Final Field Research Report

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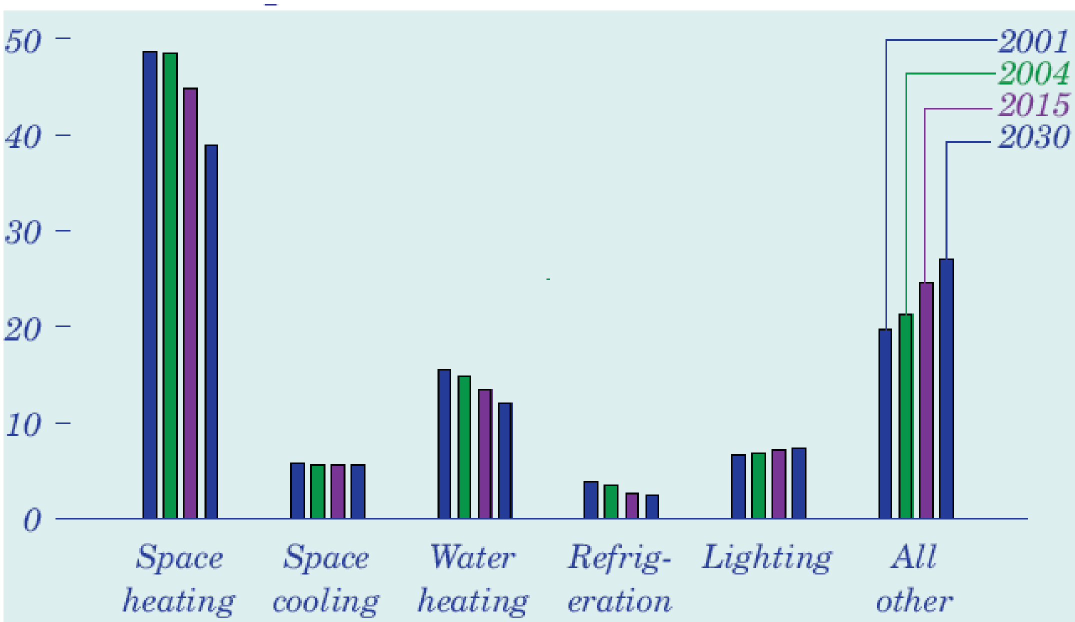
1. Introduction

In the last decade, the energy efficiency community has turned increasing attention to the efficiency of consumer electronics, office electronics and other miscellaneous plug load devices. This group of "miscellaneous" or "other" residential energy use used to be a relatively small percentage of residential electric demand, which was dominated by space heating and cooling, water heating, refrigeration, large appliances, and lighting. Now that state and federal standards have "locked in" substantial efficiency improvements in these traditional residential end uses, miscellaneous energy use represents an ever-growing share of total residential energy use ("All other", Figure 1).

Figure 1. Delivered residential energy consumption by end use, 2001, 2004, 2015, and 2030 (million Btu per household)



Source:(Energy Information Administration 2006)

DOE's projections in Figure 1 agree with other estimates that consumer electronics and miscellaneous plug loads constitute approximately 10% to 15% of residential electricity consumption, and the overall energy use of these products is expected to grow (Energy Information Administration 2001; Roth, Ponoum et al. 2006) (Ecos Consulting 2004). Lawrence Berkeley National Laboratory was the first to investigate miscellaneous residential energy use by focusing on standby power. Its studies in the mid to late 1990s revealed standby power consumption of various residential products to be a significant portion of energy use in the residential sector (Ross and Meier 2000). Later, we (Ecos) and others began to quantify the energy use of not only standby and low power modes, but also of active modes in consumer electronics and miscellaneous plug loads (Ecos Consulting 2004) (Foster 2005) (Ostendorp, Foster et al. 2005). Our reports contained detailed lab measurements of power use in active and standby as well as market data on annual sales, but usually relied on assumptions about the device usage patterns in order to create energy savings opportunity estimates. Detailed information on usage patterns of these products was simply unavailable.

This research pioneers a field measurement approach to reveal not only usage patterns of individual products, but also measure product power use by mode and count the incidence of products in homes. Specifically, this study had the following goals:

- Survey the number of plug load products in a representative sample of California homes
- Measure the power consumption of a wide range of common household plug load devices for a week, logged at one-minute intervals
- Determine the usage patterns, energy consumption, and load profiles for different categories of plug load products in the home
- Use standard statistical methods to scale the survey's results up to the state level

This report explains this study's purpose, collaborators, data collection and analysis procedures, as well as its key findings and recommendations. This research produced a large volume of data on hundreds of plug load devices measured in dozens of homes. Therefore, in the text, we discuss selected characteristics of specific high-profile products such as televisions and computers as part of three broad product categories (entertainment, information technology and battery chargers). We then highlight typical usage patterns for these products. Finally, we examine the macro-scale implications of this study for all of California. Supporting tables and data can be found in the appendices.

2. Methodology

A. Team Overview

Our research goal was to determine usage patterns and energy consumption of miscellaneous residential plug load devices in California through time-series measurement in a representative set of households. Our approach gave equal emphasis to all product energy use, including energy use in active, low, power, and standby modes. The focus of our study was those product types prior research suggested would have the highest total energy use. The products could have high energy use because individual devices use a lot of energy, because there are a significant number of devices used in homes, or both. We gathered our field data through a combination of surveying and measurement methods at our disposal, including telephone surveys, home visits to perform detailed time-series power measurements, and state-of-the-art statistical and visual analysis tools.

The study involved a team of experienced researchers, each bringing unique skills to the effort. We (Ecos) provided overall project management oversight, supplied technical information about the products to be surveyed, directed the development of custom power meters, and synthesized the final results in this report. Our partner, RLW Analytics (RLW) developed the sampling frame for California homes, managed the recruiting and scheduling of the study participants, and developed data collection and data management tools. RLW also led the team that performed the home visits, collected on-site information, and performed statistical analysis on large batches of data to help automate the analysis process.

In addition, we leveraged the activities of a concurrent research project led by Lawrence Berkeley National Laboratory (LBNL). LBNL researchers were also interested in examining miscellaneous energy use in homes, so we worked with LBNL and RLW to knit the two studies together to take advantage of cost savings synergies and complimentary data collection protocols. LBNL's study focused primarily on low power modes. They developed a telephone survey that was conducted prior to on-site visits to gauge the number of miscellaneous products in a home, supplemented our on-site time-series data collection efforts by conducting instantaneous measurements of plug load power use, and collected a complete inventory of miscellaneous electric products on site.

The following sections discuss the process of data collection that was used on each of the 300 homes surveyed and the methods used to analyze the collected data after the study was complete.

B. Data Collection

1. Design of Household Sampling Plan

At the time that this study was conceived, RLW Analytics had recently completed hundreds of residential audits for three of California's largest investor-owned electric utilities (IOUs)[1] and the Sacramento Municipal Utility District (SMUD) as part of the 2005 California Lighting and Appliance Saturation Study (CLASS). This prior research gave RLW Analytics access to a demographically diverse pool of hundreds of homes that had previously been willing participants in energy research.

RLW designed a clustered sampling plan from the original pool of CLASS homes to ensure an even geographic distribution of homes to be surveyed. The pool of roughly 900 (896) CLASS households was

[1] Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric (SDG&E) and Southern California Edison (SCE)

divided into 14 geographic territories (Figure 2).[2] First, 300 of the 896 CLASS households were surveyed via telephone to get basic counts of miscellaneous products. Of the 300 homes phoned, 75 were then metered using LBNL's instantaneous power measurement protocol.[3] A further subset of these homes – 50 – was *also* subject to time-series logging of power use using Ecos' measurement protocol. Figure 3 below illustrates the "nesting" of the different populations studied.

Figure 2. Geographic Territories Used in Study

RLW completed telephone surveys for 33% of the randomly selected households in each territory and achieved a statewide total of 300 phone survey results. As part of the phone survey, RLW successfully recruited 50% of the phone surveyed homes as willing participants in the on-site survey. Finally, half of these willing on-site participants were selected at random for home visits. Two of every three homes selected for on-site visits were randomly selected for Ecos time-series protocol and the LBNL protocol. Because LBNL's survey required 75 total homes, the other third of the homes selected used the LBNL instantaneous metering protocol only.

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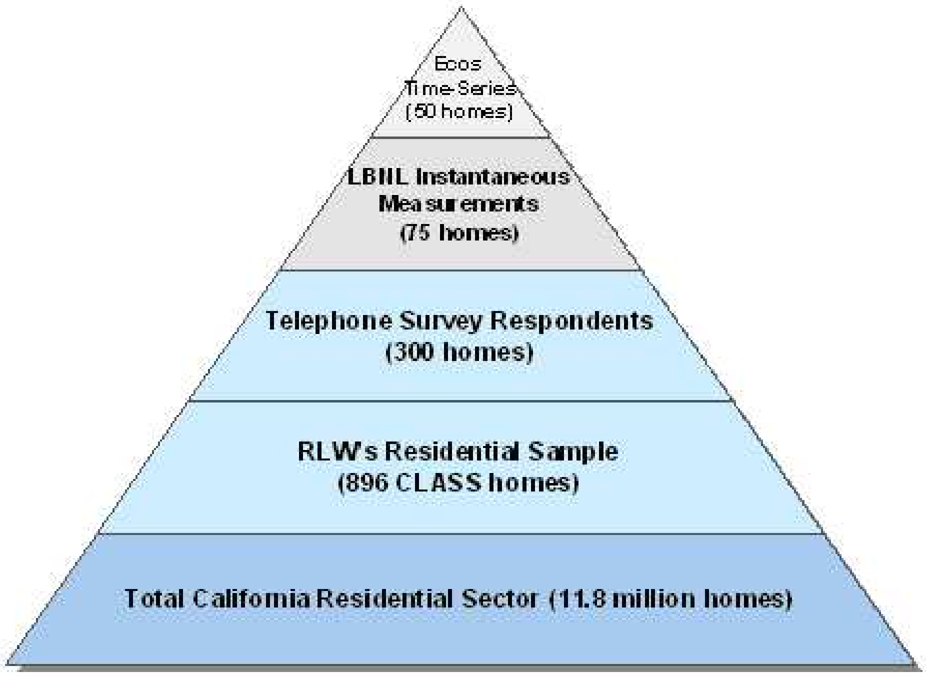
[2] Because the CLASS sample was created from the major IOU and SMUD territories, the entire geographic region of CA is not included in our sample frame. The regions sampled represented 9.7 million of the11.8 million occupied homes in California. A weighted average of energy use of the 9.7 million homes in the sample frame was used to estimate the plug load energy use of the 1.1 million homes not included in the survey.

[3] Although not the focus of its survey, LBNL also made a few time-series measurements to compliment its instantaneous power measurements.

Figure 3. Nesting of Population Samples



2. Phase 1: Recruiting Homes and Preliminary Counts of Products

Ecos, LBNL, and RLW collaborated in the development of the telephone survey instrument, and RLW administered the surveys. The technical portion of the phone survey script can be found in Appendix A, Phone Survey Protocol. The survey began by requesting counts of the plug load products currently operating in the home.[4] Questions were grouped by product categories to increase clarity for the respondent. These product categories, ranked in order of priority, included: home entertainment, home office/computers, portable (e.g. cell phones, digital cameras, etc.), general (products that can be found anywhere in the home, such as telephones), garage/outdoor, mobility/vehicles, kitchen, and other. Survey respondents were given a $10 incentive for participating in the phone survey.

At the end of the phone survey, respondents were asked if they wished to be considered for an on-site survey of their plug load devices. They were made aware that researchers would enter their home and take measurements of their plug load products. Homeowners were offered a $100 incentive for every site visit made.[5] If the homeowners wished to be considered, the phone surveyor requested available slots of 2 – 3 hours during which on-site visits could be scheduled for the household.

3. Phase 2: Home Visits and Detailed Measurements

Prioritization for Time-Series Metered Products

With the broad array of plug load devices present in homes today and with a limited time period to install time-series meters in each home, it was necessary to prioritize exactly which products in a home would be time-series metered under this study. We developed a rationale for prioritization, placing the greatest value on measuring products that had already been identified as potentially high energy users,

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[4] The products needed to be regularly plugged in and operated in order to be counted.

[5] For the 50 Ecos/LBNL sites, two visits were necessary: one to gather product count information and install the time-series meters and another to collect the meters. For the 25 LBNL-only sites, only one visit was necessary.

but whose usage patterns and annual energy consumption were not well documented in published research. In addition, we did not measure plug load products that had already been the focus of research and policy efforts, specifically large "white goods" appliances and heating, ventilating, and air conditioning (HVAC) products. Product groups were prioritized in the following way:

- **High priority**
    - **Entertainment:** televisions, set top boxes, video game consoles, VCRs, DVD players, etc.
    - **Information Technology:** computers, printers, wireless routers, modems, etc.
- **Medium priority**
    - **Battery Chargers:** cell phone charger, CD player chargers, Bluetooth headset charger, toothbrush charger, cordless power tool charger, etc.
    - **Other:** night lights, corded hair clippers
- **Low priority**
    - **Other:** coffee makers, radios, clocks, clock radios, portable stereo systems, wine cooler refrigerators, etc.
- **Zero priority**
    - **White goods, building systems, and heater/cooling products**: full-size refrigerators, dishwashers, clothes washers and dryers, skylight controls, home security systems, garage door openers, etc.

LBNL's prioritization protocol for instantaneous power measurements differed slightly from our time-series prioritization protocol. LBNL had previously made an estimate of statewide low power residential energy consumption based on stock estimates, usage patterns, and power levels. With estimates of uncertainty for each of these three parameters, LBNL focused its data collection on those parameters that most contributed to refining the statewide total and low power energy estimates. Because the purposes of the studies were slightly different, the products that were time-series metered with the Ecos protocol and the products that were instantaneously metered in each mode of operation (LBNL measurement protocol) overlapped significantly, but not perfectly. For our detailed product prioritization list, see Appendix B, Product Selection Protocol.

Home Visit Overview

Field teams of three members each were directed by an RLW field lead and supported by one field specialist from RLW and one field specialist from Ecos. Teams visited 50 homes to install time-series meters using our metering protocol.[6] Depending on the size of the home and the number of plug load products in use on site, the team installed as few as 5 and as many as 35 meters per home. On average, 17 electric products were time-series metered in each home. In each home visit, the field team followed the same protocol for interacting with the homeowner, first confirming information received in the phone survey, installing time-series meters, conducting LBNL's power measurements, and following up at a later date to retrieve our time-series meters. This ensured consistent results across the population of sample homes and minimized the need for *ad hoc* on-site decision making.

A standard introduction for the homeowner was carefully crafted to ensure continued participation and to reduce bias in the survey. They were asked to sign a form to release their billing data for the most recent 12 month period. Also, they were given "leave behind" materials in case they needed additional information or needed to reschedule the pick up of the meters. A copy of the introductory homeowner script used by the RLW field lead can be found in Appendix C, Field Staff In-Home Script.

[6] In 25 of the 75 homes, teams of two RLW field technicians conducted the LBNL instantaneous measurement protocol only.

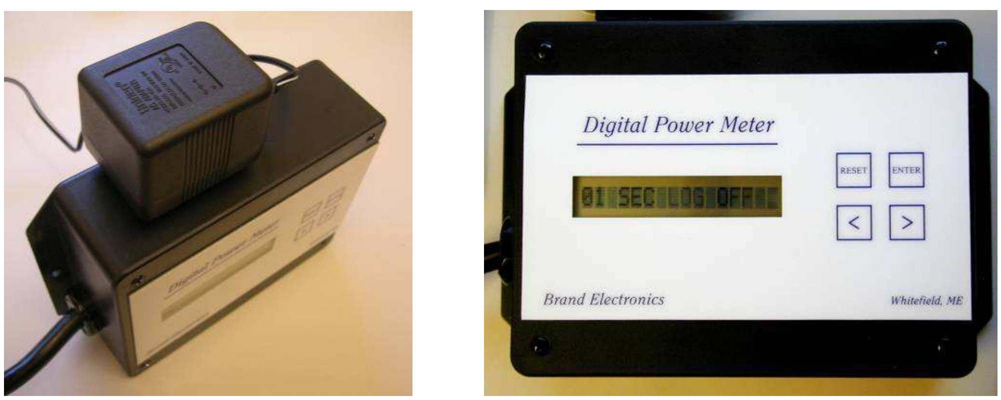
The team used two tablet computers running a database developed by RLW. This database already included counts of plug-loads in the home that were collected during the phone survey process. The team first used the tablets to confirm the counts of products given on the phone and categorized other products that were not addressed in the phone survey. During categorization, the product location and type of product were recorded.

Once all of the products were cataloged in the database, the database files from the two tablets were integrated and the product selection protocol for the time-series measurements was applied automatically by the tablet database software. Time-series power meters were installed on products identified as a priority by the automatic protocol. Meters were installed first on those products with the high priority, then on those products with medium priority, and finally products with low priority. Additional data were collected for those products that were time series metered, including manufacturer and model number, UL rating, power supply type, battery chemistry (if applicable), screen size (if applicable), and various other product-specific data.

Time Series Measurement

We worked with Brand Electronics to specify the meters installed on each plug load product. The meters, called One Meters, were custom-designed to meet the specifications of this study, including accuracy, data logging capabilities, and computer interface functions. A detailed list of product features and specifications can be found in Appendix D, Brand Meter Specifications. The meters contain a standard, grounded wall plug receptacle capable of measuring the voltage, current, power, and power factor of any plug load device with a power consumption of less than 500 watts.[7] Once installed by a field technician, the meters logged these parameters at one-minute intervals for a period of one week.

Figure 4. Brand Electronics' One Meter



Field technicians installed the One Meters by unplugging the appliance to be measured, plugging the One Meter into the wall plug previously occupied by the appliance, and then plugging the appliance into the wall plug receptacle on the One Meter. Technicians were specifically instructed *not* to alter any user settings on appliances in order to obtain the most complete and accurate picture of product use. In cases where certain plug load equipment was in use by the homeowner (a computer of television that was left on, for example), the technicians ensured that the devices were properly powered down before metering and then restored to their original usage state after connected to the One Meter.

Sites were revisited after one week for meter pickup and data collection. Field technicians turned off any equipment being metered and then disconnected the products from the One Meters. RLW Analytics field technicians then extracted the data, uploaded the data to an FTP site, reset the meters, and prepared them for their next site visit the following week.. Technicians used custom software and a

[7] A few One Meters were purchased that could handle equipment drawing up to 1800 watts so that when high power products were encounters, those could also be easily metered.

serial (RS232) connection to transfer data from the One Meters to a computer hard drive. The files were saved in a tab-delimited format so that they could later be analyzed using statistical analysis and visual display software.

4. Phase 3: Billing Data Collection

In the final phase of data collection, RLW worked with individual utilities to obtain electricity billing data for the homes that were visited. The majority of homeowners signed billing data release forms, and so we obtained monthly data on overall energy use in the homes visited in the study. These data were used to compare against the California Energy Commission published data on average energy use per home and to verify accuracy of the time-series results.

C. Data Analysis

1. Cleaning and Processing Time-series Data

Ecos collaborated with RLW Analytics to analyze time-series data files for all of the metered products and to further normalize and scale individual product measurements into macro-scale energy use estimates on the house and state level. The process consisted of two phases: data cleaning and time-series file processing.

Errors are inevitable in any field measurement process, so before analyzing results, we needed to first ensure any anomalies were removed. RLW first cleaned individual data files to control for errors that may have been introduced in the process of downloading data from the meters to hard disk. We (Ecos) provided parameters for voltage, current, power, and power factor to RLW to assist them in removing these download errors. Less than two percent of measurements were disregarded during this process.

After the time–series data files were cleaned, we needed to identify which portions of the week the product could be considered to be operating in active, low power, standby, and no power(unplugged) modes. For each product type, we provided RLW the expected number of modes and the expected power used in each mode. These initial parameters were based on our own laboratory measurements and other prior research findings. RLW used our parameters and a frequency distribution methodology in the SAS/STAT® software to make initial estimates of the "cut points" between modes. These cut points were the power values that divided the load profile of the product into various operational modes. We and RLW then refined the cut points for each product data file using an RLW-developed data visualization tool called Visualize-IT™.[8] Visualize-IT quickly displays load curve data graphically for individual products collected at a given site.

Figure 5 and Figure 6 below are Visualize-IT graphs of the modes of operation and power used by a CRT television during the week measured. Figure 5 is a chronological representation of how the television was operated during the week measured, and the power value of each mode of operation. Figure 6 displays the percentage of time that the TV used different power values. For example, this television's power demand was approximately 10 watts for 80% of the week and then ranged from 60 to 120 watts for 20% of the week. These measurements indicate operation in two modes: standby and active. The red vertical line in Figure 6 shows the cut point between the modes. Reviewing both graphs for each measured product in our study allowed us to determine the number of modes for each product and the cut points between the modes of operation for each product metered.

[8] For more information, see http://www.rlw.com/rlw/pro_visualize.htm.

Figure 5. CRT Television Usage Profile Displayed in Visualize-IT

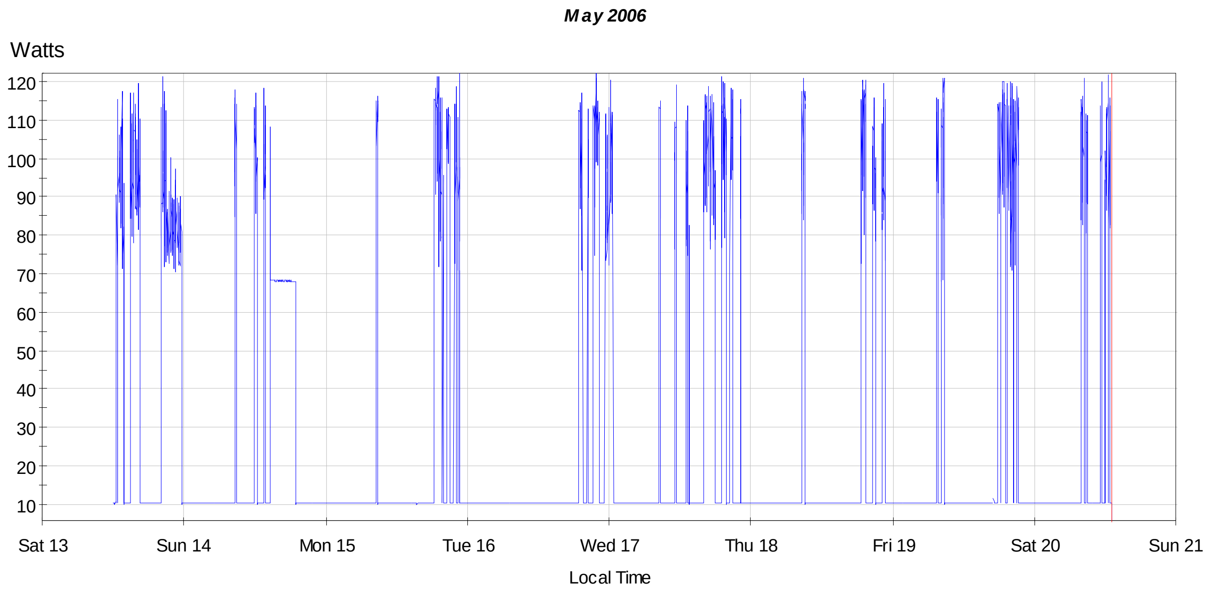
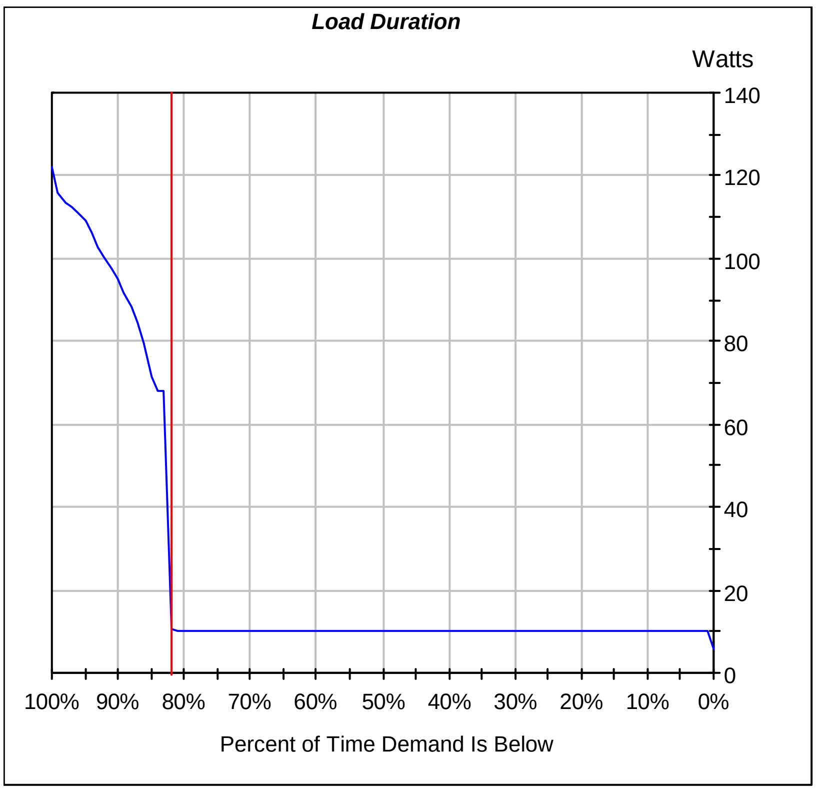


Figure 6. CRT Television Frequency Distribution Displayed in Visualize-IT



Finally, using the operational mode cut points identified for each measured product in Visualize-IT, RLW used the SAS/STAT® software to tally the total number of hours spent in each mode, power consumption by mode, and overall energy use. If two distinct modes were identified in the data, the product was considered to operate in "standby" and "active" states. If three states were present, the product was considered to operate in "standby," "low power," and "active" states. If only one mode was identified, then the product data were reviewed to see if it was reasonable to allocate that time to a particular mode. For some products whose power use in each mode of operation differs significantly (e.g. televisions), this was usually possible. For other products that do not have distinct modes of operation or whose power used in each mode is very similar, it was impossible to allocate the usage to a particular mode. For these products, we categorized their time, energy use, and power in a category called "indeterminate mode." This is not a separate mode of operation, but rather a placeholder for products where it was difficult to determine the duty cycle of the metered product.

After the time-series processing was complete, we evaluated the individual product duty cycles to confirm their reasonableness when compared to prior research. In cases where a product's duty cycle diverged greatly from commonly held assumptions and prior research findings, we manually investigated the raw data file of the product in question to determine if errors were present. Through an iterative process, we were able to identify and correct mistakes that may have been introduced in an earlier data cleaning or time-series file processing phase.

2. Normalizing Data

Because meters were installed for different amounts of time (some products were measured slightly longer than a week, some slightly less), it was necessary to normalize all energy use data for each measured product to one week (7 days, or 168 hours) and one year (365 days). By normalizing energy use data, accurate comparisons could be made between individual products, product types, and product families. No adjustments were made for potential seasonal variations in product use.

With fully normalized duty cycles for each measured product, it was then possible to create typical duty cycles for entire product types, such as desktop computers or clock radios. We identified the mean, mode, median, standard deviation, and range for multiple parameters. The results of this report focus on the power use in each state of operation and the hours spent in each state of operation. Our partners, EPRI Solutions, under Energy Commission contract number 500-06-007, will use other elements of the collected data (e.g. power factor) to assess grid impacts associated with miscellaneous product use. We also linked each encountered (measured and/or counted) product to the home in which it was found, that home's demographic information, and monthly billing data.

3. Developing Product, House, and State Characterizations

Once the data were cleaned, processed, normalized and linked to house demographic data, it was possible to develop product, house, and state level characterizations. These characterizations are outlined in the "Results" section of this report.

Product grouping allowed us to better understand the energy usage patterns of an "average" electric toothbrush, stereo system, primary TV, etc. After product usage profiles had been created for each product type, we were able to calculate average annual energy consumption of miscellaneous products in a specific home site. Products counted in the home but not time series metered were assigned an energy use based on product type generalizations as well as product location. The end result was a total estimate of energy use of electronic products in the home.

Once home profiles had been developed, we used weighting factors developed by RLW to scale the results to the total population of California homes. RLW calculated the weighting factors based on the total home population within each geographic cluster (for more information about clustering and sample design, see Section B: Data Collection above). The total population of homes residing within the geographic clusters for this study was 9.7 million; however, the total population of occupied California homes is 11.8 million (U.S. Census Bureau 2005). It was therefore necessary to use a weighted average of the 9.7 million homes and then apply that average to the remaining 1.1 million homes not included in the sampling frame.

4. Comparing to Previous Research

A handful of similar studies conducted independently of this research were used to assess the validity of our findings on the product level:

- A peer-reviewed paper jointly authored by the Florida Solar Energy Center and Lawrence Berkeley National Laboratory examining miscellaneous electricity use in new homes, presented at the American Council for an Energy-Efficient Economy's (ACEEE) 2006 summer study (Brown, Rittelmann et al. 2006)
- Research conducted by Lund University and presented at the 2006 International Energy Efficiency in Domestic Appliances and Lighting (EEDAL) conference (Sernhed 2006)
- A California Energy Commission report on energy residential energy consumption in low power modes, prepared by Lawrence Berkeley National Laboratory in 2004 (Lawrence Berkeley National Laboratory 2004)

The ACEEE and EEDAL papers were used because they rely on energy use data recorded outside California (Florida and Europe, respectively) and could serve to highlight any apparent bias in our California-centered dataset. The previous Energy Commission research on low power modes was chosen as a thorough in-state data reference – at least for low power mode energy use – and we expected our report's findings would correspond fairly well to Lawrence Berkeley National Laboratory's earlier findings on the topic. In the next section, "Results," we frequently refer to these studies and our other measurements and research to highlight where our findings agree and disagree with previous research.

3. Results

Our findings showed that the annual average energy used by electronics products in the home was between 1,069 and 1,207 kWh, costing each homeowner approximately $150 per year to operate. This is at least 9% of electricity use in a typical US household,[9] but more than 15% for a typical California home.[10] Entertainment electronics (TVs and their associated peripherals) and Information Technology (computers and their associated peripherals) were found to be the largest energy users.

We first present results by product category, then by household, and finally on the statewide level. In the product-lever results, we focused on large entertainment electronics, information technology, and products with battery chargers because these proved to be the most significant categories in terms of energy use and potential energy savings. Due to the sheer volume of data, not all results could be addressed in this section. Complete data is available in Appendices E and F.

A. Product Results

In the following section, we discuss our product-level findings. We grouped products into four broad categories: entertainment electronics, information technology (IT) electronics, battery charger electronics, and other electronics. Findings on the first three categories are included in this section; results for other electronics are provided in Appendix F. For reference, below is a review of product-level figure information on sample size and modes of operation.

Sample Size

Because of the nature of our research, sample sizes of products vary widely. For products that are less prevalent, such as the television with built-in DVD player, the sample size is only one product. More common products were measured frequently and have a larger sample size. Sample size is noted in all figures and tables.

Modes of Operation

For the majority of the products metered, we were able to examine the time series data and deduce the modes of operation (or usage patterns). For other products, it was difficult to determine the modes of operation, either because the product did not operate in different modes during the measurement period or because there is not a large difference in power use between the various operational states. For these products, we categorize their power, duty cycle, and energy use into "indeterminate mode."

For the power averages and the duty cycle results, we showed information for both products where modes were determinable and those products for which modes were not determinable. For energy use, we display product by product energy use for either the determinable averages or indeterminable averages, whichever sample size is larger. The number of products used in each annual energy use calculation compared to the total number of products metered is displayed in the x-axis of the relevant figure (e.g. N=4 of 5).

[9] According to the U.S. Department of Energy's 2001 RECS, the average household used 10,656 kWh of electricity per year.

[10] According to California Energy Commission 2003 energy statistics, the average California household consumed 6,494 kWh of electricity per year, significantly lower than the national average.

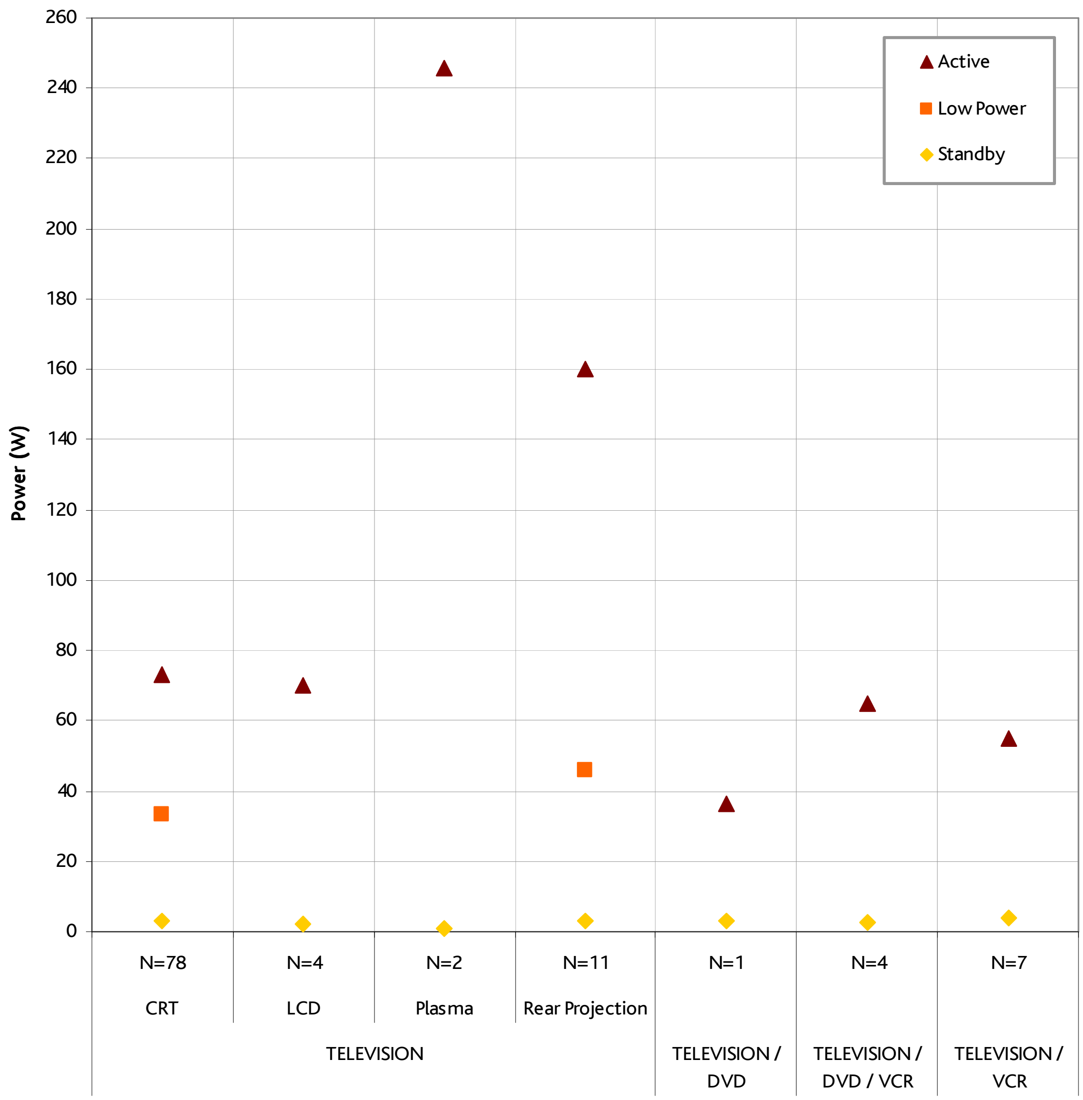
1. Entertainment Electronics

The entertainment electronics category includes televisions, their associated peripherals, and audio equipment, including VCRs, DVD players, digital video recorders (DVDs or TiVos), set top boxes, video game consoles, amplifiers, tuners, mini stereos, receivers, speakers. A total of 305 time-series measurements of entertainment electronics products were made as a part of our research.

Power Averages by Mode

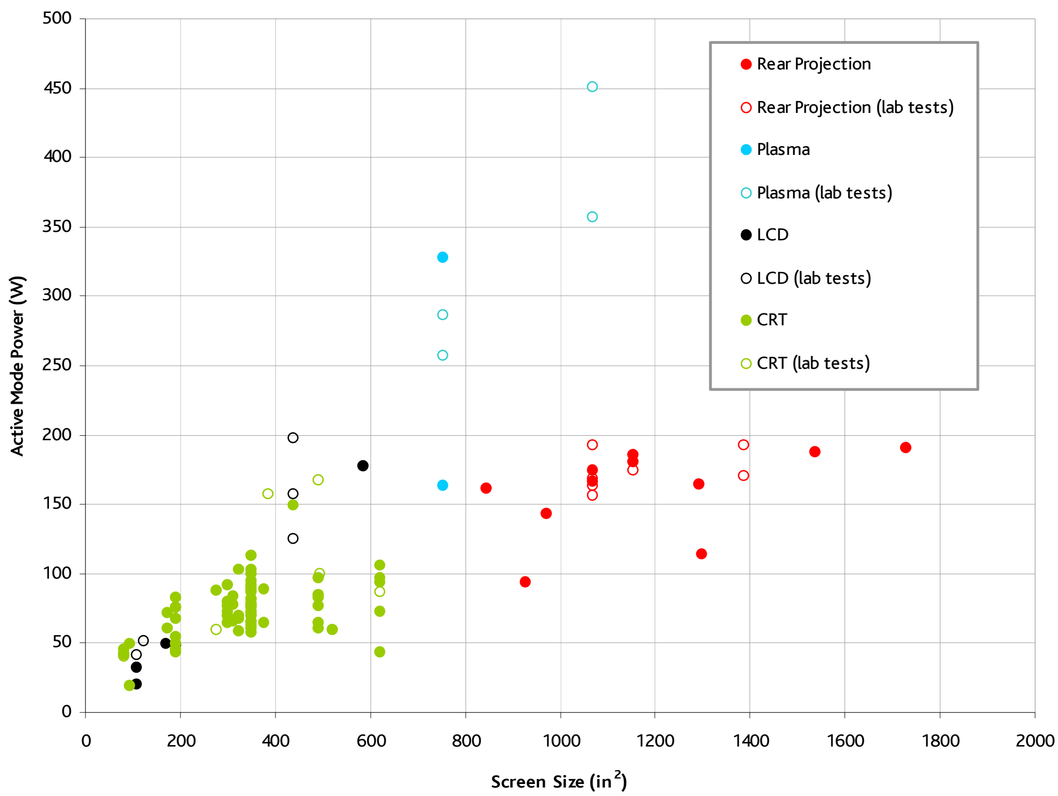
Our average power results for televisions confirm previous laboratory testing. All television technologies we measured (CRT, LCD, Plasma, and Rear Projection) exhibited low standby power values (0.9 watts to 3.7 watts), indicating efficiency standards targeting standby mode have effectively lowered standby power in these products. Also notable was the prevalence of CRT televisions in this study; seventy-eight of the ninety-five televisions metered in our study were CRTs. While newer technologies such as Plasma and LCD are heavily promoted in store displays and advertisements, findings from our study indicated the newer technologies have only started to make an entrance in California homes.

Figure 7. Television Power Use by Mode



When we compared television active power values recorded in the field to their respective screen sizes (in square inches), we found very similar values to 2004 measurements of TVs conducted in Ecos' in-house laboratory (Ostendorp, Foster et al. 2004). As screen area increases, so does active power—from 19 watts for a 94 square inch CRT TV to 190 watts for a 1,700 square inch rear projection television. One plasma television measured in this study strayed far from that trend— 328 watts for a 754 square inch screen. For comparison, the second plasma TV measured in the field was also 754 square inches; however its average active power was in line with the overall TV trend at 164 watts. In our laboratory measurements, we also observed TVs with identical screen size, but very different active power.

Figure 8. Television Active Power by Screen Area[11]

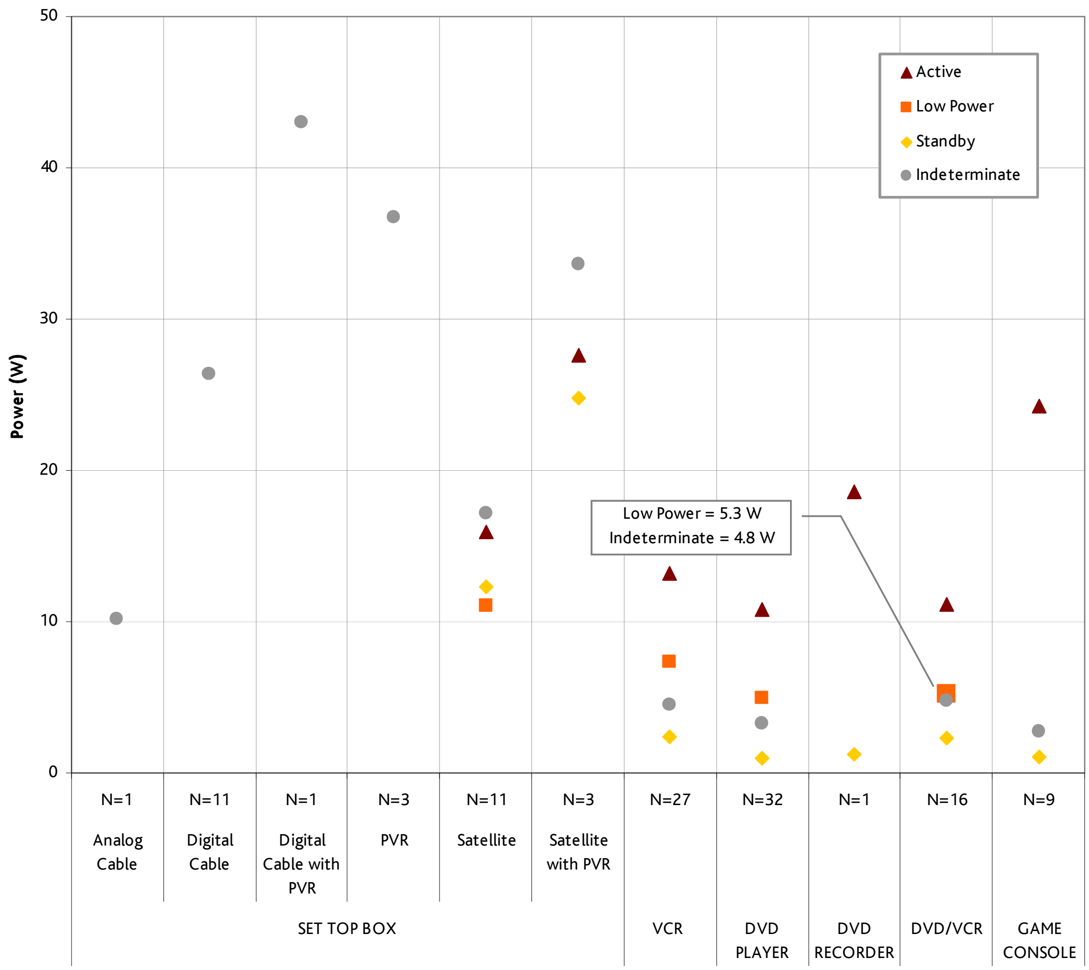


Power data from television peripherals showed that these auxiliary electronics can have significant power demands as well. Measurements of set top box power values confirmed that, unlike TVs, standby and low power modes are not being effectively utilized. In many cases, a standby or low power mode was not distinguishable from active operation. In those instances, we classified all recorded power values for the week in one mode: "indeterminate." Average "indeterminate" power values for measured set top boxes ranged from 10 watts for simple STBs to more than 35 watts for STBs with personal video recorders (PVRs).

VCR and DVD measurements generally fell into previously measured ranges. However average active power of game consoles (24 watts) was much lower than expected. Of the nine metered game consoles, only two were operated in active mode during the week metered. Based on the low active power, these are likely older models. For comparison, a current model game console that was measured in our lab outside of this study had active power values registering near 140 watts.

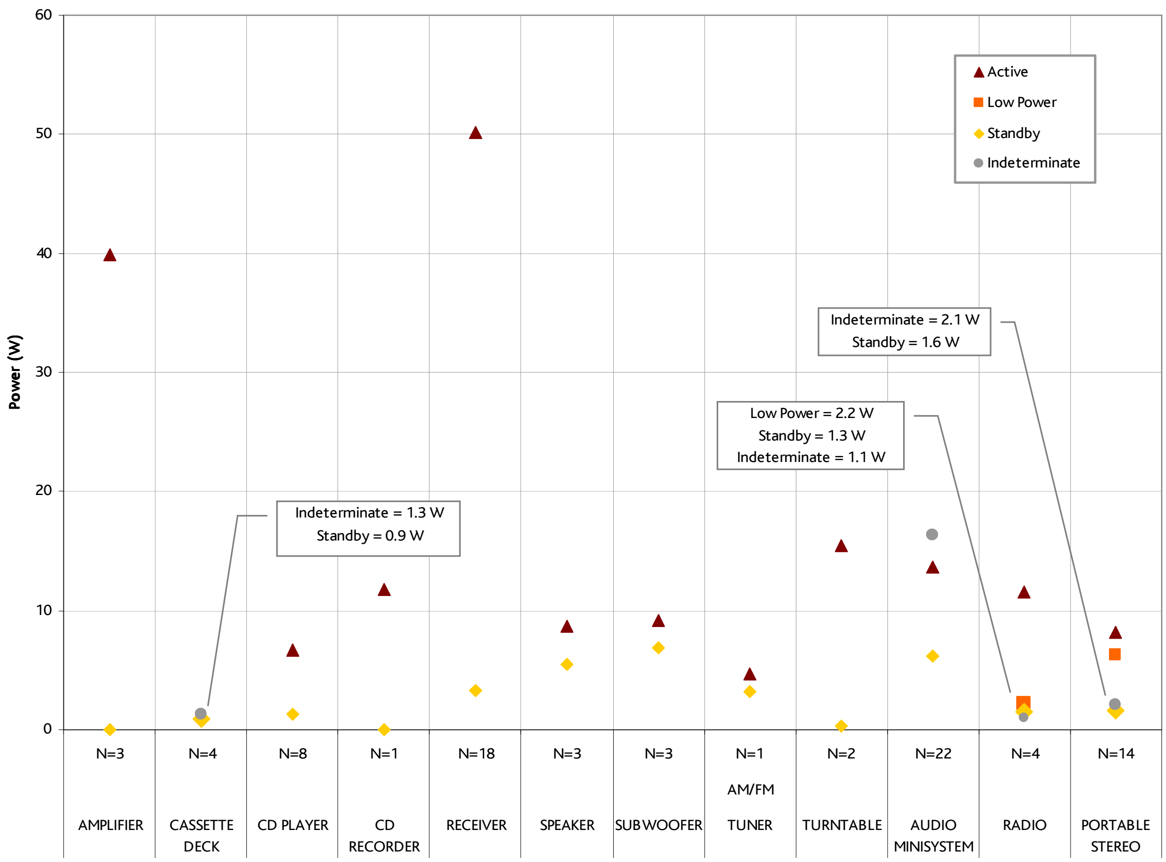
[11] All TV measured in Ecos' lab in 2004 were high definition (HD).

Figure 9. Television Peripherals Power Use by Mode



In the Audio category, two noticeable products were amplifiers and receivers, with active power values in the 40 to 50 watts range (Figure 10). Some audio products have been subject to initiatives to reduce standby power, but active mode power values are high, suggesting that a policy focus on active operation, by introducing a sleep function or increasing the efficiency during operation, could offer significant energy savings for some products.

Figure 10. Audio Products Power Use by Mode



Duty Cycle Results

TVs were operated in active mode between 13 and 34% of the week. This is consistent with previous estimates of 5 hours per day (20% of the week) used by Ecos and other researchers (Ostendorp, Foster et al. 2004). As was also expected, larger televisions (plasma and rear projection) tended to be in active mode more frequently than the smaller televisions. This is likely because larger televisions are almost always the primary television in the home, and are often the centerpieces of home theaters and living rooms. We also observed the extremes of these averages. Some TVs were never turned on, whereas a few were left on all day every day for the entire week of measurement. We also observed that a few of the rear projection and CRT televisions had some type of low power mode. This was unexpected, but could be related to warming the backlight of a rear projection TV or the electron element of a CRT.

For many STBs, it was difficult to determine the modes of operation, so in many cases, the time was classified as "indeterminate." Standby mode is the most prevalent mode for most Audio electronics, often accounting for more than 90% of the week. The exceptions are the audio receivers and speakers, which are likely to be used not only with the televisions, but also to play music.

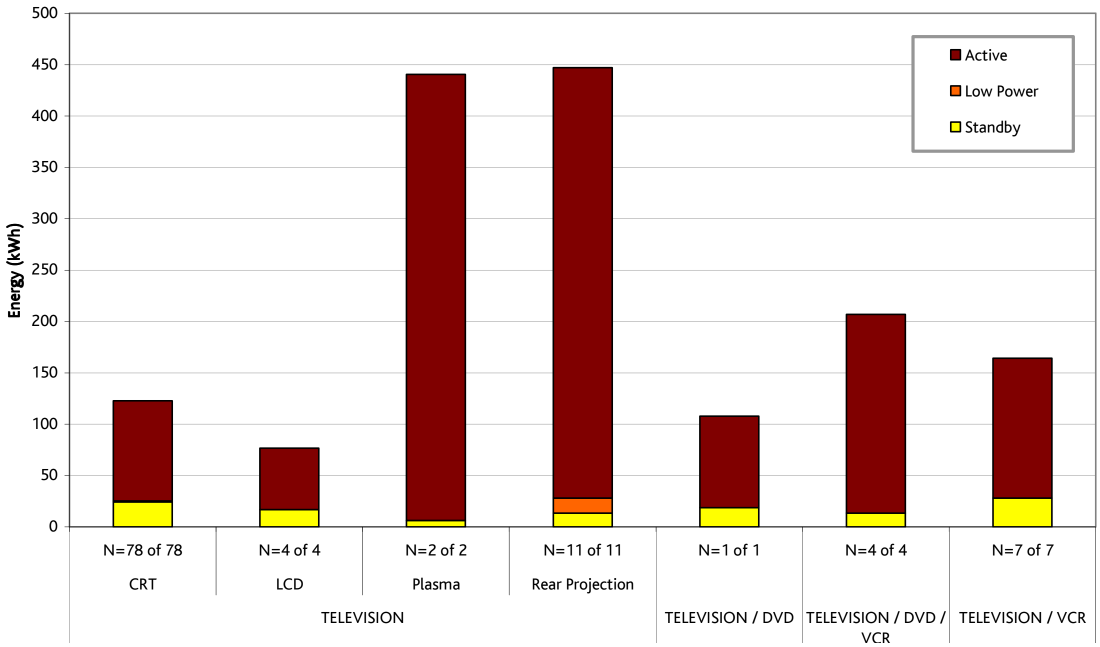
Table 1. Average Measured Duty Cycle of Entertainment Electronics

Average Product Duty Cycles: Entertainment							
Product	Modes Determined / Modes Indetermined	Number Metered	Average Time in No Power	Average Time in Standby	Average Time in Low Power	Average Time in Active	Average Time in Indeterminate
CRT Television	Modes Determined	78		84%	1%	15%	
LCD Television	Modes Determined	4		87%		13%	
Plasma Television	Modes Determined	2		71%		29%	
Rear Projection Television	Modes Determined	11		63%	7%	30%	
Television / DVD	Modes Determined	1		72%		28%	
Television / DVD / VCR	Modes Determined	4		66%		34%	
Television / VCR	Modes Determined	7		78%		22%	
Analog Cable Set Top Box	Modes Indetermined	1					100%
Digital Cable Set Top Box	Modes Indetermined	11					100%
Digital Cable w/ PVR Set Top Box	Modes Indetermined	1					100%
PVR Set Top Box	Modes Indetermined	3					100%
Satellite Set-top Box	Modes Determined	6		33%	27%	40%	
	Modes Indetermined	5					100%
Satellite w/ PVR Set-top Box	Modes Determined	2		21%		78%	
	Modes Indetermined	1					100%
VCR	Modes Determined	16		75%	11%	14%	
	Modes Indetermined	11					100%
DVD Player	Modes Determined	30		88%	1%	11%	
	Modes Indetermined	2					100%
DVD Recorder	Modes Determined	1		73%		27%	
DVD/VCR	Modes Determined	10		92%	6%	2%	
	Modes Indetermined	6					100%
Game Console	Modes Determined	8		97%		3%	
	Modes Indetermined	1					100%
Amplifier	Modes Determined	2		96%		4%	
	Modes Indetermined	1					100%
Cassette Deck	Modes Determined	3	67%	33%			
	Modes Indetermined	1					100%
CD Player	Modes Determined	8		99%		1%	
CD Recorder	Modes Determined	1		99%		1%	
Receiver (audio)	Modes Determined	18		75%		25%	
Speaker (powered)	Modes Determined	3		63%		37%	
Subwoofer	Modes Determined	3		94%		6%	
AM/FM Tuner	Modes Determined	1		97%		3%	
Turntable (audio)	Modes Determined	2		98%		2%	

Annual Energy Use

Because standby power is similar for TVs regardless of technology or screen size, TVs with high active power values predictably also had high annual energy use (Figure 11). In addition because larger, more energy consumptive TVs (plasma and rear projection) tend to be used more frequently, the energy use of these types of televisions is over 400 kWh per year—approximately the same as a new refrigerator.

Figure 11. Annual Average Energy Use of Televisions by Mode



TV annual energy use compared to screen area also revealed the important effect of user operation patterns (Figure 12). While some televisions that are likely used in bedrooms or guest rooms use less than 50 kWh per year, some primary televisions can use as 1000 kWh per year, or nearly 10% of U.S. average annual household electrical energy consumption! High TV energy use is not necessarily dominated by only large screen technologies. While CRT active power was lower than all other TV technologies except LCD, the annual energy use of three CRT TVs was higher than many rear projection models, and even one plasma model. The reason was that each of these three CRT TVs spent between 89 and 100% of the week measured in active mode.

While many people assume that the TV is the largest energy-user of all entertainment electronics, results of our study revealed that set top boxes used the same amount of energy as TVs, and in some cases even exceeded TV energy use (Figure 13). Based on energy use of the metered digital cable set top box with personal video recorder (PVR), we estimated an average annual energy use for this product of roughly 376 kWh per year. We estimated the LCD and CRT TVs' annual energy use at 77 kWh and 123 kWh respectively.

As our previous research has shown, entertainment electronics represent a significant portion of residential energy use. If a home entertainment center includes a large screen TV, STB, audio receiver, speakers, DVR, and DVD player, our results show that entertainment center would use an average of 1,200 kWh per year. This figure does not include any other secondary entertainment centers in bedrooms, kitchens, garages, or playrooms. If these are included, the total can exceed 1,500 kWh annually.

Figure 12. Annual Television Energy Use by Screen Area

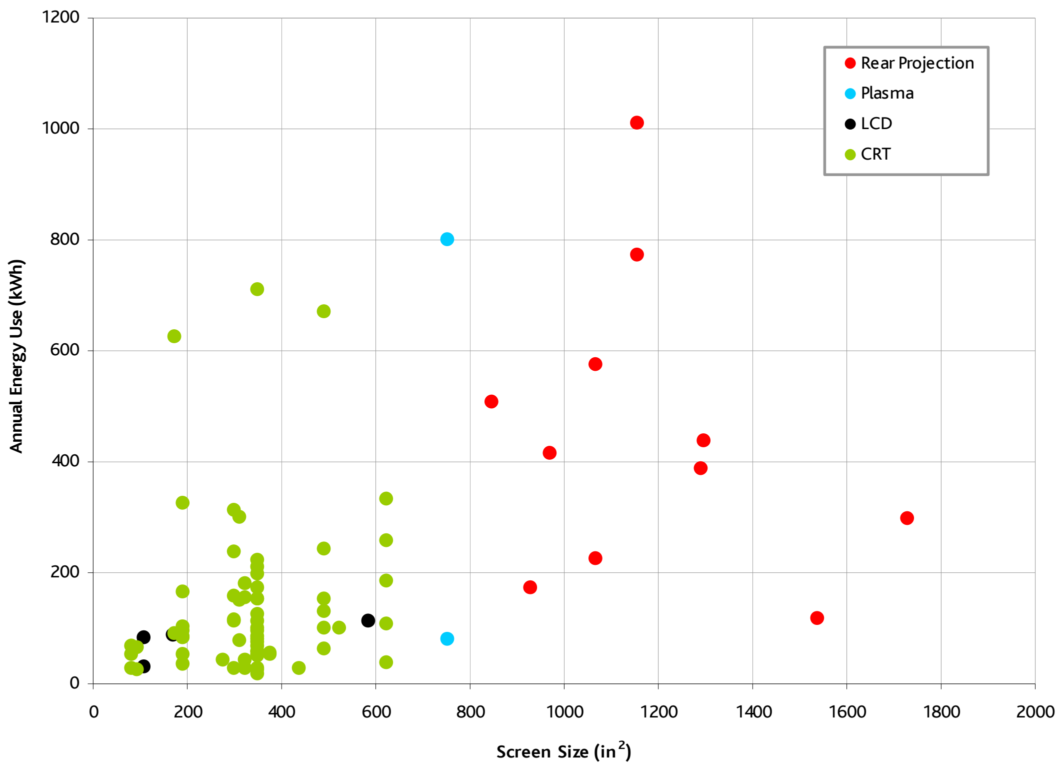


Figure 13. Annual Average Energy Use of Television Peripherals by Mode

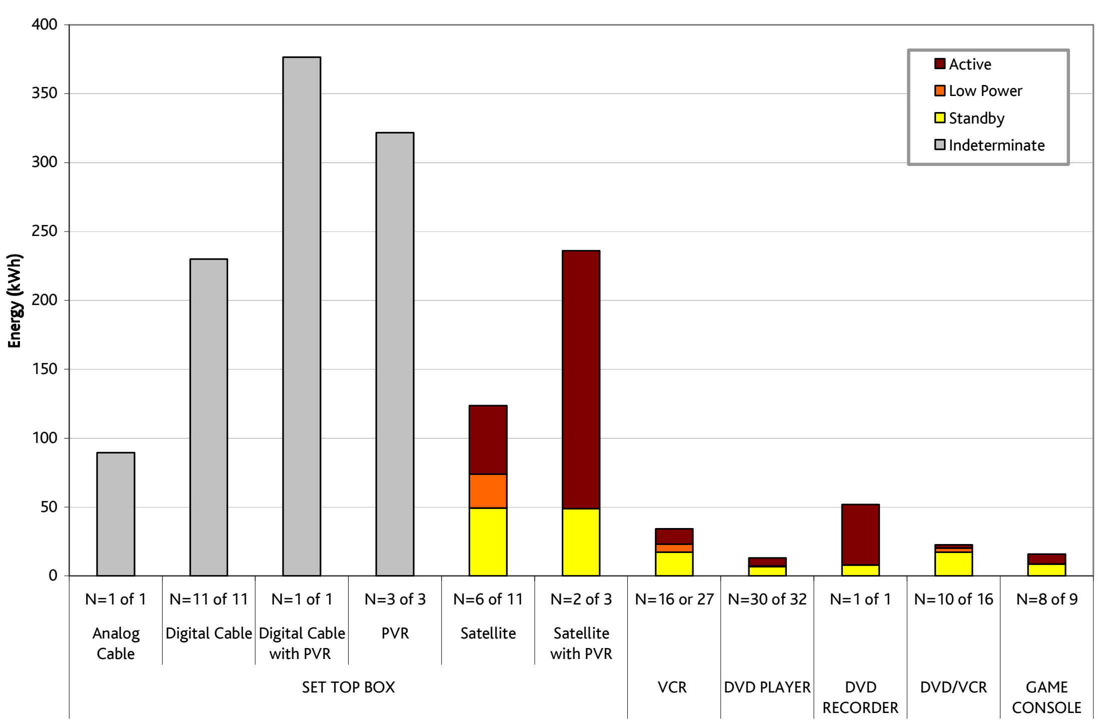
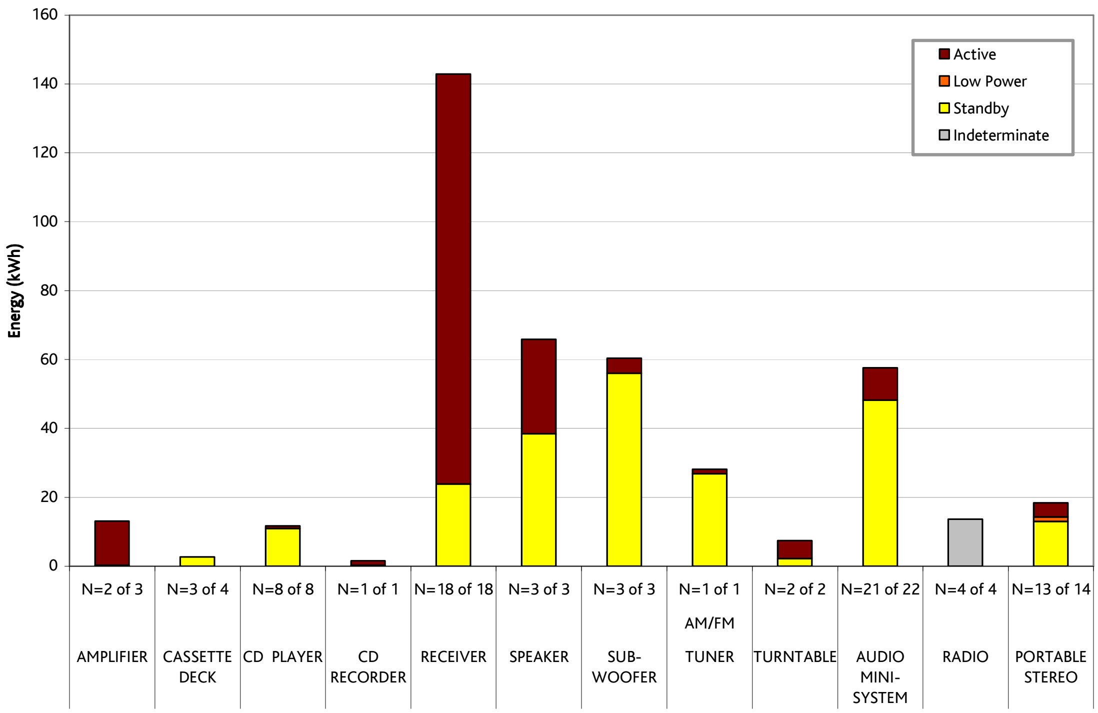


Figure 14. Annual Average Energy Use of Audio Products by Mode



2. Information Technology Electronics

IT Electronics includes computers and their associated peripherals, such as monitors, faxes, hubs and modems, printers, routers, scanners, and computer speakers. A total of 170 products in this category were time-series metered as a part of our research. This section summarizes the average power use by mode by product, average usage pattern by product, and the annual energy use of each product. We further divided IT electronics into three sub-categories for the purposes of discussion: computers and monitors, printing and imaging equipment, and small computer peripherals.

Power Averages by Mode

For power use of computers and monitors, our findings showed that laptop computers use significantly less power to operate than do desktop computers (Figure 15). Average active power for the seven laptops metered was 22 watts, while 43 desktop computers' average active power was 70 watts. When combined with a CRT display, the total power demand of a desktop system was 140 watts. This means that a laptop in active mode uses just 15% of the power as a desktop system. However, a low power mode was observed in both laptop and desktop computers, as well as CRT and LCD displays.

In the printing and imaging category (Figure 16), results showed that the average active power for laser devices tended to be higher than for inkjet devices. Because of the differences in printing technology, this result was expected. In some cases, active power values shown seem low, specifically for copiers and laser faxes. This could be because many of these devices were never actually used during our measurement period and so what we have labeled as active mode could actually be a low power mode. More research would be needed to confirm this. Other printing and imaging equipment and small computer peripheral measurements (Figure 17) typically fell within the range of previous research.

Figure 15. Computer and Monitor Power Use by Mode

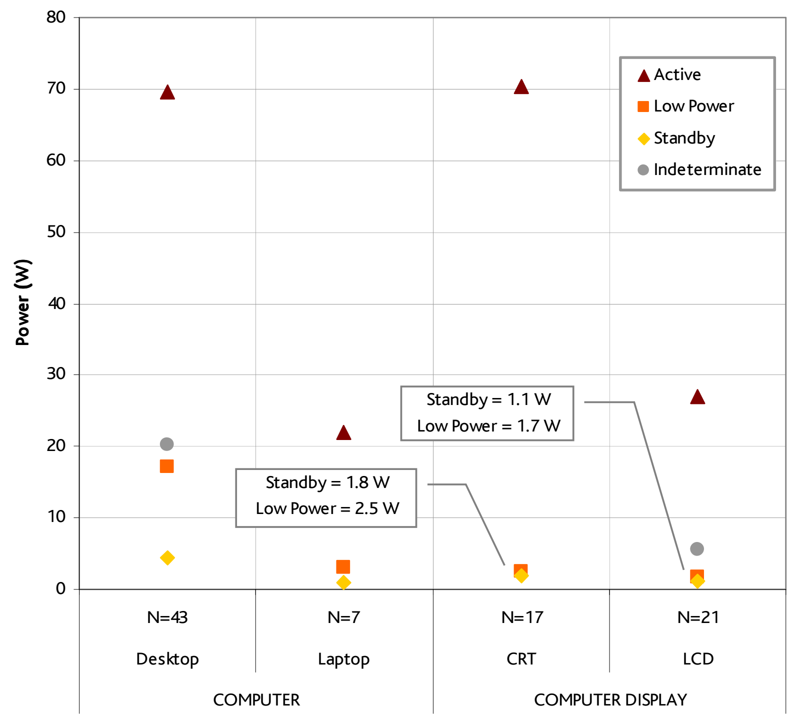


Figure 16. Printing and Imaging Equipment Power Use by Mode

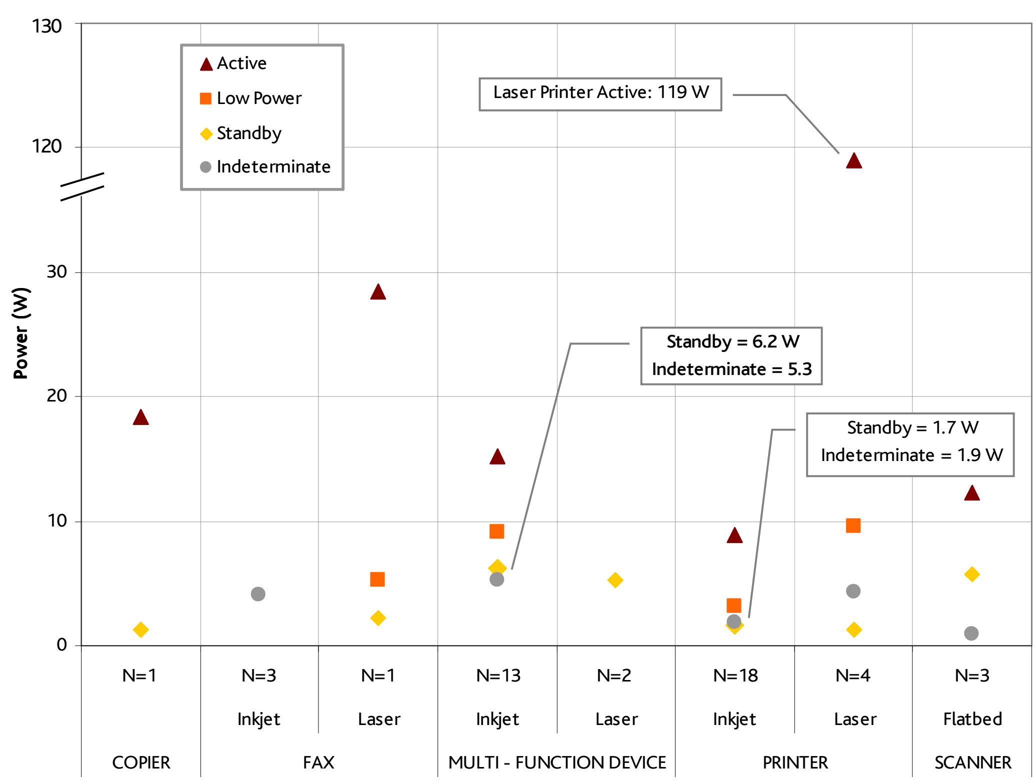
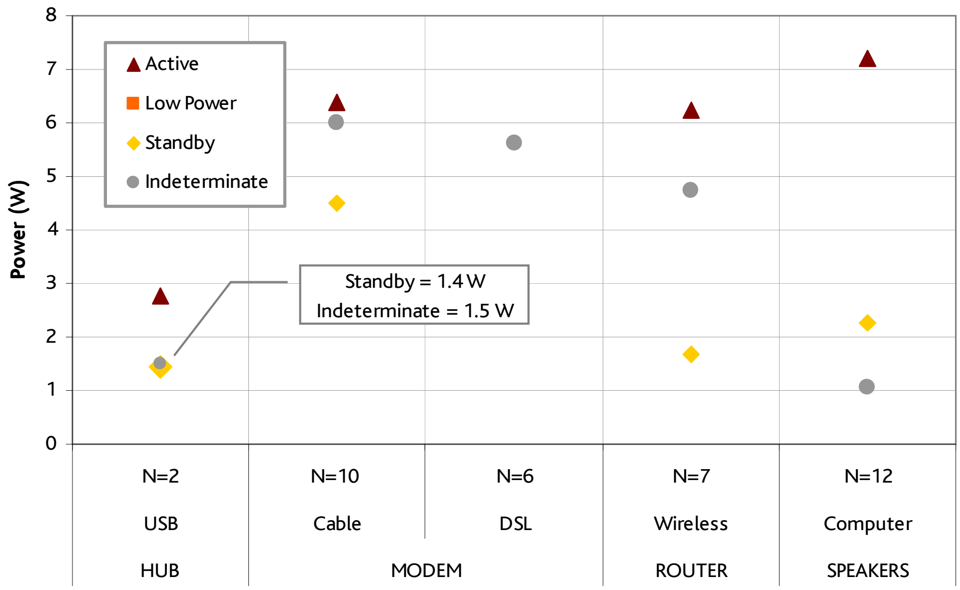


Figure 17. Small Computer Peripherals Power by Mode



Duty Cycle Results

Our duty cycle measurements suggest that many users are unlikely to enable computer sleep functions. On average, about 6% of desktop computer time was spent in that low power mode. About half of the time, computers were turned off or hibernating (47 to 59%). Computers were turned on slightly more than televisions, about 35% of the time. Although computers did not tend to move into a low power or sleep mode that often, we observed high sleep enabling rates for monitors. (Our laboratory measurements suggest that the lowest power mode observed, standby, is likely the sleep mode for monitors.) The active mode time for monitors is likely to be a more accurate predictor of when the computer was actually being used. Monitors were on between 13 and 26% of the time.

Printers and Imaging Equipment tended to spend most of their time in low power modes. Small computer peripherals had duty cycles difficult to determine, either because they operated at one power level for the whole measurement period, or because the differences between the power levels observed were within the measurement error of the metering equipment. When we were able to determine modes of operation for modems, routers, hubs, and speakers, a significant amount of time spent was in active mode.

Table 2. Average Measured Duty Cycle of IT Electronics

Product	Modes Determined / Modes Indetermined	Number Metered	Average Time in No Power	Average Time in Standby	Average Time in Low Power	Average Time in Active	Average Time in Indeterminate
Desktop Computer	Modes Determined	39		59%	6%	35%	
	Modes Indetermined	4					100%
Laptop Computer	Modes Determined	7	8%	47%	11%	34%	
CRT Computer Display	Modes Determined	17		82%	5%	13%	
LCD Computer Display	Modes Determined	20		73%	1%	26%	
	Modes Indetermined	1					100%
Copier	Modes Determined	1		100%			
Inkjet Fax	Modes Indetermined	3					100%
Laser Fax	Modes Determined	1	44%	14%	40%	2%	
Inkjet Multi-function Device	Modes Determined	12	7%	83%	7%	3%	
	Modes Indetermined	1					100%
Laser Multi-function Device	Modes Determined	2	50%	48%		2%	
Inkjet Printer	Modes Determined	14		99%		1%	
	Modes Indetermined	4					100%
Laser Printer	Modes Determined	3		97%	2%	1%	
	Modes Indetermined	1					100%
Flatbed Scanner	Modes Determined	1		100%			
	Modes Indetermined	2					100%
USB Hub	Modes Determined	1		52%		48%	
	Modes Indetermined	1					100%
Cable Modem	Modes Determined	2		50%		50%	
	Modes Indetermined	8					100%
DSL Modem	Modes Indetermined	6					100%
Wireless Router	Modes Determined	3		15%		85%	
	Modes Indetermined	4					100%
Computer Speakers	Modes Determined	7		78%		22%	
	Modes Indetermined	5					100%

Annual Energy Use

Our results confirm that majority of residential energy use of computers and displays are attributable to the time when the device is on and in active mode (Figure 18). In addition, the average laptop computer requires 75% less energy annually than a typical desktop computer combined with a CRT monitor. The annual energy use of printing and imaging equipment is an order of magnitude lower than the desktop and monitor energy use, and is generally dominated by low power mode energy use (Figure 19). Other computer peripherals, although small in size, tend to use a roughly the same amount of energy as the printing and imaging products (Figure 20). Devices such as modems and routers accounted for between 40 and 50 kWh per year, higher than most printing and imaging devices, and on par with the physically-larger inkjet multi-function device.

Figure 18. Computer and Monitor Annual Average Energy Use by Mode

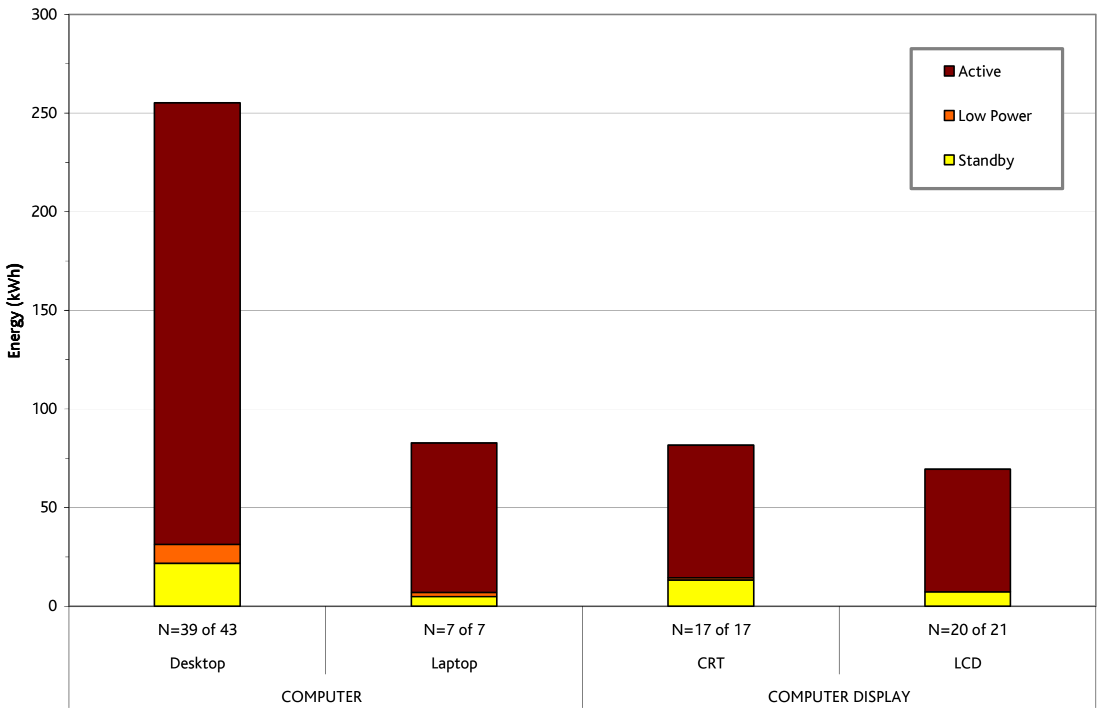
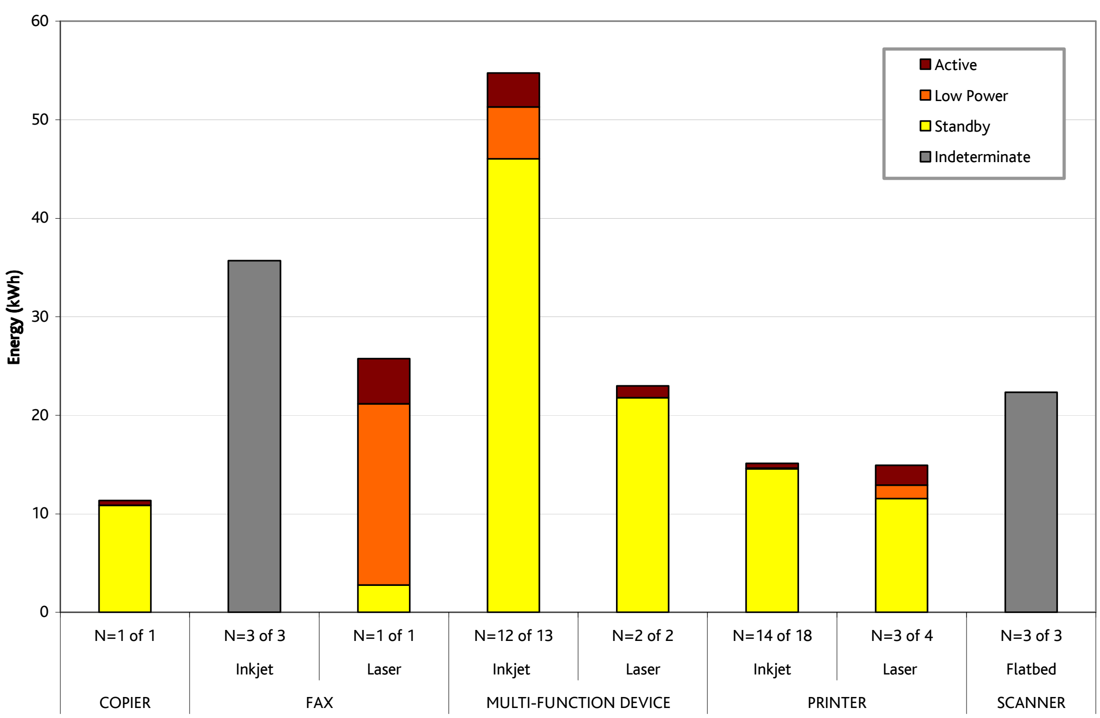


Figure 19. Printing and Imaging Equipment Average Annual Energy Use by Mode[12]



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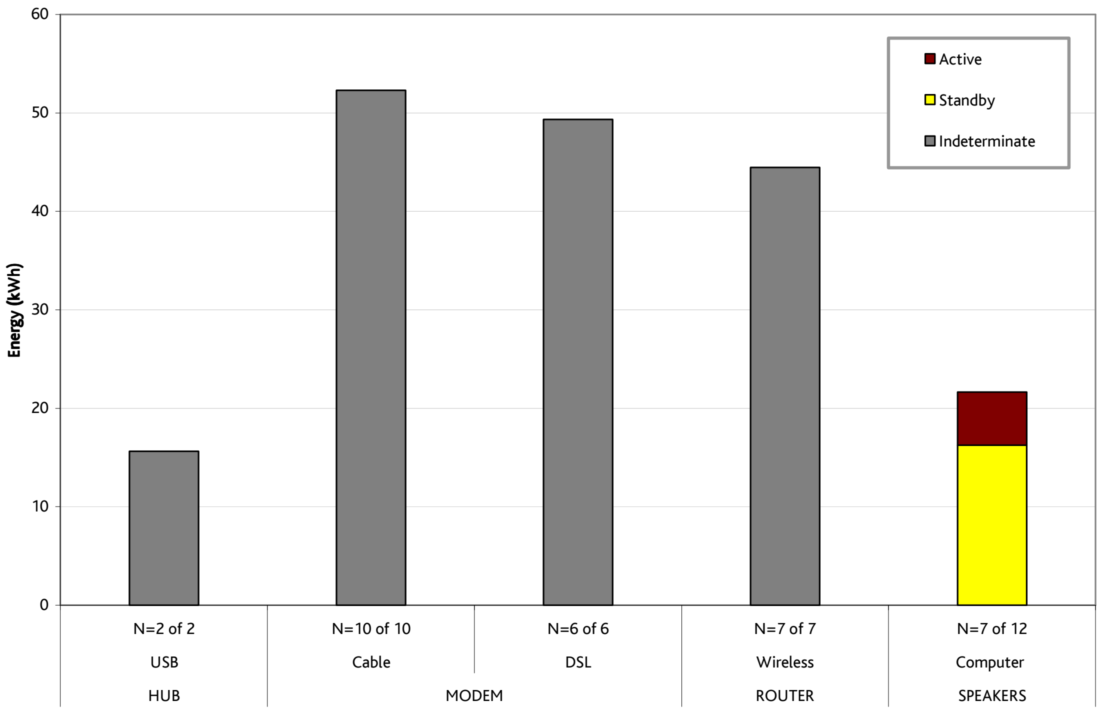
[12] The disparate energy values for inkjet and laser multi-function devices can be explained in part because of the two laser multi-function devices metered, one was unplugged by the owner for the entire week.

Figure 20. Small Computer Peripherals Annual Energy Use by Mode



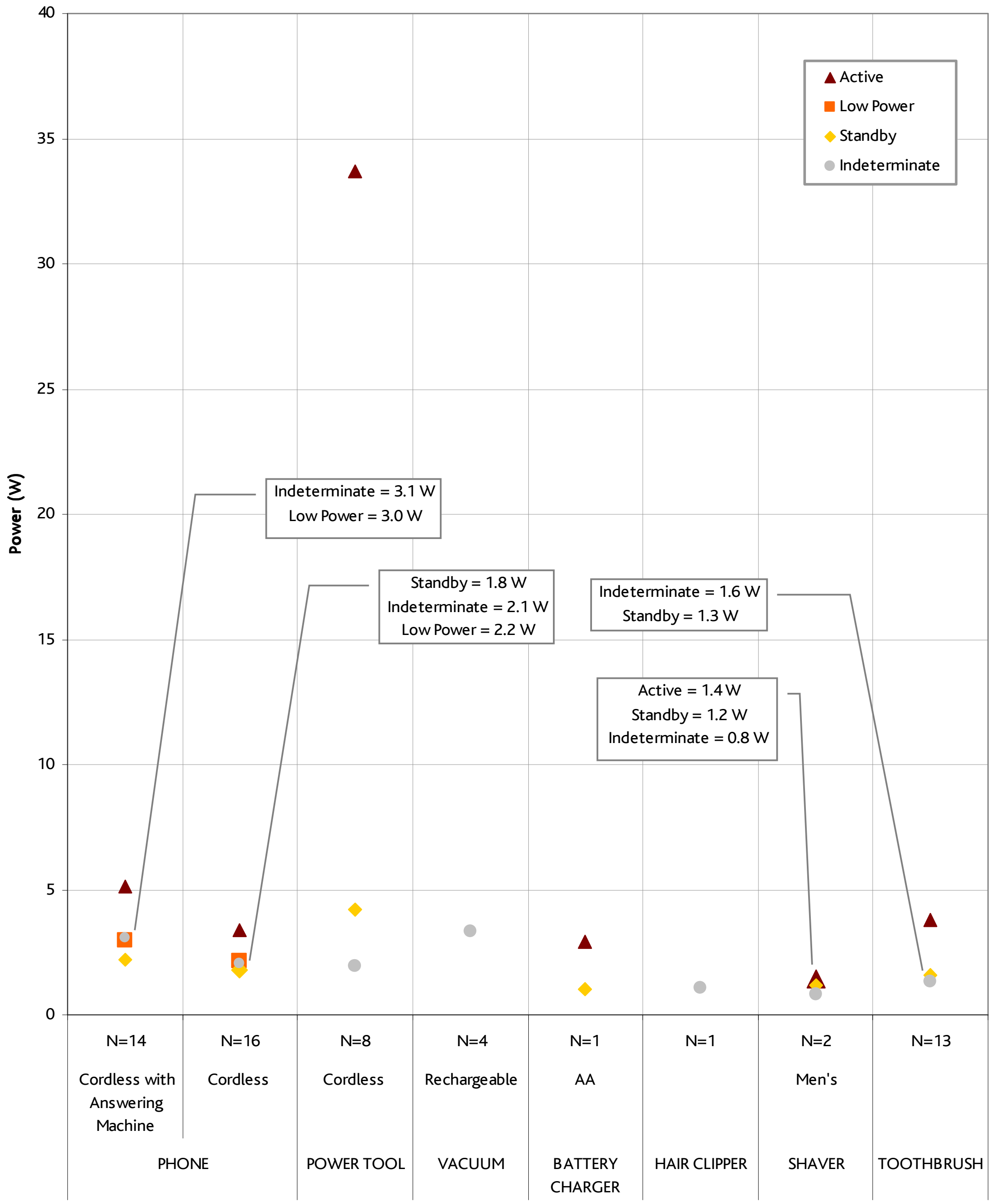
3. Battery Chargers

Battery chargers include many common household items like cordless phones, power tools, and personal care items. These products are typically described as "cordless" due to the fact that they can be powered directly from a portable, rechargeable battery. Some battery charger products could also be classified in entertainment or in information technology categories already discussed. (e.g. laptop computer or personal music player). In those cases where overlapping classifications occurred, we grouped the products in a way that allowed us the clearest presentation in this report. In no cases does the same product appear in two categories. Battery charger electronics were divided into two sub-categories for discussion:1) telephony, small appliance, and personal care; and 2) consumer electronics. We based the findings in this section on measurements of 96 battery charger electronics.

Power Averages by Mode

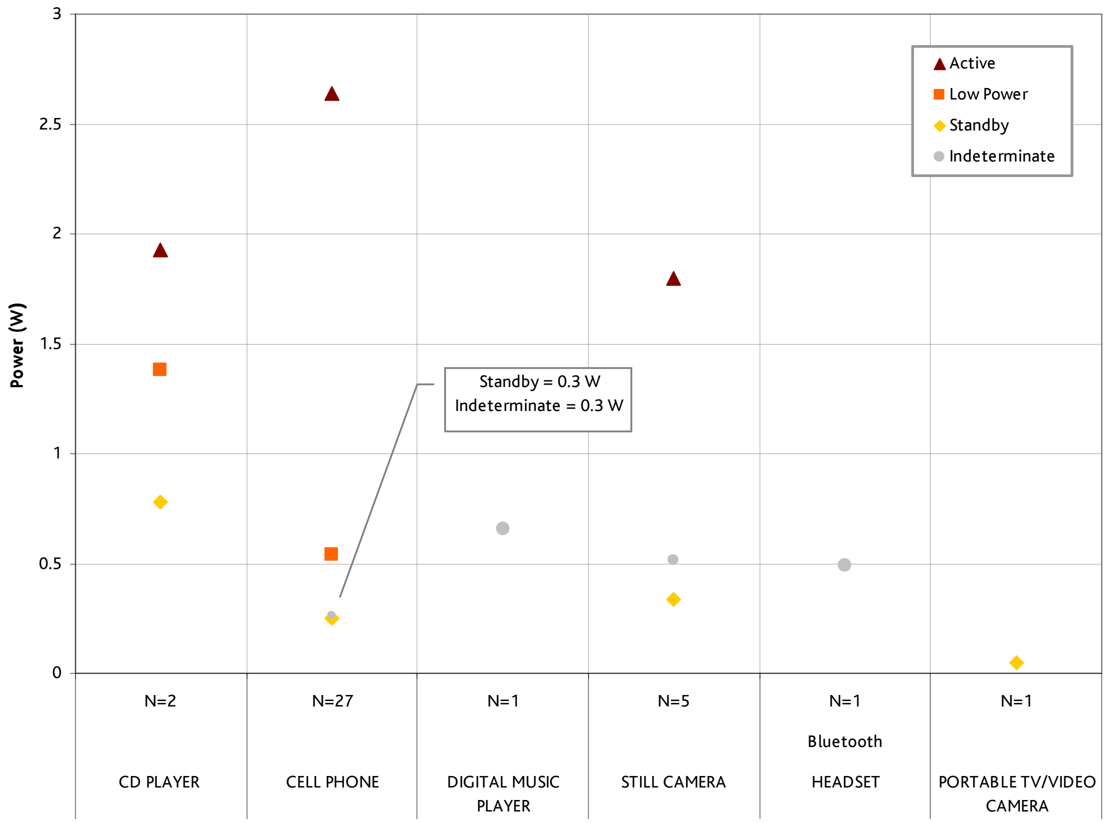
Cordless phones, and cordless phone/answering machine combination units, dominated the sample set of telephony, small appliance, and personal care. For both product types, three modes (standby, low power, and active) were apparent in the majority of samples. In the case of these products, standby is typically when the phone is off the receiver, low power is when the battery is being maintained, and active is when the battery is being charged or a phone call is occurring. Cordless power tools had the widest range of power demand, with an average standby power of less than 5 watts, and an average active power of greater than 30 watts. Other products in this category clustered in the 1 to 5 watt range for all modes detected (Figure 21).

Figure 21. Telephony, Small Appliance, and Personal Care Battery Chargers Power Use by Mode



The consumer electronics battery charger sample set was dominated by 27 cell phone chargers. Other products measured in smaller numbers included CD players, still cameras (digital cameras), and bluetooth headsets. Power values for all modes of these products were below 3 watts, even in active mode (Figure 22).

Figure 22. Consumer Electronic Battery Chargers Power Use by Mode



Duty Cycle Results

Many products in the battery charger category showed significant amounts of time as unplugged, from 1% up to 50%. This finding met our expectations since these products are typically physically small and owners often carry chargers with them while traveling and at work. Also, many products spend the majority of their time in low power modes, although energy use in active mode still is important to consider, particularly for products like shavers and cordless phones. In addition, because of our relatively limited one-week measurement period, some of the less frequently used products like power tools and hair clippers, may have periods of heavy use surrounded by long periods of unplugged time and standby time. Our methodology did not enable us to capture all of those user intensive periods. Finally, because very few of these products were measured, more research needs to be done to help verify their usage patterns.

Table 3. Average Measured Duty Cycle of Battery Chargers

Product	Modes Determined / Modes Indetermined	Number Metered	Average Time in No Power	Average Time in Standby	Average Time in Low Power	Average Time in Active	Average Time in Indeterminate
Cordless Phone with Answering Machine	Modes Determined	11		60%	31%	9%	
	Modes Indetermined	3					100%
Cordless Phone	Modes Determined	9		42%	17%	41%	
	Modes Indetermined	7					100%
Cordless Power Tool	Modes Determined	5	20%	75%		5%	
	Modes Indetermined	3					100%
Rechargeable Vacuum	Modes Indetermined	4					100%
AA Battery Charger	Modes Determined	1		97%		3%	
Hair Clipper Charger	Modes Determined	1					100%
Men's Shaver	Modes Determined	1		86%		14%	
	Modes Indetermined	1	1%				99%
Toothbrush	Modes Determined	4		>99%		<1%	
	Modes Indetermined	9					100%
CD Player Charger	Modes Determined	2	50%	45%	3%	2%	
Cell Phone Charger	Modes Determined	26	8%	85%	2%	5%	
	Modes Indetermined	1					100%
Digital Music Player Charger	Modes Indetermined	1					100%
Still Camera Charger	Modes Determined	2		97%		3%	
	Modes Indetermined	3	9%				91%
Bluetooth Headset Charger	Modes Indetermined	1					100%
Portable TV/Video Camera	Modes Determined	1		100%			

Annual Energy Use

Cordless power tools showed the highest annual energy consumption at an estimated 37 kWh, followed closely by the rechargeable vacuum at an estimated 29 kWh. These two products, along with the cordless phones and cordless phones with answering machines, were the largest energy consumers in this category. All other products in this category used approximately10 kWh per year or less.

Figure 23. Telephony, Small Appliance, and Personal Care Battery Chargers Annual Average Energy Use by Mode

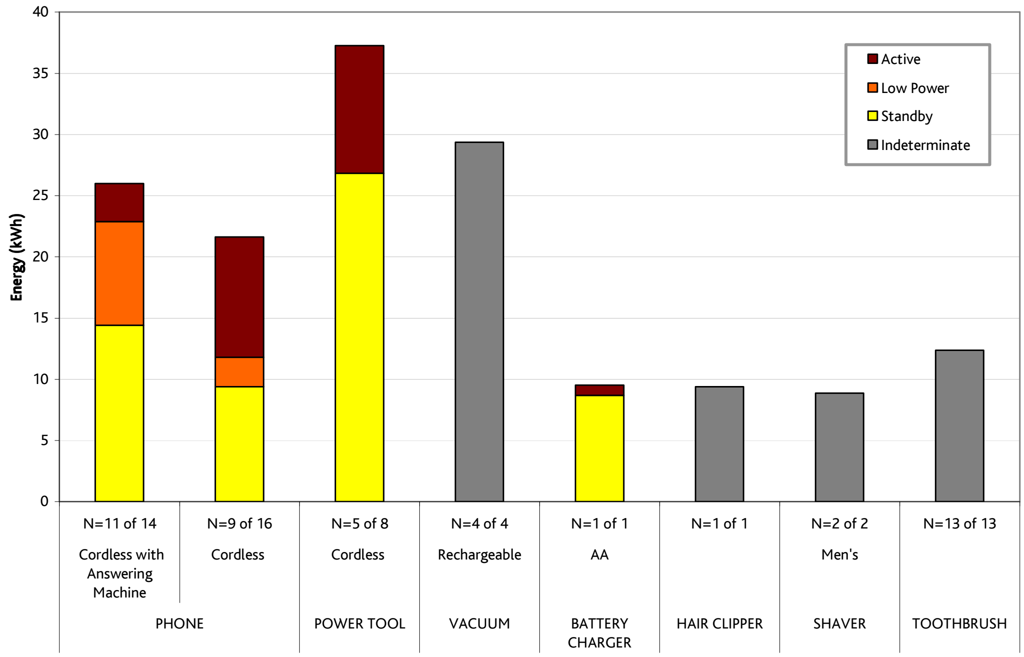
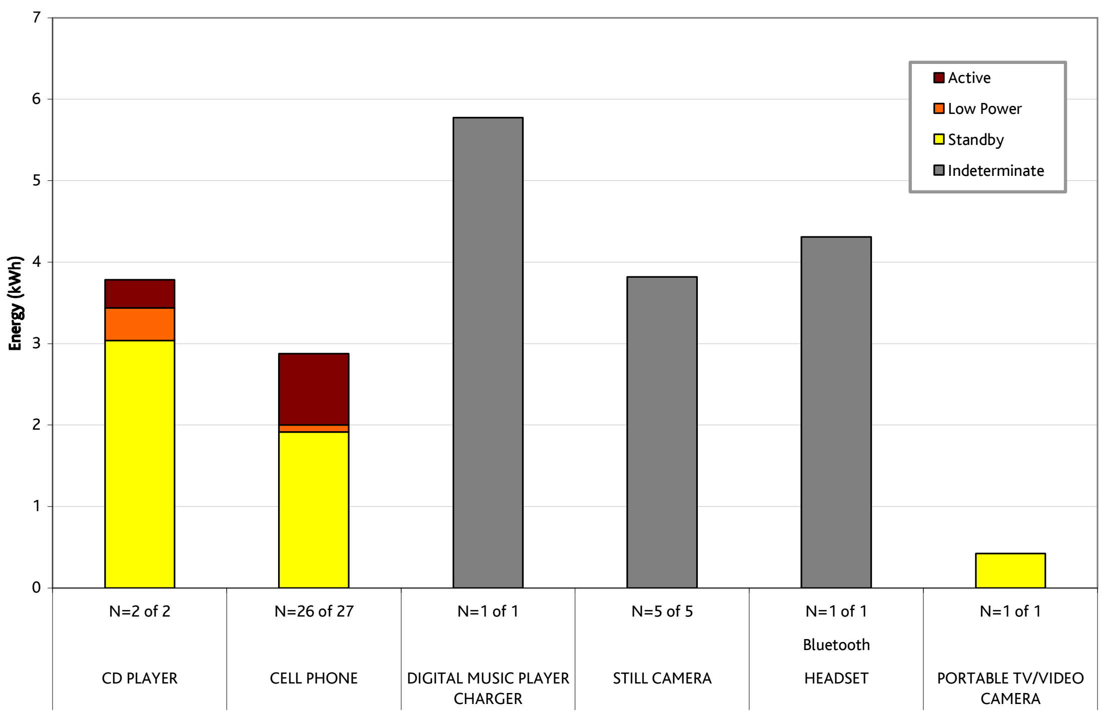


Figure 24. Consumer Electronic Battery Charger Annual Average Energy Use by Mode



B. House-Level Analysis

1. Analysis of Plug Load Product Categories

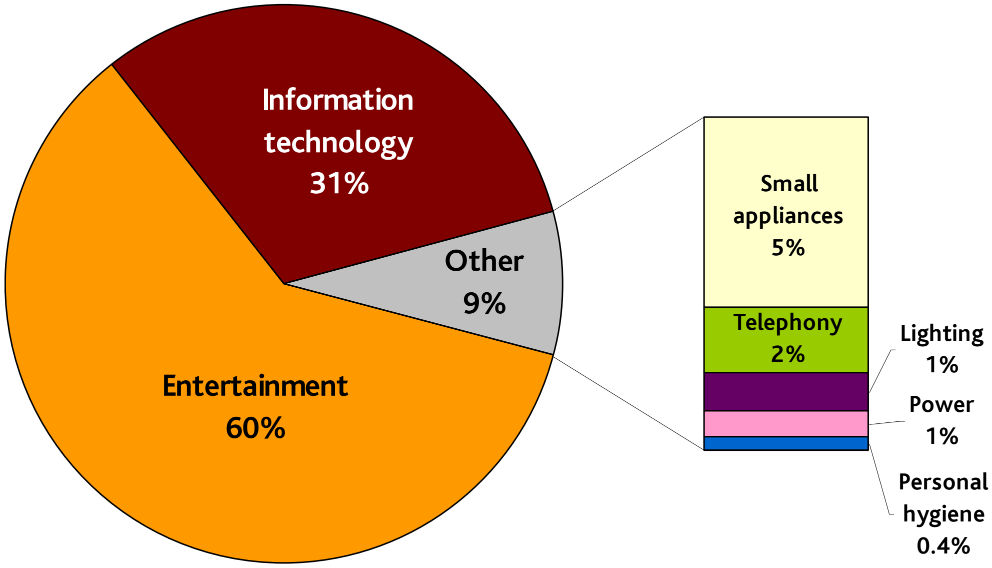
Though no two homes are completely alike, our research shows that the usage profiles and energy use of miscellaneous devices do follow some predictable trends. The top two categories of plug load electricity use in nearly all homes metered in this study were consistently entertainment (including TVs, DVD players, cable/satellite boxes, etc.) and information technology (including computers, printers, scanners, modems, etc.). On average, these two categories constitute over 90% of the energy consumed in miscellaneous plug load devices, with the remaining end uses falling into an assortment of small appliances, telephony products, nightlights, and other small devices.

In total, an average California household uses between 1,069 and 1,207 kWh of electricity per year to power its miscellaneous plug loads and electronics. This equates to about $138 to $156 per year in electric bills. The lower bound of this range represents only our time series metered results. We extrapolated the upper bound of the range by calculating the average annual energy use by product and then applying that average to the non-metered products in each home. So the upper bound of this range represents the total energy consumption of both non-metered (counted) and time-series metered plug load products in the home. Because our prioritization protocol for product metering ensured that we captured the vast majority of energy use, the difference between the upper and lower bound is relatively small. The “other” category shows the largest spread between the lower and upper estimate because our prioritization protocol tended to focus on larger overall energy users. As a result, we measured a smaller fraction of the total number of “other” products in the home. Table 4 and Figure 25 show the average amount of miscellaneous electricity use for the homes metered in this survey as well as the average energy consumption by each end use category in a typical home.

Table 4: Average Plug Load Electricity Consumption per Household by Product Category

Product Category		Average Products per Household	Annual Energy Use - Low (kWh)	Annual Energy Use - High (kWh)
Entertainment		8	644	697
Information technology		6	335	357
Other	*Small appliances*	3	51	77
	Telephony	3	17	51
	Night lights	2	10	13
	Power	3	7	7
	Personal hygiene	1	4	5
	Video	1	nearly 0	1
	Hobby-Leisure	1	nearly 0	1
	Medical	1	nearly 0	nearly 0
Total Other		15	89	155
TOTAL		30	1,068	1,208

Figure 25: Share of Plug Load Energy Use by Product Category [13]



According to our results, entertainment electronics constitute over half of the energy used by miscellaneous and electronic plug loads. The amount of energy consumed by entertainment electronics was on average about double that of any other category. Note that for certain product categories, such as hobby-leisure and medical, the annual energy consumption is negligible and is noted as "nearly 0" in the table. These categories with near-zero energy use do not appear in Figure 25.

A combination of factors may contribute to the high overall energy use of the information technology (IT) and entertainment product categories:

- A high number of products per household drawing a continual standby base load
- Frequent usage of those products with typically high levels of power during active operation

In a weekday and weekend 24 hour snapshot of a typical household shown in Figure 26 and Figure 27, IT plug loads consumed a constant base load of 100 watts all day long due to a large number of products sitting idle or in standby. When computers, monitors, printers, etc. *were* turned on, power consumption from IT plug load equipment nearly doubled. For entertainment plug loads like televisions, we saw predictable usage during pre-work morning hours and prime time viewing hours on weekdays, with more prolonged usage on weekends.

Products outside of the entertainment and IT categories often have a lower overall energy impact due to their limited use in active mode. Note in Figure 26 and Figure 27 below how the electricity use in the "other" product category only spikes for very brief periods in the early morning on both weekdays and weekends. The spike is due to a coffee maker brewing at power levels around 250 watts. The *demand* impacts of small appliances like this can be temporarily large; however, their overall energy impact is negligible compared to the more frequently used entertainment and IT devices.

[13] Because of the uncertainty of assigning energy use to non-metered products, this figure is based on the low estimate of annual energy use. If the high estimate of energy use is used, the entertainment and IT share of the total lowers a few percent and the other category goes up by a few percent. This slight change does not alter the conclusion presented in the discussion.

Figure 26. Plug Load Power Consumption by Product Family (Weekday)

PGE1271, Thursday May 25, 2006

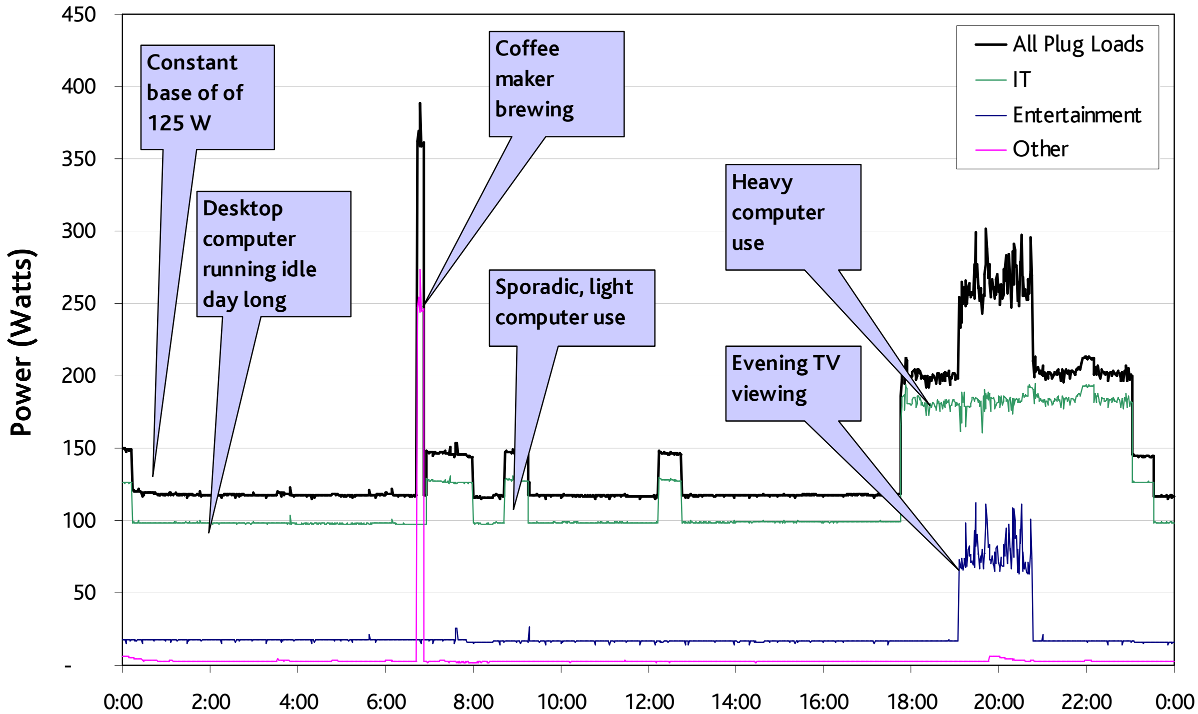
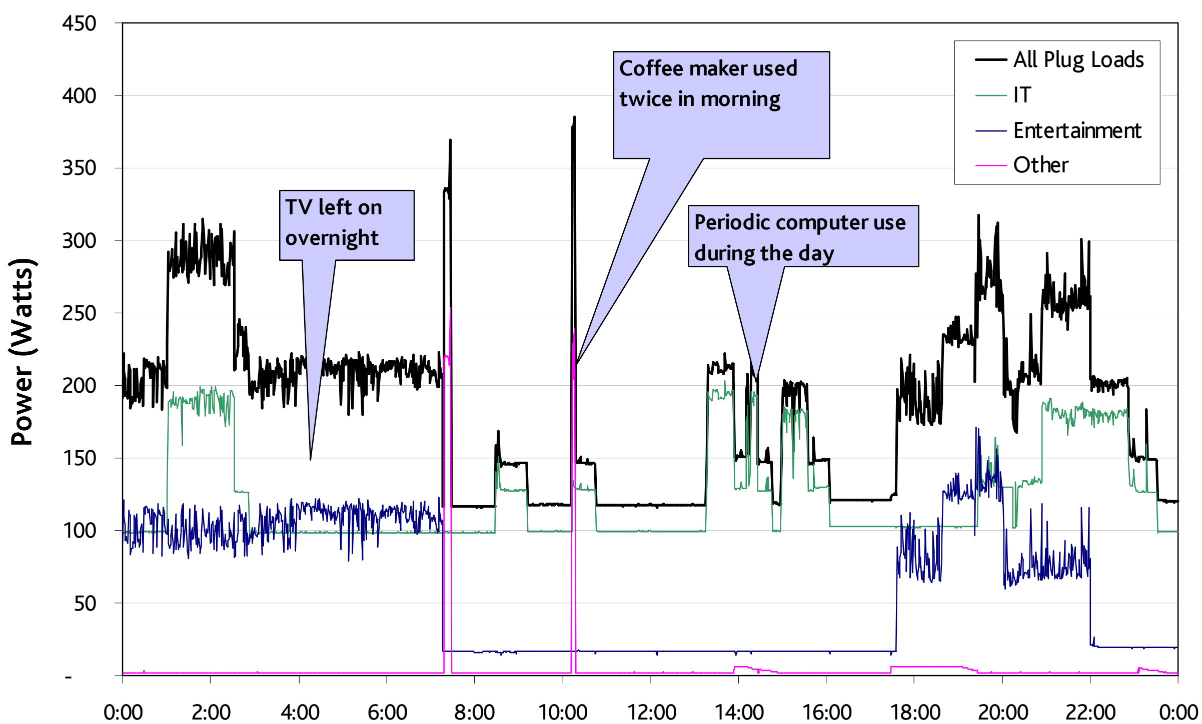


Figure 27. Plug Load Power Consumption by Product Family (Weekend)

PGE1271, Saturday May 27, 2006



2. Comparing Results to Other Studies

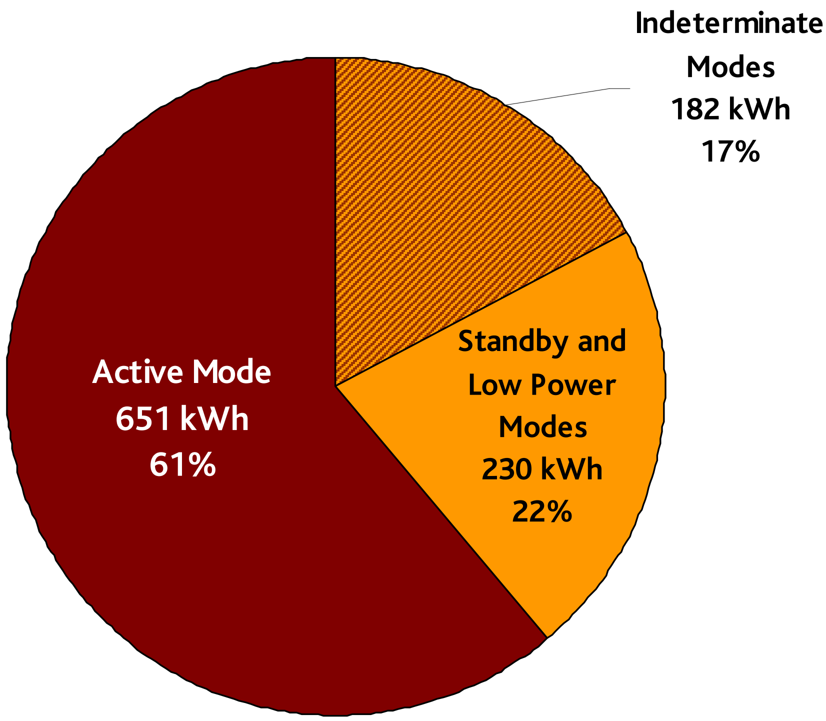
Our research shows that the typical California home consumes between 1,000 and 1,200 kWh per year through its plug loads. Assuming that California homes are relatively representative of households elsewhere in the country (i.e. California's climate, demographics, etc. do not significantly change the usage patterns and product ownership of plug load devices), this means that miscellaneous plug loads constitute between 9% and 12% of the electricity use of a typical U.S. household. Since *per capita* electricity use in California is significantly lower than most of the rest of the country – largely due to the successful implementation of appliance and building standards to address non-plug load energy use – a typical Californian home will consume between 15% and 17% of its electricity purely through plug loads.

As California's example illustrates, the more a home is able to reduce electricity consumption in other major end uses like HVAC and fixture-based lighting, the more important miscellaneous plug load energy use becomes in terms of its share of overall energy use. A recent study of the energy use of highly efficient new homes, conducted jointly by the Florida Solar Energy Center and Lawrence Berkeley National Laboratory, (Lawrence Berkeley National Laboratory 2004) found that although the homes had an average electricity consumption below the national average, the amount of electricity consumed by so-called "other" end uses – that is, end uses not considered "traditional" end uses, such as water heating, cooling, and heating – consumed 46% to 88% of the home's electricity. In one low-energy home in Aspen, CO for which the paper's authors had a detailed breakdown of end uses, plug loads alone were found to consume 2,439 kWh per year – over 40% of that home's otherwise sparing electricity use.

The U.S. DOE's Energy Information Administration has estimated through its Residential Energy Consumption Survey (RECS) research that miscellaneous plug loads – comprising DOE's "miscellaneous" and "electronics" end use categories – make up 15% of residential electricity consumption or about 1,600 kWh per year. Our findings show that, at least based on the California example, this is a reasonable estimate. Although the total miscellaneous average energy use we measured is lower than DOE's estimate, the scope of products included in DOE's categories is broader than ours and may include some more traditional end uses. Our research enriches and informs DOE's existing numbers, because we have been able to further segment the largest product categories and end uses within the miscellaneous category. For example, we have demonstrated that, on average, over 90% of the energy use in miscellaneous plug loads goes to entertainment electronics and information technology.

Our research has further informed the debate on the topic of miscellaneous plug loads by identifying which operational modes are most important to their overall energy consumption. Results indicate that the vast majority of energy use for the products examined in our survey occurs during the active mode of operation when the product is turned on and performing its intended function. This finding corroborates earlier research by Ecos and others which has only been able to *estimate* the impact of the active mode (because of lack of usage pattern data). These reports identified active mode energy efficiency in consumer electronics, IT equipment, and other devices containing power supplies as a high priority for policymakers. Our current study finds that the average home measured uses from 650 kWh to 833 kWh per year, or 61% to 78% of the energy consumption of all miscellaneous plug loads, solely in the active mode of operation, as shown in Figure 28. The chart expresses some of the uncertainty in quantifying the active mode exactly, due to the large number of products that we measured – set top boxes, for example – that consume the same amount of power regardless of whether they are "on" or "off." The chart denotes this energy use that could not be ascribed to either active or standby/low power modes as "Indeterminate Modes."

Figure 28: Average Household Energy Use of Miscellaneous Plug Loads by Operational Mode



While our research shows that over half of the energy used by these products is consumed when they are turned on, we found that these devices consume relatively large base load of 54 watt through standby power consumption. It is as if every household is leaving a standard incandescent light bulb turned on all of the time, equating to over 640 MW of constant load across California just to supply standby power to miscellaneous plug loads. Previous studies by Lawrence Berkeley National Laboratory estimated an average base load of approximately 77 to 87 watts for all loads in a household, including hard-wired HVAC equipment and controls as well as white goods (Lawrence Berkeley National Laboratory 2004). If one subtracts out the amount of power attributed to so-called infrastructure, HVAC, and food/beverage end uses – largely white goods or hard-wired products – from LBNL's findings, we are left with a base load of 64 to 74 watts. This range is extremely close to our study's estimate of plug load base loading of about 54 watts, and we feel that our results agree with and corroborate LBNL's previous findings.

C. State and National Analysis

Using statistically developed weighting factors created by RLW Analytics[14], we were able to scale the house-level results of our study to the California and national levels. Table 5 illustrates our findings, showing the total amount of electricity use by miscellaneous plug loads for both California and the United States. As with the house-level analysis, the lower bound on the range presented in the table represents our time series metered results only, whereas the upper bound includes an extrapolation of the energy use of a small number of products that were merely counted in our house surveys and not time-series metered.

We estimate that the devices measured in this report currently consume 12 to 16 billion kWh of electricity per year in California alone or roughly 15% to 19% of the electricity used by all California

[14] See the Methodology section, in which the details of weighting factor development are discussed.

homes. This is enough energy to power about 2 million homes in California today. On the national scale, these products account for anywhere from 114 to 146 billion kWh per year or between 3% and 4% of *all* electricity used in the country. This is enough energy to fully power *all* of the homes in California and *all* the homes in Washington for one year, or enough to provide electricity to the entire state of Michigan across *all* sectors for one year.

Table 5: Estimated California and National Electricity Consumption by Miscellaneous Plug Loads

	Low Estimate	High Estimate
Estimated CA Statewide Electricity Consumption (B kWh/yr)	12.5	16.0
Percent of CA Statewide Residential Electricity Consumption	15%	19%
Percent of CA Statewide Total Electricity Consumption	5%	6%
Equivalent Number of CA Households Operated for One Year Based on Electricity Use (millions)	1.8	2.3
Estimated National Electricity Consumption (B kWh/yr)	114.4	146.5
Percent of National Residential Electricity Consumption	9%	12%
Percent of National Total Electricity Consumption	3%	4%
Equivalent Number of US Households Operated for One Year Based on Electricity Use (millions)	10.7	13.8

4. Conclusions and Next Steps

Policy Implications

Policymakers and utilities have already started to address the energy use of miscellaneous plug loads. The EPA ENERGY STAR ® Program has had, for several years, standby power specifications for multiple products, and more recently, they have revised older specifications, such as those for computer displays, to include active mode efficiency. Mandatory standards recently passed in California and other U.S. states that create requirements for low standby power of some entertainment products will soon go into effect. Additionally, external power supply specifications that address active and standby efficiency of small electronics have been a part of the ENERGY STAR program for a few years; these same levels will become mandatory in California and other U.S. states in 2007 and 2008. Electric utilities concerned about desktop computer energy use have recently opted into a unique electric utility efficiency program, 80 Plus (www.80Plus.org), which addresses desktop computer efficiency.

Our results clearly show the success of many early ENERGY STAR efforts to lower standby power in assorted miscellaneous products. Specifically, the standby power average of computer displays in our survey was less than 2 watts, VCR standby power average was less than 2.5 watts, and television standby power average was less than 3.5 watts. The mandatory standards recently adopted by many states should take these averages down as consumers replace older products.

Our research revealed that between 9 and 13% of all residential energy use is attributable to the active mode operation of miscellaneous plug loads, suggesting that the active mode efficiency initiatives recently adopted by policymakers at EPA, California, and elsewhere have the potential to have a significant energy savings impact. These findings suggest that policymakers should continue to find ways to address the efficiency of products when they are operating, instead of only focusing on standby energy use.

Our results summary highlighted the majority of miscellaneous products in the home, but there are many other small products that are continuously being introduced on the market (e.g. battery powered robot vacuums). "Common-denominator" policies, like efficiency requirements for external power supplies and battery chargers that address the efficiency of hundreds of smaller products with one policy approach can most systematically address the efficiency of smaller, low-power products.

Research Implications

This research approach used a relatively small sample of 50 homes to, for the first time, measure and characterize residential miscellaneous products by power modes, usage patterns, and energy use. Although the first study of its kind, it needs to be verified against other similar studies in other parts of the U.S. and the world. This type of verification would enable researchers, policymakers, and utilities to understand if plug load energy use differs from region to region. In addition, if investigations were strategically placed over time, the results would enable stakeholders to see the effects of international, national, and local policies addressing consumer electronics, office equipment and other miscellaneous uses. Effects of these policies combined with the influence of utility programs could be mapped to track the progress and success over time.

Conclusion

Progress on reducing miscellaneous energy use has been made, particularly with lowering standby power levels. But, as efficiency improvements to the building shell, HVAC and appliances continue, miscellaneous energy use, if left unchecked, will become as DOE predicts, a larger and larger share of total residential energy use. The results of our study further confirm that in curbing miscellaneous energy use, policymakers and electric utilities are likely to achieve the greatest total energy savings by creating whole product specifications that tighten further standby mode requirements and also call for high efficiency when the product is in operation. In addition, adopting common denominator strategies for small products (where product level specific specifications are less feasible) will enable policymakers to improve the efficiency of hundreds of low power products that use external power supplies or battery charger systems.

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6. Appendices

A. Phone survey protocol

***<<Customer>>*:________________________________** ***<<Utility* >> # ________________**
***<<Address>>* _________________________________** ***<<City>>*: __________________________**
***<<Phone>>*: __________________**
Mail Merge from CLASS database: Name, address, phone #, contact, date of audit, (maybe # of calls total), utility

Call Log

Codes:

1=Completed 2=Callback 3=Left Message 4=Busy
5=No Answer 6=Refusal 7=Termination 8=Wrong Number 9=Disconnected
Number 10=Language Barrier

	Date:	Time:		Code	Initials	Outcome	Notes
Call 1	_____/_____	_____:_____	AM PM				
Call 2	_____/_____	_____:_____	AM PM				
Call 3	_____/_____	_____:_____	AM PM				
Call 4	_____/_____	_____:_____	AM PM				
Call 5	_____/_____	_____:_____	AM PM				
Call 6	_____/_____	_____:_____	AM PM				
Call 7	_____/_____	_____:_____	AM PM				

Introduction

Hello <customer name>:

This is <surveyor name> calling on behalf of RLW Analytics. You may recall we came to your house on <audit date> to do a <utility> in-home audit on your home's lighting and major appliances (CLASS). Does this sound familiar to you? Yes or No

Because of your previous participation, your household is being offered an exclusive opportunity to participate in a study for the California Energy Commission. This study will help determine the amount of energy associated with electronic devices plugged into your home's wall outlets. If you are willing to complete our phone survey today, we will send you a $10 gift card. The phone survey should only take approximately 15 minutes.

Is this a convenient time for you? (Did we catch you at a good time?) Y or N

Great then let's proceed with the survey. I will go through and ask you about lists of electronic devices that you usually leave plugged in and some portable devices. If a particular product is kept in the closet and plugged in only on special occasions, we won't need to include it.

I would first like to verify that the address we have on file is correct.

I have your address as < MAIL MERGE ADDRESS, CITY, ZIP>, is that correct? Y or N
If no,
Address ________________ City____________________ CA Zip code_____________

Home Entertainment Products

The first group of products we would like to ask about are home audio/video entertainment devices.

1. We would first like to start with televisions in your home.
   a. I'm going to read a short list of some common types of TVs. Please tell me how many of each type you have in your home.
   b. For each of the TVs you just mentioned, how many hours a day is it turned on?

SURVEY_PROD	QNTY	Hours Per Day
Standard TV		
LCD or Plasma TV		
Big Screen TV		
Television built-in VCR , DVD		

2. I will now ask about entertainment devices that may be connected to your TVs.
   a. Of the following list of products please tell me how many of each type you have in your home.
   b. For each of the devices you just mentioned, how many hours a day is it turned on?

SURVEY_PROD	QNTY	Hours Per Day
DVD Players/Recorders		
VCR		
VCR/DVD		
Video Game System		

3. If you have satellite or cable TV you might have a set-top box. Which of these do you have?

SURVEY_PROD	QNTY
Cable Box	
Satellite Receiver	
DVR / TiVo (not built in)	

4. Regarding audio equipment and stereos in your home. Do you have a stereo or home theater made of individual components? Y or N, if no go to other 5.
If yes, which of the following are part your component stereo system?

SURVEY_PROD	QNTY
Receiver	
Tuner (only)	
Amplifier (only)	
CD Player	
Tape Deck	
Record Player	
Subwoofer	

5. Does your household have any of these other audio products?

SURVEY_PROD	QNTY
Compact Stereo (Separable Speakers)	
Home radio	
Boombox (plugged in, but can be battery powered)	

Home Office/Computers

The next set of questions is about computers and computer-related products. Do you have a computer? Y or N, if no then go to 9.

6. Of the following, what type(s) of computer(s) do you have?

SURVEY_PROD	QNTY
Desktop Computer	
Laptop	
Standard Monitor	
LCD Monitor	
Computer with integrated monitor	

For your primary desktop and laptop:
Do you have the computer turned on when you aren't using it? Always on or Turn on to Use
How many hours do you or another household member use that computer on a weekday? # Hours
Weekend day? # Hours

For your primary monitor:
Do you turn the monitor off when you turn the computer off? Y or N
Does the monitor turn itself off? Y or N

7. Do you have any of the following types of printers?

SURVEY_PROD	QNTY
Inkjet Printer	
Laser Printer	
Inkjet Printer with Copy/Scan/Fax	
Laser Printer with Copy/Scan/Fax	

Is the primary printer on all the time or do you turn it on when you want to print something? Always On or On for Printing

8. Which of these computer accessories (peripherals) do you have?

SURVEY_PROD	QNTY
Computer speakers (powered)	
USB Hub	
Wireless Router	
Cable Modem	
DSL Modem	
Scanner	

If NO speakers go to 9:
Do you turn the speakers off when you turn the computer off? Y or N

Portable Products

The next sets of products are portable electronic devices that plug in or have battery chargers plugged in.

9. For the following list of products consider how many your household has?

SURVEY_PROD	QNTY
Camcorders	
Digital Camera	
MP3 player	
PDA	
Cell Phone	

If NO cell phone go to 10: About how many times would you say you charge your phone? Always in Charger, Daily, Multiple per week, Once per week to bi-weekly, Once per month or less

10. Which of these other portable products do you have?

SURVEY_PROD	QNTY
Discman	
Portable DVD player	
Portable Gaming devices	
Bluetooth Headset	
Hand-Held GPS (Global Posistioning System)	
Portable Media Centers (video, pictures, music)	

General Products

The next group of products may be plugged in at various locations in your home.

11. Which of these telephone and telephone-related products do you have?

SURVEY_PROD	QNTY
Telephone	
Cordless Phone	
Answering Machine (not built in to phone)	
Caller ID (not built-in to phone)	
Fax machine	

12. The next products are typically plugged in around the home; please indicate which your household has.

SURVEY_PROD	QNTY
Alarm Clock	
Clock radio	
Rechargeable Flashlight/Lamps	
Home security system	
AA Battery Charger	
Musical Instruments (Electric)	
Exercise equipment (Electric)	
Night Light	
Remote control for drapes, skylights, etc.	
Water cooler (Electric bottled water dispenser)	

If NO nightlights go to 13:
How often are the light(s) on each day? (If multiple) This would be the average amount of time considering all your nightlights. # Hours Use 8 hours if response is photocell

Garage/Outdoor Products

The following products are either plugged in or recharged in garages and outdoors.

13. Which of the following products does your household have?

SURVEY_PROD	QNTY
Garage Door Opener	
Battery Powered Lawn mower	
Rechargeable Power Tools	
Lawn/Garden sprinkler timer	
Landscape lighting with low-voltage lamps	

If NO garage door openers go to 14:
How many times did you open and close the garage door?

If NO Power Tools go to 14:
About how often would you say that your tools are left to charge? Always in Charger, Daily, Multiple per week, Once per week to bi-weekly, Once per month or less

If NO outdoor low-voltage landscape lights go to 14:
Are they on a manual on/off switch, a timer, or a photocell? Switch Timer Photocell
How many hours are the landscape lights turned on each night? # Hours

Mobility/Vehicles

The following products are used to provide mobility or are recreational vehicles.

14. Which of the following do you have?

SURVEY_PROD	QNTY
Electric Vehicles (Not Hybrids)	
Battery Powered Wheelchairs	
Battery Powered Bikes	
Electric Golf carts	
Battery Powered Scooters/Segway	

Kitchen Products

The next group of products may be in your kitchen.

15. What type of cooking range (stove-top) and oven do you have?

Range	QNTY
Gas	
Electric	
Gas Top, Electric Oven	

16. Which of the following kitchen products does your household have?

SURVEY_PROD	QNTY
Coffee Maker	
Microwave	
Electric Can Opener	
Bread maker	

If NO microwave go to 17:
About how often would you say you use your microwave per day? #

Other Products

The last list products we want to ask about may be plugged in or have battery chargers plugged in around your home.

17. Which of the following cleaning products does your family have?

SURVEY_PROD	QNTY
Rechargeable Vacuum	
Central vacuum	

18. Which of the following bathroom products does your family have?

SURVEY_PROD	QNTY
Electric Toothbrush	
Rechargeable Shavers/Hair Clippers/Trimmers	

19. Does your household own either of the following toys?

SURVEY_PROD	QNTY
Radio Control Toy	
Battery Powered Ride on toy	

Plug Strips and Timers

I'd like you to think back to the products we've discussed so far. Of the ones you mentioned you have, some may be plugged into plug strips and clock timers.

20. Computers and home entertainment products are sometimes plugged into plug strips. Are any of the products we discussed connected to plug strips (surge protectors) or uninterruptible power supplies (UPS)? Y or N, How many of each?

SURVEY_PROD	QNTY
Plug Strip (Surge Protector)	
Uniteruptible Power Supply	

If None Go To 21

Do you use the on/off switch located on the plug strip or is it always on? Yes use switch, No Always on

If Yes, What do you have connected to each plug strip that you turn off? Text
How often do you have the plug strip turned on? # Hours

Some people automatically turn equipment on and off with a timer. One common example of this is putting lamp on a timer when you go on vacation. Are any of the products that we covered today normally connected to one of these timers?

SURVEY_PROD	QNTY
Time Clock	

(For each timer) What do you have connected to the timer? Text
How often does the timer turn on? # Hours

In-home metering study

Now that we have completed this survey we would like to let you know your home may be selected to participate in a more thorough in-home survey. We would be requesting to come into the home for approximately 2 hours for each visit, two visits in total, and we would have three surveyors installing roughly 20 metering devices throughout the home. Some homes selected will only require one visit and only spot measurements will be taken. You would receive $100 per visit from our field staff. If selected, would you participate in this in-home metering study? Y or N

If **yes**,
Thank you for your consideration. If you are selected we will call to schedule an appointment. When would you or someone in your household most likely be available for a few hours?

Weekday or Weekend
Morning, Mid-day, Evening

This concludes our survey; you will receive your $10 gift card in the coming weeks.
Thank you for your assistance

Call Duration: ____________________________

B. Product Selection Protocol

As described in "Prioritization for Time-Series Metered Products" in the Methodology section of this report, we created four priority groupings for time-series measurement in the home. Once inside a home, field staff installed time-series meters on as many "high" priority products as were available, then allocated other available meters to "medium" and "low" priority products, respectively. Some high and medium priority products were not metered during the course of the study because they did not exist, or were not accessible, in any of the 50 homes that participated in the time-series metering portion of the study. Additionally, "zero" priority products were time-series metered if meters were available after the home's accessible high, medium, and low priority products had meters installed. See Table 6 below for the number of each product metered by prioritization category. See Figure 29 below for the percent of products metered according to prioritization.

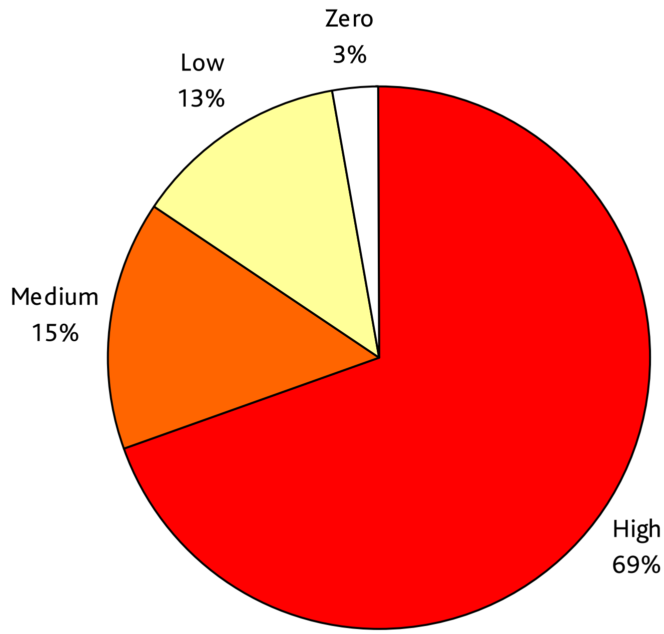
Table 6. Number of Products Metered for Study (by Prioritization)

High Priority	Number Metered for Study:
CRT Television	78
Rear Projection Television	4
Liquid Crystal Display (LCD) Television	2
Plasma Television	11
Front Projection Television	0
Television / DVD Combination	1
Television / DVD / VCR Combination	4
Television / VCR Combination	7
Digital Cable STB	11
Digital Cable with Personal Video Recorder (PVR or DVR) STB	1
Analog Cable STB	1
Satellite STB	11
Satellite with PVR STB	3
PVR STB (TiVo)	3
Internet Protocol (IP) STB	0
DVD/VCR Combination	16
VCR	27
Compact Disk (CD) Player	8
CD Recorder	1
Digital Video Disk (DVD) player	32
DVD Recorder	1
Game Console	9
Audio Equalizer	0
Audio Receiver	18
AM/FM Tuner	1
Satellite Radio Tuner	0
Amplifier	3
Cassette Deck	4
Audio Turntable	2
Subwoofer	3
Powered Speaker	3
Wireless Speaker	0
Desktop Computer	43
CRT Computer Display	17
LCD Computer Display	21
Notebook/Laptop Computer	7
Computer with Integrated CRT Monitor	0

Computer with Integrated LCD Monitor	0
Media Center Computer	0
Uninterruptible Power Supply (UPS)	0
Copier	1
Flatbed Scanner	3
Inkjet Printer	18
Laser Printer	4
Inkjet Multi-function Device	13
Laser Multi-function Device	2
Inkjet Fax	3
Laser Fax	1
Computer Speakers	12
USB Hub	2
Wireless Router	7
Cable Modem DSL Modem	10
DSL Modem	6
Corded (ac powered) Phone	0
Cordless Phone	16
Cordless Phone with Answering Machine	14
Telephone Answering Machine	3
Caller ID Unit	0
TOTAL:	468
Medium Priority	
Digital Music Player Charger	1
PDA Charger	0
CD Player Charger	2
Portable DVD Player Charger	0
Portable Game Console Charger	0
Portable Media Center Charger	0
Remote Control Toy Charger	0
Ride-on Toy Charger	0
Global Positioning System (GPS) Charger	0
Battery Charger (standard size like AA)	1
Cordless Electric Can Opener Charger	0
Cordless Electric Lawn Mower Charger	0
Bluetooth Headset Charger	1
Battery Powered Bike Charger	0
Electric Vehicle Charger	0
Wheelchair or Golf cart Charger	0
Scooter Charger	0
Segway Charger	0
Still Camera Charger	5
Mobile Phone Charger	27
Cordless Vacuum Charger	4
Rechargeable Flashlight/Lamp Charger	0
Toothbrush Charger	15
Men's Shaver Charger	2
Women's Shaver Charger	0
Hair Clipper Charger	1
Cordless Power Tool Charger	8
Night light	35
Women's Corded Shaver	0
Men's Corded Shaver	0
Hair Clipper Corded	0
TOTAL:	102

Low Priority	
Electric Table Radio	4
Exercise Equipment	0
Bread Maker	0
Wine Cooler Refrigerator	0
Compact Refrigerator	0
Video Camera Charger	0
Portable TV/Video Cameras	1
Audio Minisystem	22
Portable Stereo	14
Clock	16
Clock Radio	19
Musical Instruments	0
Coffee Maker	6
Espresso Maker	0
Bread Maker	0
Wine Cooler Refrigerator	0
Compact Refrigerator	0
Irrigation Timer	4
Stationary Electric Can Opener	0
Surge Protector	0
Power Strip	0
TOTAL:	86
Zero Priority:	
Garage Door Opener	17
Low-voltage Landscape Lighting	1
Bottled Water Dispenser	1
Combination Range (Gas Burners Electric Oven)	0
Gas Range with Electric Controls	0
Electric Clothes Dryer	0
Clothes Washer	0
Home Security Systems	0
Room/Wall Air Conditioner	0
Baseboard Heater	0
Central Furnace	0
Central Vacuum	0
Ceiling Fan	0
Windows / Skylights Controls	0
Refrigerator	0
TOTAL:	19
TOTAL ALL PRIORITIES:	**675**

Figure 29. Percentage of Total Products Metered in the Study Allocated by Prioritization Category



C. Field Staff In-Home Script

Introductory Script

Hello my name is ______________ with RLW Analytics here for our ____<time>_____ appointment. My colleagues are _______________ and ______________.

Today we will begin with a walkthrough with you in and around your home. For this part, we will need you close by to answer questions and provide any special instructions for particular items.

> Q. Why do I have to be around?
> A. It will speed up our total time in your home if you are near by for the first phase.
>
> Q. How long will this take?
> A. About an hour. If you need to get to something we can try to speed up this process.

We will then go room by room and perform measurements and install meters on products that are part of our study. All of our measuring devices work like an extension cord or plug strip. One end plugs into the wall and the other end is used like the wall outlet. If we want to measure a device you may plug in and unplug such as a cell phone charger, you will simply plug it into the meter.

> Q. How long will this take?
> A. No more than 2 hours
>
> Q. What is this study all about? What are you using this for?
> A. In the past, energy research focused on big end-uses for example air conditioning and lighting. Our research is studying everything else that uses electricity in the home. The best way you can help is answer our questions and go about your normal business.
>
> Q. Can I get a report or recommendations about my home?
> A. All of our reporting is anonymous so we are not allowed to provide specific reports. I can take down your email address at the end of our appointment if you would like a copy of the final report from our study.
>
> Q. How do I learn more about this? Tell me more?
> A. I can offer you the details of our appointment today and an electronic copy of the final report for this study. If you have other specific questions please contact our manager Jarred Metoyer at (707) 939-8823 x.27

Finally, while my colleagues gather our things I will have you complete a simple form and provide you with a $100 money order for your participation.

You will receive another $100 when we return on <scheduled pickup time> OR <one-week and a day – same time>.

Departure Checklist

☐ All products left in state found

☐ Billing release form completed

☐ Contact information magnet

Money Order Numbers (or attach stubs)

If interested in the final research results:
Email Address ________________________

D. Brand Meter Specifications

117 of these meters were "Configuration A," defined below and 5 of these units were "Configuration B," also defined below. Units were configured for one of either of the following ranges:

Configuration A: ONE meter configured for 0 to 500 watt range:

a. ± 5% of true power and true power factor reading for > 0.5 and < 5 watts
b. ± 3% of true power and true power factor reading for > 5 and < 50 watts
c. ± 1% of true power and true power factor reading for > 50 and < 500 watts

Note: These specifications obviously require certain tolerances for voltage and current readings, but they are not called out specifically in this agreement

Configuration B: ONE-meter configured for 0 to 1850 watt range (continuous), with non-continuous power readings up to 2300 watts:

a. ± 5% of true power and true power factor reading for > 0.5 and < 50 watts
b. ± 3% of true power and true power factor reading for > 50 and < 500 watts
c. ± 1% of true power and true power factor reading for > 500 and < 1850 watts

Note: These specifications obviously require certain tolerances for voltage and current readings, but they are not called out specifically in this agreement. All components are capable of, and UL rated for, a 15 amp continuous load.

In addition, all meters developed under this contract shall meet the following specifications:

1. The physical configuration of the meter casing shall be no larger than six (6) inches by six (6) inches by three (3) inches. The measurement input plug shall be positioned such that a large external power supply (three (3) inches by two and one half (2.5) inches by two (2) inches) should plug easily into the housing of the case, with the case still able to sit flush on its feet, as designed. The meter shall have a 1 x 16 character display on housing, with a button configuration that allows user functionality described in the other requirements below.

   Note: Ecos has reviewed Brand's standard box of this size and finds that it meets the specifications outlined above, assuming that the input plug is turned ninety (90) degrees, enabling the large power supply described above to sit flush to the housing of the meter.

2. The meter shall be able to connect to a personal computer (PC), using either RS232 or USB connection. This connection shall enable the user to control the meter's functions as well as enable the user to download data. If an RS232 connection to the PC is employed, Brand shall test and recommend to Ecos a USB (PC side) to RS232 (cable side) hardware converter to insure operational compatibility.

3. For the purposes of this agreement, a "data record" is defined as a simultaneous data output from the meter that, in the downloaded form, contains the following information:
    a. date stamp for each record stored in the format day/month/year
    b. time stamp for each record stored in the format HH:MM:SS, using 24 hour or military time.
    c. true r.m.s. watts
    d. r.m.s. volts
    e. r.m.s. amps
    f. volt-amps
    g. power factor (true)

    In addition, the user shall be able, through selection of the appropriate menu, to view these parameters on the LCD screen of the meter itself in real time while the meter is unlocked and logging data.

4. The meter shall be shipped with factory defaults, which can be restored via the PC connection. These factory defaults are described in Appendix A and B, but are also listed below:
    a. Default time shall be Pacific Standard Time
    b. Default data record interval shall be one (1) minute
    c. Default maximum number of data records is 10,080

5. When the meter is plugged in, it will begin logging using the defaults currently assigned to it when the meter was last unplugged.

6. The meter shall have the ability to store a data record at regular intervals in the on-board memory. The shipped default for the data-taking interval of the meter shall be 60 seconds, but the user shall be able to change the data-taking interval from 1 second to 1 hour (or more) using the PC interface.

7. The meter shall have the ability to log a minimum10,080 data records in on-board memory. This data should be retained indefinitely even if the meter is disconnected from ac power.

8. Every time the meter is first plugged in, the user shall have the ability to enter the "no logging" mode, where no data is recorded and the meter displays the real time meter values outlined in provision 3 of the required meter specifications. The user shall be able to scroll through these real-time values with the button interface, such that they could choose to observe one parameter (such as power) for a theoretically infinite amount of time.

9. The output displayed on the meter and downloaded from the meter shall give the appropriate number of significant figures for the reading. This is particularly important in the low power range (0 to 10 watts), where the hundredth digit may be important for true power and power factor calculations.

II. Required Software Specifications

The functionalities described herein must be met to satisfy the terms of the agreement. The details of how that software functionality is achieved are open to negotiation by Ecos and Brand. Ecos ultimately determines whether or not these software specifications are met.

1. Software that is used to download data from the meter and control all of its functions shall be supplied with the meter.

2. The software shall run on Windows 2000 Professional and Windows XP operating systems.

3. This software shall use a graphical interface, not a command line interface.

4. The download time for 10,080 records, from the meter to a PC via the standard connection shall be three (3) minutes or less. The calculated (versus measured) data points may be incorporated into either the download software or the ONE-meter providing the required data points and the download times meet the required specifications.

   Note: The three (3) minute requirement stems from our overall project goal to accomplish in five (5) minutes or less the following activities: connecting one meter to the PC, downloading and saving 10,080 records, preparing the meter for a seven (7) day logging period with 60 second intervals, and disconnecting the meter.

5. The downloaded data shall be configured in a standard data format, such as a comma or tab delimited file.

6. This software shall enable the user to control the meter with the PC, and shall feature an option that allows the user to store data collected with the meter real-time on the hard drive of the PC (rather than storing it to the onboard memory of the meter). Simultaneous data storage on the PC and within the memory of the meter is not required.

7. The user shall have the capability of changing the defaults of the meter, through a PC software interface. The changes in the meter defaults persist until the user makes another change. The meter shall never, without explicit user intervention, return to the factory default settings.

8. The user shall have the ability to revert to factory default settings by selecting a PC interface function called "revert to factory default." This function is the only way the meter returns to all factory defaults simultaneously.

9. The user shall, via the PC interface, be able to set the time on the meter to any date and time, and that date and time shall be retained by the meter until the user again employs this function. The shipped default time on the meter shall be Pacific Standard Time.

10. The user shall have the ability to choose any logging interval via the PC connection to the meter. The user shall have the ability to choose to log that data to the PC memory via its data connection to the meter, or be able to direct the meter to log the data on its local memory. In the latter case, this would allow the user to disconnect the PC after setting the interval.

11. The user shall have the ability to set any maximum number of records from the PC interface. There should be an option on the PC for “No Maximum,” where the meter would record data records on the PC memory or on the local meter memory until the user, via the PC interface, told the meter to stop logging, or the meter was disconnected from ac power.

12. A data record download sequence shall be incorporated into the software. When the data record download process is complete, a question shall automatically appear to the user on the PC screen that asks whether or not the memory should be cleared. The user then shall have the opportunity to answer “yes” or “no.” Then, the PC software shall display the defaults of the meter that are currently in place and asks the user to confirm that the default settings are preferable. If user answers “no” to the second question, the user shall have the option of selecting the defaults that are preferred, and then, through another question, confirming those defaults. These defaults would persist as the defaults of the meter until the user changes them in a subsequent configuration, or selects the option to “revert to default.”

    Note: this functionality is meant to speed up the download process, since the memory has to be cleared and the default settings confirmed each time a download is conducted.

13. The user shall, from the PC interface, have the ability to manually stop the meter logging to the PC memory or the local memory.

E. Product Category Level Results

Table 7. Average Power Use by Mode: IT, Entertainment & Battery Chargers

	Product	Type	Number Metered	Standby (W)	Low Power (W)	Active (W)	Indeterminate (W)
Information Technology	COMPUTER	Desktop	43	4.4	17.2	69.7	20.3
		Laptop	7	1.0	3.1	21.9	
	COMPUTER DISPLAY	CRT	17	1.8	2.5	70.3	
		LCD	21	1.1	1.7	27.0	5.6
	COPIER		1	1.2		18.4	
	FAX	Inkjet	3				4.1
		Laser	1	2.2	5.3	28.4	
	MULTI - FUNCTION DEVICE	Inkjet	13	6.2	9.1	15.2	5.3
		Laser	2	5.2			
	PRINTER	Inkjet	18	1.7	3.2	8.9	1.9
		Laser	4	1.3	9.6	39.0	4.3
	SCANNER	Flatbed	3	5.7		12.2	1.0
	HUB	USB	2	1.4		2.8	1.5
	MODEM	Cable	10	4.5		6.4	6.0
		DSL	6				5.6
	ROUTER	Wireless	7	1.7		6.2	4.7
	SPEAKERS	Computer	12	2.3		7.2	1.1
Entertainment	TELEVISION	CRT	78	3.2	33.1	73.0	
		LCD	4	2.2		69.9	
		Plasma	2	0.9		245.9	
		Rear Projection	11	3.2	45.7	159.9	
	TELEVISION / DVD		1	3.0		36.5	
	TELEVISION / DVD / VCR		4	2.5		65.0	
	TELEVISION / VCR		7	3.7		54.8	
	SET TOP BOX	Analog Cable	1				10.2
		Digital Cable	11				26.4
		Digital Cable with PVR	1				43.0
		PVR	3				36.7
		Satellite	11	12.3	11.1	16.0	17.2
		Satellite with PVR	3	24.8		27.6	33.6
	VCR		27	2.4	7.4	13.2	4.5
	DVD PLAYER		32	1.0	5.0	10.8	3.3
	DVD RECORDER		1	1.2		18.6	
	DVD/VCR		16	2.3	5.3	11.2	4.8
	GAME CONSOLE		9	1.0		24.2	2.7
	AMPLIFIER		3	0.0		39.9	70.9
	CASSETTE DECK		4	0.9			1.3
	CD PLAYER		8	1.3		6.7	
	CD RECORDER		1	0.0		11.7	
	RECEIVER		18	3.3		50.1	
	SPEAKER		3	5.5		8.6	
	SUBWOOFER		3	6.9		9.1	
	TUNER	AM/FM	1	3.2		4.7	
	TURNTABLE		2	0.3		15.4	
	AUDIO MINISYSTEM		22	6.2		13.6	16.3
	RADIO		4	1.5	2.2	11.6	1.0
	PORTABLE STEREO		14	1.6	6.3	8.2	2.1
Battery Chargers	PHONE	Cordless with Answering Machine	14	2.2	3.0	5.1	3.1
		Cordless	16	1.8	2.2	3.4	2.1
	POWER TOOL	Cordless	8	4.2		33.7	1.9
	VACUUM	Rechargeable	4				3.4
	BATTERY CHARGER	AA	1	1.0		2.9	
	HAIR CLIPPER		1				1.1
	SHAVER	Men's	2	1.2		1.4	0.8
	TOOTHBRUSH		13	1.6		3.8	1.3
	CD PLAYER		2	0.8	1.4	1.9	
	CELL PHONE		27	0.2	0.5	2.6	0.3
	DIGITAL MUSIC PLAYER		1				0.7
	STILL CAMERA		5	0.3		1.8	0.5
	HEADSET	Bluetooth	1				0.5
	PORTABLE TV/VIDEO CAMERA		1	0.05			

Table 8. Average Annual Energy Use by Mode: IT, Entertainment & Battery Chargers

	Product	Type	Number Metered	Standby (kWh)	Low Power (kWh)	Active (kWh)	Indeterminate (kWh)	Total (kWh)
Information Technology	COMPUTER	Desktop	39	21.7	9.6	223.8		255.2
		Desktop M.I.	4				177.5	177.5
		Laptop	7	5.0	2.0	75.9		82.9
	COMPUTER DISPLAY	CRT	17	13.3	1.1	67.2		81.6
		LCD	20	7.4	0.0	62.1		69.6
		LCD M.I.	1				49.2	49.2
	COPIER		1	10.9		0.5		11.3
	FAX	Inkjet M.I.	3				35.7	35.7
		Laser	1	2.8	18.4	4.6		25.8
	MULTI-FUNCTION DEVICE	Inkjet	12	46.0	5.3	3.4		54.7
		Inkjet M.I.	1				46.5	46.5
		Laser	2	21.8		1.2		23.0
	PRINTER	Inkjet	14	14.6	0.1	0.5		15.1
		Inkjet M.I.	4				16.6	16.6
		Laser	3	11.6	1.4	2.0		14.9
		Laser M.I.	1				37.4	37.4
	SCANNER	Flatbed	1	49.7		0.4		50.1
		Flatbed M.I.	2				8.5	8.5
	HUB	USB	1	6.6		11.7		18.3
		USB M.I.	1				13.0	13.0
	MODEM	Cable	2	32.4		28.0		60.4
		Cable M.I.	8				52.5	52.5
		DSL M.I.	6				49.3	49.3
	ROUTER	Wireless	3	2.3		46.2		48.4
		Wireless M.I.	4				41.5	41.5
	SPEAKERS	Computer	7	16.3		5.4		21.7
		Computer M.I.	5				9.3	9.3
Entertainment	TELEVISION	CRT	78	24.4	0.9	97.5		122.7
		LCD	4	17.0		59.7		76.7
		Plasma	2	6.3		434.4		440.7
		Rear Projection	11	13.3	14.8	418.9		447.1
	TELEVISION / DVD		1	18.8		89.0		107.8
	TELEVISION / DVD / VCR		4	13.6		193.5		207.2
	TELEVISION / VCR		7	28.1		136.4		164.4
	SET TOP BOX	Analog Cable	1				89.4	89.4
		Digital Cable	10				239.3	239.3
		Digital Cable with PVR	1				376.4	376.4
		PVR	2				362.6	362.6
		Satellite	6	49.3	24.7	49.6		123.7
		Satellite with PVR	2	48.9		187.2		236.1
		Satellite with PVR M.I.	1				294.2	294.2
	VCR		16	17.4	5.7	11.2		34.2
		M.I.	11				39.3	39.3
	DVD PLAYER		30	6.8	0.4	5.9		13.2
		M.I.	2				28.6	28.6
	DVD RECORDER		1	7.9		44.0		51.9
	DVD/VCR		10	17.3	3.0	2.3		22.6
		M.I.	6				42.0	42.0
	GAME CONSOLE		8	8.8		7.0		15.8
		M.I.	1				23.8	23.8
	AMPLIFIER		2	0.2		12.9		13.1
		M.I.	1				620.8	620.8
	CASSETTE DECK		3	2.6				2.6
		M.I.	1				11.7	11.7
	CD PLAYER		8	10.9		0.8		11.7
	CD RECORDER		1	0.3		1.3		1.5
	RECEIVER		18	23.9		119.0		142.9
	SPEAKER		3	38.5		27.3		65.8
	SUB- WOOFER		3	56.0		4.3		60.3
	TUNER	AM/FM	1	26.8		1.3		28.1
	TURNTABLE		2	2.2		5.3		7.4
	AUDIO MINI- SYSTEM		21	48.2		9.4		57.6
		M.I.	1				143.1	143.1
	RADIO		2	11.7	1.5	4.9		18.1
		M.I.	2				9.2	9.2
	PORTABLE STEREO		13	12.9	1.4	4.1		18.4
		Portable M.I.	1				18.0	18.0
Battery Chargers	PHONE	Cordless with Answering Machine	11	14.4	8.5	3.1		26.0
		Cordless with Answering Machine M.I.	3				26.9	26.9
		Cordless	9	9.4	2.4	9.8		21.6
		Cordless M.I.	7				18.2	18.2
	POWER TOOL	Cordless	5	26.8		10.4		37.3
		Cordless M.I.	3				17.0	17.0
	VACUUM	Rechargeable M.I.	4				29.4	29.4
		AA Battery	1	8.7		0.8		9.5
	HAIR CLIPPER	M.I.	1				9.4	9.4
	SHAVER	Men's	1	8.9		1.8		10.7
		Men's M.I.	1				7.1	7.1
	TOOTHBRUSH		4	13.9		0.02		13.9
		M.I.	9				11.7	11.7
	CD PLAYER		2	3.0	0.4	0.3		3.8
	CELL PHONE		26	1.9	0.1	0.9		2.9
		M.I.	1				2.3	2.3
	DIGITAL MUSIC PLAYER	M.I.	1				5.8	5.8
	STILL CAMERA		2	2.8		0.5		3.3
		M.I.	3				4.2	4.2
	HEADSET	Bluetooth M.I.	1				4.3	4.3
	PORTABLE TV/VIDEO CAMERA		1	0.4				0.4

F. DETAIL ON OTHER PRODUCT CATEGORIES

Table 9. Average Measured Duty Cycle of Other Electronics

Product	Modes Determined / Modes Indetermined	Number Metered	Average Time in No Power	Average Time in Standby	Average Time in Low Power	Average Time in Active	Average Time in Indeterminate
Garage Door Opener	Modes Determined	17		98%		2%	
Low-voltage Landscape Lighting	Modes Determined	1		90%		10%	
Bottled Water Dispenser	Modes Determined	1	63%	26%		11%	
Coffee Maker	Modes Determined	6	17%	82%		1%	
Irrigation Timer	Modes Determined	3		97%		3%	
	Modes Indetermined	1					100%
Answering Machine	Modes Determined	3		67%		33%	
Clock Radio	Modes Determined	19		41%		59%	
Clock	Modes Determined	16				100%	
Interior Night Light	Modes Determined	30	29%	7%		64%	
	Modes Indetermined	5	18%				82%

Table 10. Average Power Use by Mode: Other

	Product	Type	Number Metered	Standby (W)	Low Power (W)	Active (W)	Indeterminate (W)
Other	GARAGE DOOR OPENER		17	4.8		108.0	
	LANDSCAPE LIGHTING	Low-voltage	1	1.0		91.3	
	WATER DISPENSER	Bottled Water	1	100.2		628.0	
	COFFEE MAKER		6	1.5		182.5	
	IRRIGATION TIMER		4	2.5		8.8	3.0
	ANSWERING MACHINE		3	2.1		2.9	
	CLOCK	with Radio	19	5.4	3.1	4.7	
		without Radio	16			1.7	
	NIGHT LIGHT	Interior	35	0.8	0.6	2.4	2.7

Table 11. Average Annual Energy Use by Mode: Other

	Product	Type	Number Metered	Standby (kWh)	Low Power (kWh)	Active (kWh)	Indeterminate (kWh)	Total (kWh)
Other	GARAGE DOOR OPENER		17	40.7		17.6		58.3
	LANDSCAPE LIGHTING	Low-voltage	1	7.7		83.5		91.2
	WATER DISPENSER	Bottled Water	1	226.3		600.3		826.6
	COFFEE MAKER		6	11.1		8.7		19.8
	IRRIGATION TIMER		3	20.8		3.0		23.8
		M.I.	1					26.5
	ANSWERING MACHINE		3	15.8		3.2		19.0
	CLOCK	with Radio	19	19.7	0.1	8.6		28.4
		without Radio	16			14.7		14.7
	NIGHT LIGHT	Interior	30	0.6	0.02	10.0		10.5
		Interior M.I.	5				18.4	