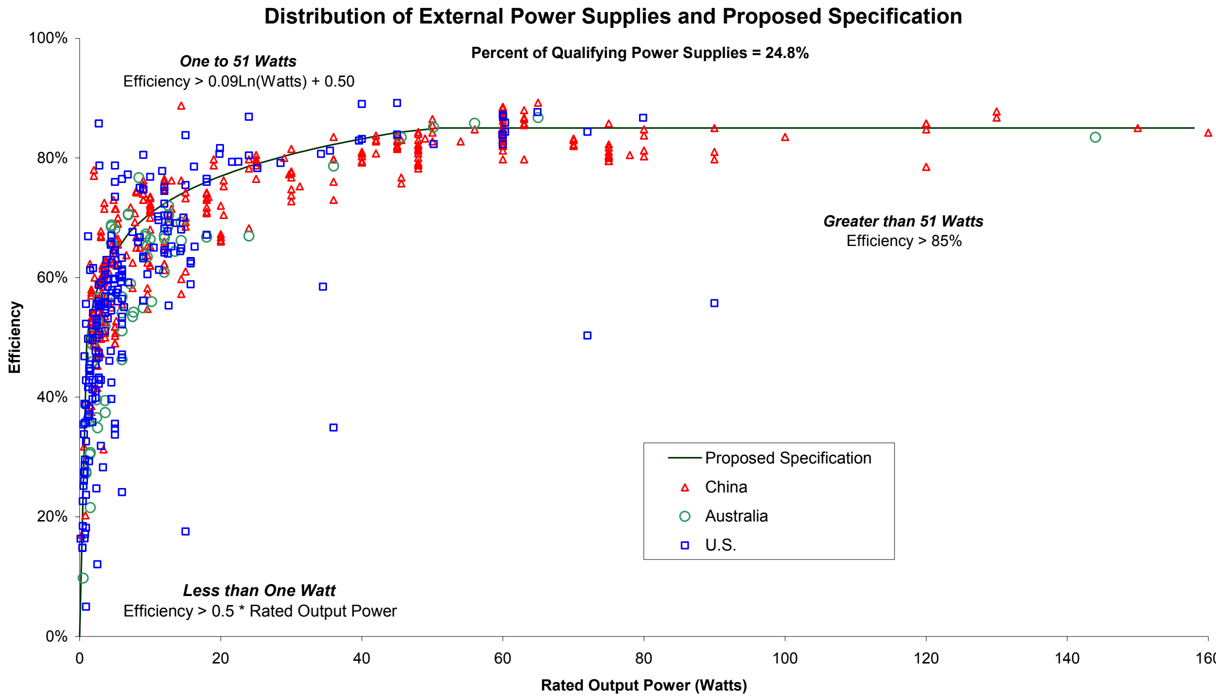
Depending on the complexity of the performance metric, it sometimes may be necessary to incorporate into the efficiency test procedure a set of standard setup and adjustment conditions, so performance may be fairly and objectively compared across models. For example, in the case of the computer, it is possible to measure the performance of the computer with a software based performance benchmark. While the computer is running the benchmark, the energy consumed can be measured. The efficiency metric then becomes the ratio of the benchmark score to the energy consumed over the course of the benchmarking process, rather than simply the absolute energy consumption.

Gathering consumer usage data. In addition to developing test procedures, consumer usage data must be gathered in order to calculate the annual energy consumption of the product and determine the savings potential. It is important to know how many hours a product is operated each day, how many hours it is unplugged or completely switched off, and how many hours it is in its various low power modes. The California Energy Commission's PIER program is funding ongoing work at LBNL and by other researchers to estimates usage patterns, but measured data on usage patterns and duty cycles remain scarce.

Recommending Efficiency Specifications

After assembling energy consumption data and proposing an efficiency metric, NRDC and Ecos recommend efficiency levels that represent the top tier of products in the marketplace for consideration by ENERGY STAR and others. In order to ensure broad representation, large numbers of products must be tested according to the standard test procedure, either independently or by manufacturers. Then, efficiency thresholds are determined based on the pattern presented by the data. An example of this type of recommendation for external power supplies demanded an approach that combined three equations to create the active mode efficiency threshold (Figure 7). Data from the U.S., China, and Australia were used to create the proposed specification.

Figure 7. Proposed Active Mode ENERGY STAR External Power Supply Specification



Source: Ecos Consulting 2004

Policy Implications

Labeling Electronic Products

Voluntary labeling. The Energy Guide label process for appliances is complex because products are tested over all the relevant modes of operation and annual energy consumption of the products was computed using an established duty cycle. All of this effort allows products to be compared on a single scale: annual energy consumption (kilowatt-hours per year). On the contrary, ENERGY STAR specifications for electronics traditionally set a threshold for every operational mode of a product, usually power limits for low power modes and, in the case of desktop computer monitors and external power supplies, an active mode efficiency threshold. This operational mode approach may be simpler and less controversial in the short term. Over the long term, though, the duty cycle approach offers compelling advantages:

- Manufacturers could trade off standby, sleep, and active mode energy use with each other to achieve the greatest total energy savings at the lowest cost.
- A single annual energy consumption number allows the consumer to easily compare one product to another on the basis of kilowatt-hours per year (or more meaningfully, dollars per year), instead of having multiple numbers for each mode of operation. It could become standard practice for magazines like *Consumer Reports* to report the energy efficiency of particular tested products quantitatively, institutionalizing consideration of energy use in a wider range of purchases.
- The annual energy consumption approach gives more universal and consistent meaning to a voluntary label like the ENERGY STAR. Today, the label can be found on 25% of

products in one particular category, and as many of 90% of products in another category, which can be confusing to many shoppers.

- Because one value would determine which products qualify for ENERGY STAR, the specification could easily be automatically recalculated on a regular basis. This would reduce the amount of time required by ENERGY STAR staff to revise specifications, enabling more frequent updates than currently possible. One idea worth considering is to set each year's ENERGY STAR specification at the top 25% level of all models for which annual energy use data are available from the previous year. Updates to specifications could become more quantitative, automatic, and transparent, instead of a process that is often political, subjective, and protracted.

Mandatory labeling. Voluntary labels like ENERGY STAR inform the consumer that a labeled product is somewhat more efficient than average, but do not give the consumer a sense of how the efficiency of a labeled product compares to the efficiency of other unlabeled products. Mandatory energy product labels in China, Australia, and Europe characterize the energy efficiency of a product categorically, using letters, one to five stars, etc. These categorical labels provide positive incentives at both ends of the efficiency spectrum, because manufacturers want to avoid a label on their product that indicates a low efficiency. At the other end of the scale, a manufacturer can distinguish itself as an energy efficiency leader and participate in a voluntary labeling program like ENERGY STAR. Mandatory labels currently exist in the U.S. for refrigerators, freezers, clothes washers, heat pumps, air conditioners, furnaces, hot water heaters, and pool heaters, but there are no labels for electronics. We recommend that the U.S. develop these types of mandatory labels for electronics, including categorical comparisons, annual energy use, and energy cost information based on a standard duty cycle.

Conclusion

Taken together, efforts to establish meaningful measures of efficiency, assess power use in all modes, create standard duty cycles, establish labeling specifications, and disclose total energy consumption can help curb the nation's growing appetite for energy to power consumer electronics. Without them, many of the efficiency successes achieved to date with lighting, appliances and HVAC equipment are at risk, even as Americans race to purchase the next generation of electronic products for their homes and offices.

References

Calwell, Chris. 2004. "Tired of tubes? Fixed your fridges? Check out the energy savings from efficient power supplies!" Presentation at ACEEE Market Transformation Symposium, Washington, D.C., Mar. 2, 2004.

Calwell, Chris and Travis Reeder. 2001. "Power Supplies: A Hidden Opportunity for Energy Savings." Report produced for the Natural Resources Defense Council. Available online: http://www.nrdc.org/air/energy/appliance/app2.pdf. San Francisco, Calif.: Natural Resources Defense Council.

Consumer Electronics Association. 2004. "U.S. Consumer Electronics Sales and Forecasts 1999-2004." Available online at www.ce.org. Arlington, Virginia: Consumer Electronics Association.

Ecos Consulting. 2004. "Power Supply Efficiency: What Have We Learned?" Report Produced for the California Energy Commission. Available online: www.efficientpowersupplies.org. Durango, Colo.: Ecos Consulting.

Foster, Suzanne, Chris Calwell, and Travis Reeder. 2004. "The Energy Efficiency of Televisions in Active Mode." Report produced for the Natural Resources Defense Council. Available from Project Manager, Project Manager Noah D. Horowitz, Sr. Scientist nhorowitz@nrdc.org.

Mansoor, Arshad. November 2003. "Power Measurement of Residential Cord Connected Appliances: Low Power Mode and Active Mode." EPRI PEAC Corporation.

Roberson, Judy A., Carrie A. Webber, Marla C. McWhinney, Richard E. Brown, Margaret J. Pinckard, and John F. Busch. 2004. "After-hours Power Status of Office Equipment and Inventory of Miscellaneous Plug-Load Equipment." Available online at http://enduse.lbl.gov/Projects/OffEqpt.html. Berkeley, Calif.: Ernest Orlando Lawrence Berkeley National Laboratory.

Shepard, Jeff. 2004. "Power Supply Markets – an overview" Darnell paper presented at the Worldwide Power Supplies Summit, Anaheim, Calif., Feb. 22.