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Energy Consumption by Consumer Electronics in U.S. Residences

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2. Executive Summary

Over the past several decades, consumer electronics (CE) have played an increasingly greater role in peoples' lives and, as a result, the number of CE devices in peoples' homes has grown. Furthermore, CE has gone from a small portion of U.S. residential electricity consumption in the mid-1970s (Sanchez et al. 1998), to a distinct energy consumption end use. In addition, in recent years, CE increasingly has been a focus of energy efficiency programs and initiatives in the United States and around the world.

Wanting to ensure that high-quality data are used to make energy-related policy decisions for CE products, the Consumer Electronics Association (CEA) commissioned TIAX LLC to carry out a study to develop an up-to-date understanding of CE energy consumption in U.S. residences in 2006. TIAX LLC and CEA agreed upon the following project approach:

1. Generate a list of CE device types and collect existing data from literature.
2. Develop a preliminary estimate of national energy consumption for each equipment type.
3. Select up to 15 device types for further evaluation, based upon preliminary calculations and the degree to which prior studies have quantified their annual electricity consumption.
4. Develop refined bottom-up estimates of national energy consumption of each selected equipment type in 2006. This included composing and carrying out a consumer survey conducted by CEA to help fill key data gaps that impact energy consumption, such as product installed base and annual usage by usage mode.
5. Compare the current results with the results of other studies.
6. Publish the findings in a peer-reviewed report.

Energy Consumption by CE in U.S. Residences in 2006

This study characterizes the energy consumption of sixteen CE devices in detail (see Table 2-1) and includes preliminary estimates for the annual electricity consumption (AEC) of thirteen other devices.

Table 2-1: List of Consumer Electronics and Devices Analyzed in Detail

Answering Machine
Cable Set-top Box
Compact Audio
Cordless Telephone
Desktop Personal Computer (PC)
Digital Versatile Disk (DVD) Player
Digital Versatile Disk (DVD) Recorder
Home Theater in a Box (HTIB)
Monitor
Notebook Personal Computer (PC)
Personal Video Recorder (PVR)
Satellite Set-top Box (STB)
Television, Analog
Television, Digital (DTV)
Video Games
Video Cassette Recorder (VCR)

The current study does not, however, include the energy consumed by digital televisions (DTV) because a standard test procedure that accurately characterizes DTV active mode power draw does not yet exist. Hence, all subsequent references to CE energy consumption exclude DTV energy consumption. We will complete the DTV analysis and integrate the findings into an updated version of this report[1].

Excluding DTV, CE consumed about 147 TWh of electricity in U.S. homes in 2006 (see Figure 2-1). Analog TVs accounted for 36% of the total, PCs and monitors 21%, set-top boxes 13%, and audio products 12%[2].

[1] At the time of this report, we anticipate releasing the updated report in spring of 2007.
[2] These category values include contributions from devices not analyzed in detail, e.g., component stereos are included in the audio category.

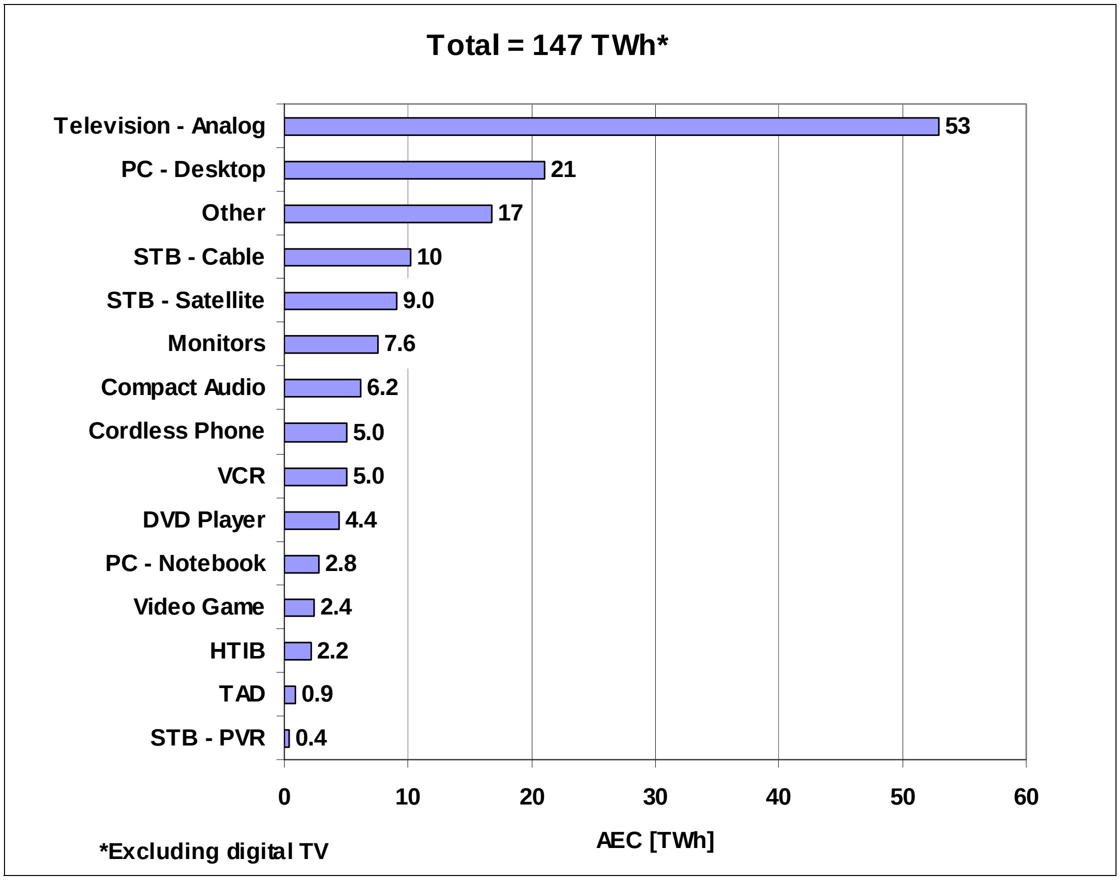

Figure 2-1: CE Energy Consumption in U.S. Residences in 2006

To place this in a national context, CE represents about 11% of U.S. residential electricity consumption (see Figure 2-1) and 4% of total U.S. electricity consumption (EIA 2006). This translates into about 7.3% and 1.6% of residential and total U.S. primary energy consumption[3], respectively.

The average annual unit electricity consumption (UEC) varies significantly between CE devices. For example, the devices with the highest UEC, desktop PCs, stand-alone PVRs, and analog televisions, consumed about an order of magnitude (i.e., ten times) more electricity per unit than the product with the lowest UEC, cordless phones (see Figure 2-2).

[3] Primary energy, as opposed to site energy, takes into account the energy consumed at the power plant to generate the electricity. On average, each delivered kWh of electricity in the U.S. in 2006 was estimated to consume 10,815 Btus to generate (i.e., including transmission and distribution losses; EIA 2006).

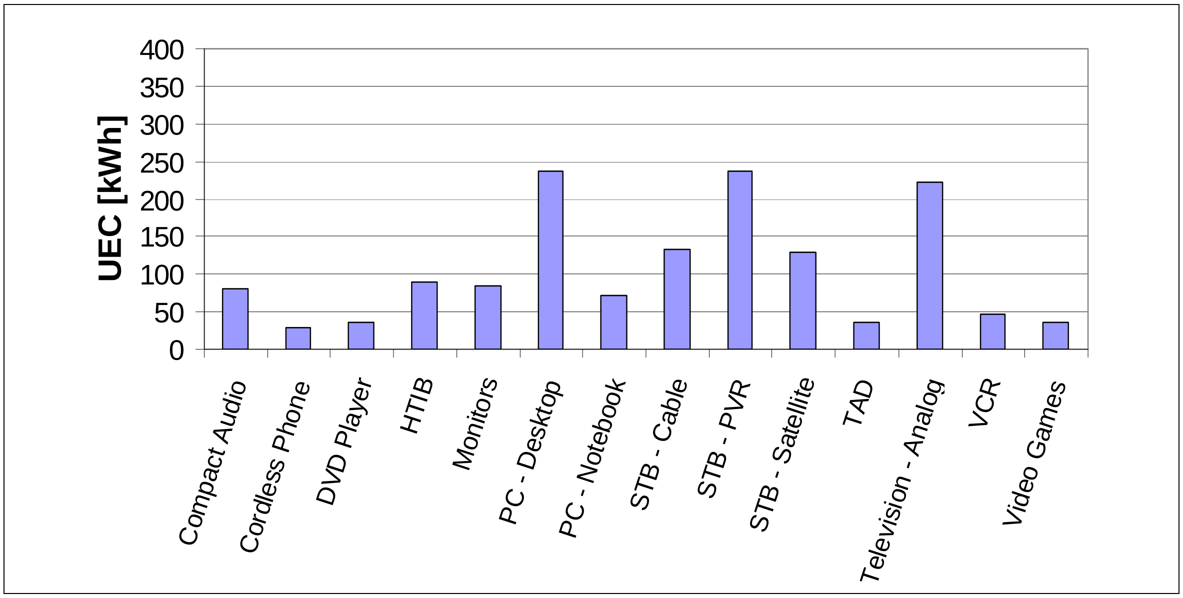

Figure 2-2: Unit Energy Consumption (Per Year) of Devices Selected for Further Analysis

The active mode[4] dominates CE energy consumption and accounts almost 70% of the total AEC of the products analyzed in further detail (see Figure 2-3). Off mode accounts for about one quarter of total AEC, while the idle (8%) and sleep (<1%) are much smaller portions of total AEC.

[4] The product-specific sections (see Section 5) include more detailed discussion of the different modes for each product.

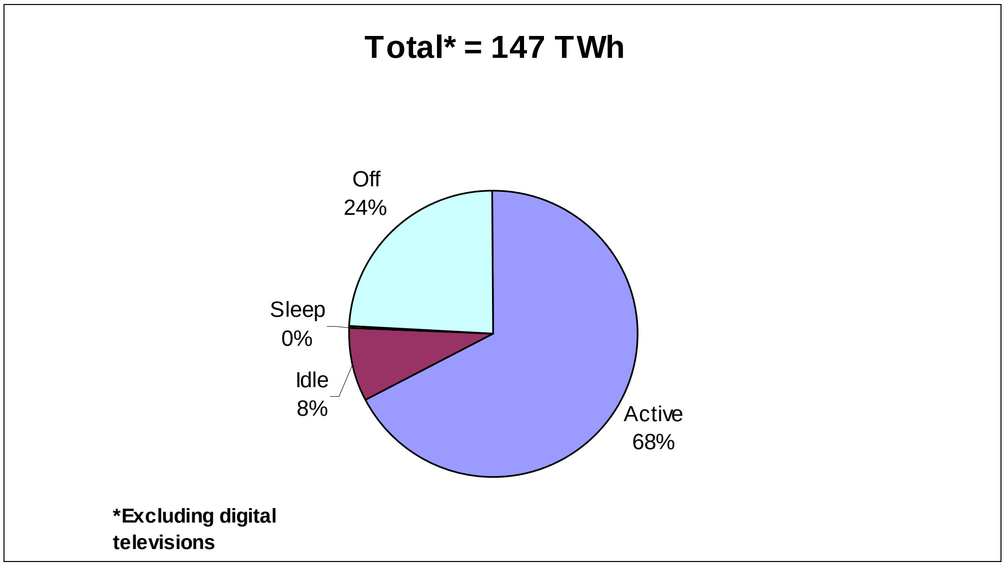

Figure 2-3: Residential CE AEC by Mode (for Devices Analyzed in Further Detail)

The UEC breakdown by mode varies greatly from one device type to another, with the active mode energy consumption dominating (>80% of UEC) for monitors, PCs, and analog televisions (see Figure 2-4). In contrast, the off mode accounts for the majority of compact audio, DVD player, VCR, and set-top box UEC. The idle mode energy consumption is most important for devices that remain on all of the time but are only actively used a small portion of that time, such as cordless phones and telephone answering devices (TADs).

Key Trends in CE Energy Consumption

The electricity consumption of residential CE has grown significantly over the past five to ten years. Data challenges with prior studies (discussed below) make it, however, difficult to develop a precise estimate for the magnitude of the increase of CE energy consumption. Keeping these caveats in mind, the current CE AEC estimate is approximately 2 and 2.5 times greater *relative to* prior estimates made approximately five (EIA 2001) and ten (Sanchez et al. 1998, ADL 1998) years ago, respectively.

Several key trends have had a major impact on the three key factors that impact CE electricity consumption: installed base, power draw by mode, and usage by mode. The installed base of CE products continued to grow over time, with some products experiencing dramatic growth over the past decade and new products coming to market. As a result, the estimated installed base of the products shown in Figure 2-4 has approximately doubled[5] since 1997.

[5] Typically, installed base estimates have appreciably less uncertainty than those for usage or power draw.

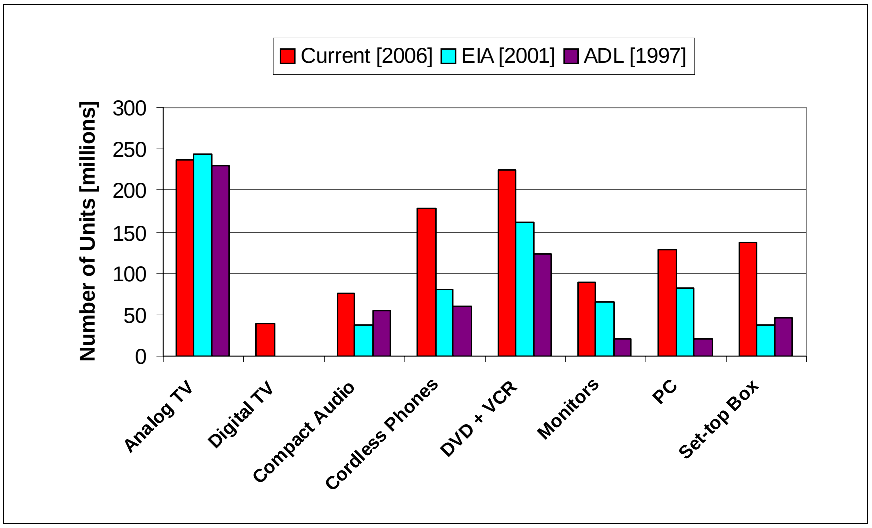

Figure 2-4: Comparison of Current and Prior Estimates for the Installed Base of Selected CE Products

In addition, the power draw characteristics of some CE products have changed appreciably. The trend for the active mode power draw of CE products, which accounts for about two-thirds of CE energy consumption, varies appreciably from one product to another (see Table 2-2). All of these trends have occurred while the performance and range of features offered in CE products has generally increased.

Table 2-2: Power Trends in CE Products' Active Mode Power Draw

Increase	• ***TVs*****:** Growth in screen sizes • ***Video Games***: Increased processing power • ***PCs***[6]**:** Increased processing power
Decrease	• ***Monitors*****:** Market move to LCDs • ***VCR***: Not fully clear, likely technological progress
Ambiguous	• ***Cordless Phones*****:** Generally down for basic units, inclusion of answering functionality and multiple handsets increase power draw • ***Set-top Boxes*****:** Although basic unit power draw has generally decreased, power draw has increased in units with PVR and HD functionality

[6] The average power draw of both desktop and notebook PCs has grown. On the other hand, notebook PCs account for an increasingly larger portion of the installed base and this, in turn, has decreased the average growth rate in *total* (i.e., desktop and notebook combined) PC active power draw. Overall, the UEC of *all* PCs plus monitors has decreased over time due to the greater market share of notebook PCs and LCD monitors.

In contrast, the average sleep and off (also referred to as standby) mode power draw for most CE products has decreased over the past decade, as manufacturers have produced products that meet the maximum power draw criteria established by the EnergyStar® program. In general, the decrease in off mode power draw of *typical new* units has been greater than the changes in the *average* installed base power draw shown in Figure 2-5.

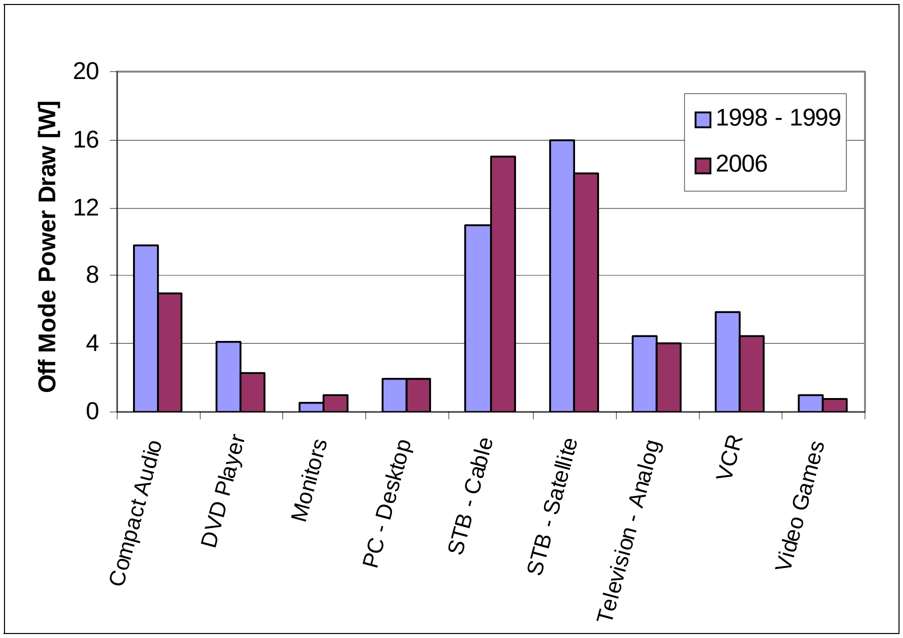

Figure 2-5: Comparison of Off Mode Average Power Draw Estimates for the Installed Bases of CE Products in 2006 and 1998/1999 (Rosen and Meier 1999a,b, Rosen et al. 2001)

Furthermore, the average sleep mode power draw of desktop PCs has decreased dramatically, from about 25W circa 1996 to approximately 4W. The trend for set-top boxes, which do not currently have an EnergyStar® specification, is less clear. Generally, there is only a slight difference between the active mode and off mode power draws. The power draw of simple STBs in both modes has generally declined. However, the recent rise in popularity of STBs with HD and PVR capability is causing an increase in both active and off mode power draw.

Potential changes in CE usage are most challenging to assess. Relative to prior studies, the current study estimates that many products spend significantly more time per year in both active and off modes and, hence, less time in idle/sleep modes. It is not, however, completely clear what portion of these changes are real and what portion reflects the availability of new data characterizing CE usage by mode. Specifically, this study draws extensively from a consumer phone survey developed by the CEA with input from TIAX and outside reviewers to generate more refined and up-to-date estimates for the usage of CE products. The survey posed several questions to 2,000 demographically-representative households about the usage, quantity, and characteristics of ten CE products for (up to) the five most-used devices per product type, per household.

Prior estimates for annual time spent in active mode for TVs, video products, and audio products were developed using credible methodologies and data. Thus, the active mode usage estimates should be generally comparable. Taking this to be the case, this study suggests analog TVs, PCs, and monitors spend appreciably more time in active mode than in the past (see Figure 2-6). As active mode power draw for analog TVs, PCs, and monitors is much greater than in other modes, increased usage tends to significantly increase device UEC and total AEC. Indeed, increased active mode usage accounts for most of the growth in analog TV UEC relative to Ostendorp et al. (2005).

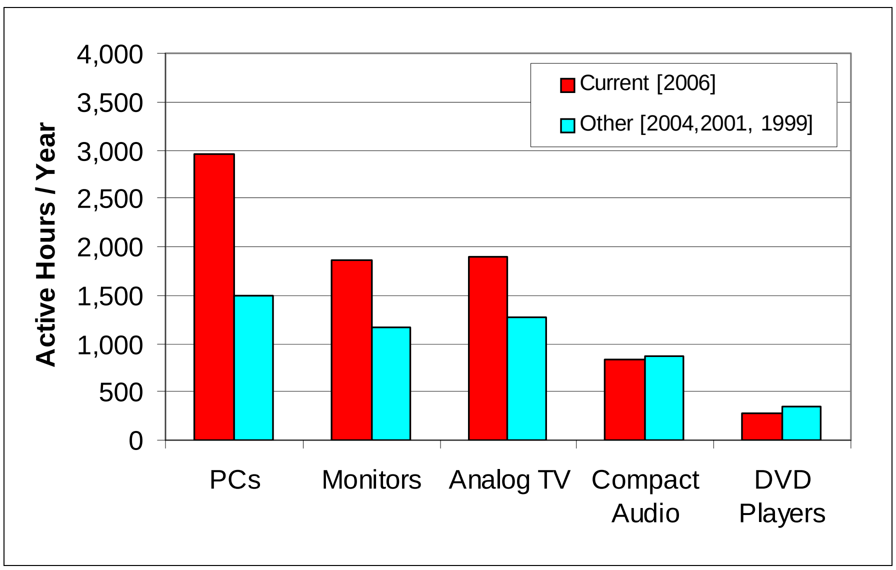

Figure 2-6: Current and Prior Active Mode Usage Estimates for Selected CE (Nordman and Meier 2004, Rosen and Meier 1999a, 1999b, Ostendorp et al. 2005)

Apparent decreases in active mode usage for compact audio and DVD players have, however, relatively little impact on their UEC values because energy consumed in idle and off modes dominate their UECs. In the case of PCs and monitors, the current study uses estimates of usage derived from a recent targeted survey that are more accurate than earlier estimates (see TIAX 2006b).

Developing meaningful comparisons of current and prior estimates of idle and off mode usage for audio and video products is more challenging. Prior estimates subtracted the active mode usage from the total number of hours in a year and dividing the remaining time between idle and off modes based upon, in essence, personal estimates (Rosen and Meier 1999a, 1999b). For all audio and video products, the survey yielded lower estimates for time spent in idle mode and higher estimates for time spent in off mode than prior estimates. Although we think that the survey-based estimates represent an improvement over prior estimates, we believe that the idle-off split values presented may still have significant uncertainty because some portion of survey respondents may not be aware of whether they have turned off audio and video devices or left them on. The probability of this scenario increases for units that the respondents' personally operate less frequently (i.e., when the respondent answers for a household with multiple occupants).

For some products, namely cable STBs, PVR STBs, satellite STBs, TADs, and, to a lesser extent, cordless phones, power draw by mode does not vary appreciably by mode. As a result, these products are insensitive to the allocation of time by usage mode.

Portable devices account for more about 22% of all residential CE units in homes, but less than 4% of CE AEC, with notebook PCs and CD boomboxes representing more than 80% of portable devices' AEC. Mobile phones represent more than half of portable CE devices, but most consume much less electricity per unit than non-portable devices.

3. Introduction

The Consumer Electronics Association (CEA) has noted the use and publication of inconsistent – and potentially misleading – estimates of consumer electronics' (CE) electricity and energy consumption. The CEA and its member companies are concerned that this can result in sub-optimal policy decisions and lead to erroneous perceptions of the contributions of CE to national energy consumption. Specifically, the CEA has noted that some recent articles about and analyses of CE energy consumption used outdated information about CE power draw by mode to characterize CE unit electricity consumption (UEC). Relative to other residential energy-consuming products, such as white goods (e.g., refrigerators, dryers, etc,), reliance upon data for CE products that are even a few years old can have a substantial and adverse impact on the accuracy of UEC estimates. That is, due to much shorter product life times for CE products (e.g., an approximate average of five years versus 10+ years for white goods) and the very rapid pace of change in CE product technology and features. This makes quantification of CE energy consumption more challenging and time intensive, because an accurate analysis inherently requires collection of up-to-date data.

For example, the documents relied upon by the California Energy Commission (CEC) to support regulation of the standby[7] mode power draw of TVs, compact audio, and DVD players and recorders drew heavily upon power draw data from the late 1990s[8] (TIAX 2006a). Since the late 1990s, the average standby mode power draw of all of these products appears to have decreased appreciably as a sizeable portion of products manufactured since that time meet the EnergyStar® performance levels that came into effect in 1999. Similarly, until recently[9], much of the characterization of CE energy consumption by the U.S. Department of Energy's Energy Information Administration (EIA) relied upon much of the same data to quantity the electricity consumption of many CE products.

Furthermore, for several CE devices, few data have existed to accurately quantify the average annual time they spend in key energy-consuming modes. For example, the authors of the studies cited in the aforementioned CEC rulemaking allocated "inactive" time between idle and off modes for compact audio, DVD players, and VCRs based on their informed estimates, noting that they could not find data for time spent in idle or off mode (Rosen and Meier 1999a, Rosen and Meier 1999b). TIAX appreciates the clarity and openness of those researchers, as well as the challenges of gathering representative usage data for these products. Regardless, the uncertainty

[7] "Standby" refers to the mode drawing the lowest level of power that a device can enter into while still plugged in. For many CE products, consumers would perceive the standby mode to be when the product is turned off.

[8] Specifically Fernstrom (2004) drew extensively from Rosen and Meier (1999a) and Rosen and Meier (1999b). All of the TVs measured were manufactured in 1998 or earlier (Rosen and Meier 1999a), while the most recent power draw measurements for audio products were made in early 1999 (Rosen and Meier 1999b).

[9] In 2006, TIAX developed new estimates for the current and future AEC of several key residential CE products for the EIA (see TIAX 2006c). Those estimates were completed before this current analysis and, thus, do not incorporate the latest data presented in this study. We informed EIA about the CEA study and these findings will be presented to the EIA to enable updating of the EIA AEC estimates and projections.

in annual usage by mode represents a major data gap that results in significant uncertainties in unit energy consumption estimates for several CE products.

To ensure that high-quality data exist to inform public policy decisions related to CE products' energy consumption, the CEA contracted TIAX LLC to analyze the energy consumption of CE products in U.S. residences in 2006. This report presents the full assessment and its key findings.

3.1. Approach

To develop an up-to-date estimate for the energy consumed by CE products in U.S. homes in 2006, TIAX and CEA agreed upon the following approach to the project:

1. Generate a list of equipment types and collect existing data from literature.
2. Develop a preliminary estimate of national energy consumption for each equipment type.
3. Select up to 15 equipment types for further evaluation, based upon preliminary calculations and the degree to which prior studies had quantified their AEC.
4. Develop refined bottom-up estimates of national energy consumption of each selected equipment type in 2006. This included composing and carrying out a consumer survey funded by CEA to help fill key data gaps that impact energy consumption, such as product installed base and annual usage by mode.
5. Compare the current results with the results of other studies.
6. Publish the findings in a peer-reviewed report.

3.2. Report Organization

This report has the following organization:

Section 4 summarizes the methodology used to assess the energy consumption of CE products in residences.

Section 5 presents the estimates of residential CE products' energy consumption for the key equipment types in 2006.

Section 6 presents the conclusions of this report.

Appendix A summarizes the data used to develop the AEC estimates for residential CE products not evaluated in greater detail, while Appendix B presents the script for the CEA Survey to refine our understanding of the installed base and usage of CE products. Appendix C contains the test procedures used by CEA staff to measure power draw by mode of CE products and Appendix D presents the power draw measurements for the devices measured.

4. Energy Consumption Calculation Methodology

Figure 4-1 shows the basic methodology used to develop the annual energy consumption (AEC) estimates; the modes shown are illustrative and vary by product.

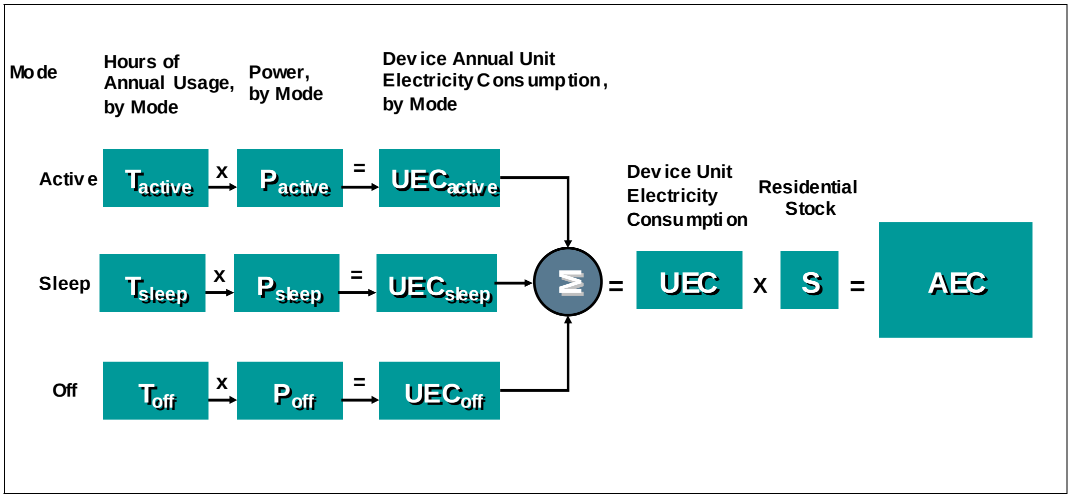

Figure 4-1: Annual Energy Consumption Calculation Methodology

For each equipment type analyzed, we calculated the average annual unit energy consumption (UEC, in kWh) of a single device (e.g., a desktop PC) for an entire year. The UEC equals the sum of the products of the approximate number of hours that each device operates in a residential setting in each power mode relevant to that product and the power draw in each mode. The product of the estimated device stock (i.e., installed base) and the device UEC yields the total annual energy consumption (AEC, in TWh) for that equipment type. ADL (2002) describes the calculation methodology in greater detail.

The following sections describe our approach to developing values for the different components of AEC calculations, while Section 5 presents the specific values used for each device type.

4.1.1. Residential Equipment Stock

The residential building equipment stock equals the number of devices in use (i.e., plugged in) in residential buildings. Stock estimates primarily came from published estimates, such as industry market reports (most notably carried out by the CEA), the residential consumer electronics (CE) survey carried out for this study, CEA shipment data, and other research reports. Overall, residential stock estimates appear to have the smallest uncertainty of all three components of device AEC calculations.

4.1.2. Usage Patterns

A device's usage pattern refers to the number of hours per week that, on average, a device operates in a given mode. Most CE products have at least two distinct operational modes, i.e., on and off, while many have more. In general, very few measurements of residential CE equipment usage patterns exist. Most prior studies of the energy consumed by specific CE products have used a variety of data to develop reasonable estimates of average per-device active mode usage (e.g., Ostedorp et al. 2005, Rosen and Meier 1999a, Rosen and Meier 1999b, Rosen et al. 2001). As noted earlier, however, very few data exist to derive accurate estimates for the average period of time that several product types spend in idle modes, notably audio and video devices.

To address these data gaps, CEA carried out a phone survey to develop more refined and up-to-date estimates for the usage of CE devices (henceforth referred to as the "CEA Survey"). The CEA Survey posed several questions to 2,000 demographically-representative U.S. households about the usage, quantity, and characteristics of ten CE products (see Table 4-1), for (up to) the five (5) most-used units per device type, per household. We used the data developed from this survey to inform the usage estimates for all ten device types, as well as the installed base estimates for selected devices.

Table 4-1: List of Consumer Electronics Devices Included in the CEA Survey

Products
Cable Set-top Box
Compact Audio
Digital Versatile Disk Player
Digital Versatile Disk Recorder
Gaming Console
Home Theatre in a Box
Personal Video Recorder (stand-alone)
Satellite Set-top Box
Television, Analog
Television, Digital
Video Cassette Recorder (VCR)

In spite of this new data, device usage in idle mode still likely has the greatest uncertainty of any component of the AEC calculations. Although consumers may have a reasonable idea of how much they have actively used various CE devices recently, they likely are not as aware of the time that the products spend in idle instead of off mode. Similarly, despite an appreciable investment of effort by the project team and helpful feedback received by reviewers to clarify the definitions of usage modes (see the "Acknowledgements" section), many respondents may not fully understand the distinction among different modes. Despite these sources of uncertainty, we think that the survey yields an improved understanding of CE usage relative to prior studies whose usage estimates were based on educated estimates.

4.1.3. Power Draw by Mode

The AEC estimates incorporated power draw data for different equipment types and segments for each mode of operation. For each mode, the power draw value represents the best estimate for the average power draw of all of the different devices included in a single equipment type or segment. This estimate assumes that annual usage by mode does not vary appreciably with power draw by mode, e.g., that desktop PCs that draw 120W in active mode do not spend appreciably more hours in active mode per year than desktop PCs that draw 50W in active mode. We investigated this effect for analog TVs, the device where we expected the most significant deviation from this assumption. On average, larger, more powerful TVs were used more, but energy consumption only increased by 5% when accounting for the power/usage correlation. We did not analyze this effect for the other CE products since the magnitude of the error introduced by this simplification is likely on the order of or less than that of the magnitude of other uncertainties in usage patterns.

For all products analyzed, the power draw values for all modes reflect power draw measurements of devices instead of rated power draw values. Rated power draws represent the maximum power that the device's power supply can handle and often exceed typical active power draw values by at least a factor of three. Ideally, the power draw values would come from measurements of a statistically representative sample of products that reflect the installed base of equipment for the entire U.S., i.e., accounting for make, model, and vintage[10]. When this information was available for product categories, this strategy was employed. However, this level of accuracy was not achieved for most equipment types analyzed. The sources of power draw data for this study vary by product type, but in general, come from current CEA measurements, current manufacturer measurements, and measurements from prior analyses. Notably, the CEA measurements of units primarily sold in 2006 attempted to represent the best-selling products for 2006 by sampling units of the best-selling brands. For each product, we determined the most accurate approach to characterize power draws based on the data available; the specific approach taken for each product is described in the report section dedicated to that product. Overall, we concluded that the uncertainty in the average power draw by mode values is probably smaller than uncertainties in annual usage for all modes except active mode for many key equipment types.

[10] For example, the Australia Greenhouse Office has carried out invasive surveys of more than 100 Australian homes where they measured the power draw by mode of all plug loads in the homes (see Energy Efficient Strategies 2006). Assuming that the homes sampled were truly a representative sample of Australian homes, that sample could approach statistical significance.

5. Energy Consumption of Consumer Electronics in U.S. Residences

5.1. Top-level findings

Consumer electronics, excluding *digital* televisions, in U.S. residences consumed about 147 TWh of electricity in 2006 (see Table 5-1). This represents about 11% of U.S. residential electricity consumption and 4% of all U.S. electricity consumption. In primary energy terms, residential CE accounted for about 7.3 and 1.6% of residential and total U.S. primary energy consumption, respectively (EIA 2006).

Table 5-1: Summary of Consumer Electronics Annual Electricity Consumption in U.S. Residences

Category / Device	UEC [kWh]	Installed Base [millions]	AEC [TWh]
Audio Products			8.4
Compact Audio	81	76	6.2
Home Theater in a Box	89	25	2.2
Cordless Telephone	28	179	5.0
Monitors	85	90	7.6
Personal Computer			24
Desktop	237	90	21
Notebook	72	39	2.8
Set-Top Boxes			22
Cable	133	77	10
Satellite	129	70	9.0
Video Game System	36	64	2.4
Stand-alone Personal Video Recorder (PVR)	237	1.5	0.4
Telephone Answering Devices (TADs)	35	25	0.9
Television			53
Analog	222	237	53
Digital	Not Included	Not Included	Not Included
Video Products			9.4
DVD Player and DVD/VCR Combo	36	110	4.1
DVD Player and Recorder	34	10	0.3
VCR	47	105	5.0
Other			17
TOTAL			**147**

The following subsection summarizes the products selected for further analysis and the subsequent subsections presents the analyses for individual products and compares the current results to prior analyses.

5.2. Products Selected for Further Analysis

Ideally, this study would have developed detailed assessments of the energy consumed by all CE products used in residences. In practice, project scope limitations dictated that we analyze a subset of CE products. Two factors drove the selection process. First and foremost, we wanted to include products that account for most of total CE energy consumption based on preliminary estimates of their annual electricity consumption (AEC). In addition, we also gave greater weight to CE products that had not been studied as thoroughly in the past, as an evaluation of these products would result in a marginally greater increased understanding of total CE energy consumption. For example, stand-alone PVRs were selected for further study even though they were not expected to account for a significant portion of residential CE AEC because their energy consumption has not been evaluated in detail. Using these guidelines and in conjunction with the CEA, we selected the sixteen products shown in bold in Table 5-2 for further analysis.

Table 5-2: List of Consumer Electronics and Devices Analyzed in Further Detail

Products	Analyzed in Further Detail?
Cable Set-top Box (STB)	**Yes**
Caller ID Equipment	No
Camcorder	No
CD Boombox	No
Cellular Telephone	No
Compact Audio	**Yes**
Component Stereo	No
Cordless Telephone	**Yes**
Desktop Personal Computer (PC)	**Yes**
Digital Camera	No
Digital Versatile Disk (DVD) Player	**Yes**
Digital Versatile Disk (DVD) Recorder	**Yes**
Facsimile Machine	No
Home Theater in a Box (HTIB)	**Yes**
Modem (Cable and DSL)	No
Monitor	**Yes**
Notebook Personal Computer (PC)	**Yes**
Pager	No
Personal Video Recorder (PVR)	**Yes**
Portable Audio (MP3 and CD Players)	No
Printer	No
Radios (home)	No
Satellite Set-top Box (STB)	**Yes**
Telephone Answering Device (TAD)	**Yes**
Television, Analog	**Yes**
Television, Digital	**Yes**
Video Game System	**Yes**
Video Cassette Recorder (VCR)	**Yes**

The current study does not, however, include a characterization of digital television (DTV) energy consumption. An international effort is underway to develop a test procedure that accurately measures TV active mode power draw; this procedure is expected to be finalized in 2007. After the test procedure is determined, CEA and its members will measure the power draw of their best-selling DTVs in all relevant modes. We will synthesize these power draw measurements to characterize DTV annual electricity consumption (AEC). These findings will be integrated into an updated version of this report. All subsequent references to CE energy consumption in this report exclude DTV energy consumption.

The following sections present the analyses of the energy consumed by all of the key products except DTVs.

5.3. Compact Audio

5.3.1. Current Energy Consumption

This section describes the number of compact audio systems in the U.S., typical usage patterns, and average power draw estimates in an effort to calculate the energy consumption in the U.S. in 2006.

5.3.1.1. Installed Base

Compact audio systems (also called shelf stereo systems, mini, or midi systems) typically consist of a center component with one or more audio media players (e.g., CD, tape, radio tuner) and two or more detached speakers (see Figure 5-1).

Figure 5-1: Compact Audio System Example (Source: JVC)

According to the CEA Survey, 48% of U.S. household owned at least one compact audio system, while the Consumer Electronics Ownership Study conducted in 2005 indicates that the compact audio penetration is 40% (CEA 2005b). Since both surveys asked the same question and were conducted by the same organization, an average of 44% is used for this analysis. Both surveys found that households owning at least one system owned an average of 1.5 systems. Based on 115 million household in 2006 (EIA 2006), there are approximately 76 million compact audio systems in the U.S. in 2006.

Table 5-3: 2006 Compact Audio Installed Base

Installed Base [millions]	Penetration	Comments and Sources
76	44%	Average of CEA Survey and CEA (2005b)

5.3.1.2. Unit Energy Consumption

Home audio products can be simply characterized by three operating modes as follows:

- *Active* – Cassette tape, CD, or radio is being played or recorded, or TV sound is being played through the stereo
- *Idle* – The system is on, but no audio function is being performed
- *Off* – The power has been turned off, but the system remains plugged in

There is some variation in active mode power draw depending on what is being played or recorded. For example, the active power draw resulting from playing the radio or television sound through the stereo is less than that required to play a CD or tape (Rosen and Meier 1999). The power draw difference between playing a CD and playing the radio is an average of 2 to 3 Watts (Nordman and McMahon 2004, Rosen and Meier 1999). On the other hand, because we do not know of data that accounts for the time spent in active mode by these different types of active modes and because the differences in power draw are rather small, we decided to use the CD playing mode to characterize the entire active mode.

The active mode power draw estimates come from measurements by the CEA of 51 compact audio systems (see Figure 5-2; Appendix D contains the power draw measurements for the units tested, Appendix C test procedure used). The systems were manufactured from 1991 through 2006, although 37 of the 51 were made in 2005 or 2006. In an attempt to have the power draw data approach the characteristics of the units actually sold and used in 2005 and 2006, the manufacturers asked to supply equipment for measuring were identified as manufacturers with major market shares for that product. Furthermore, the equipment request specifically asked manufacturers to provide their better-selling products.

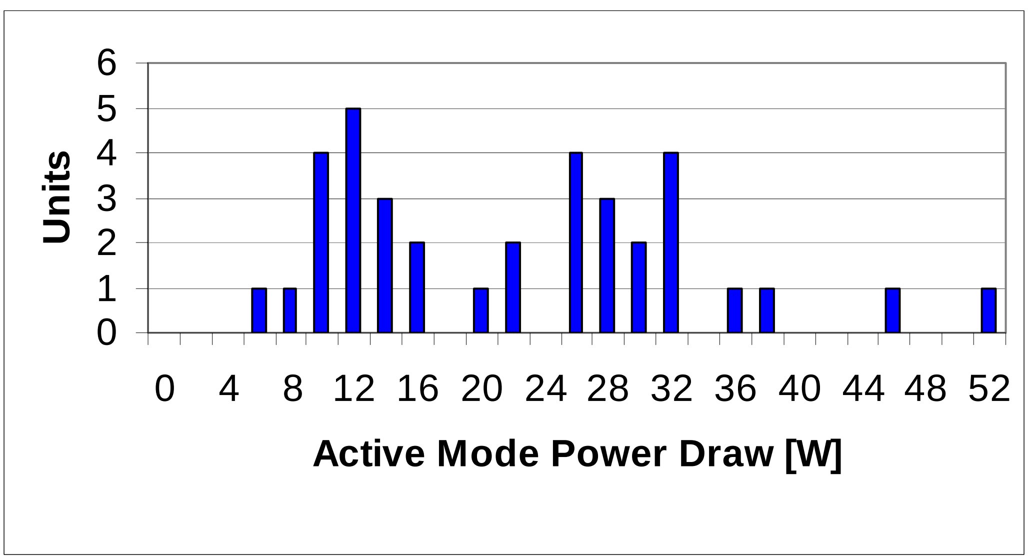

Figure 5-2: Distribution of Active Mode Power Draw for Compact Audio Systems Using 2 W Increments

Figure 5-2 reveals a wide range of active power draw among compact audio systems. This reflects, at least in part, the wide variety of functions and speaker capabilities (i.e., power). The above distribution indicates that there appear to be two main compact audio groups based on active mode power, one centered in the 12 to 14 Watt range, and one in the 28 to 30 Watt range. It is not clear, however, whether or not these two power groupings have equal weighting in the measured sample and the U.S. installed base. Assuming that the sample is statistically representative of the installed base, the overall average active power draw is approximately 23 Watts. Although most of the measured units are of newer vintage, historical data suggest that the year of manufacture has little effect on the average active mode power draw (see Figure 5-4).

The off mode power draw of compact audio systems likewise exhibits a large range. 40% of the measured devices drew less than 1 Watt in off mode, but one unit drew as much as 21 Watts (see Figure 5-3).

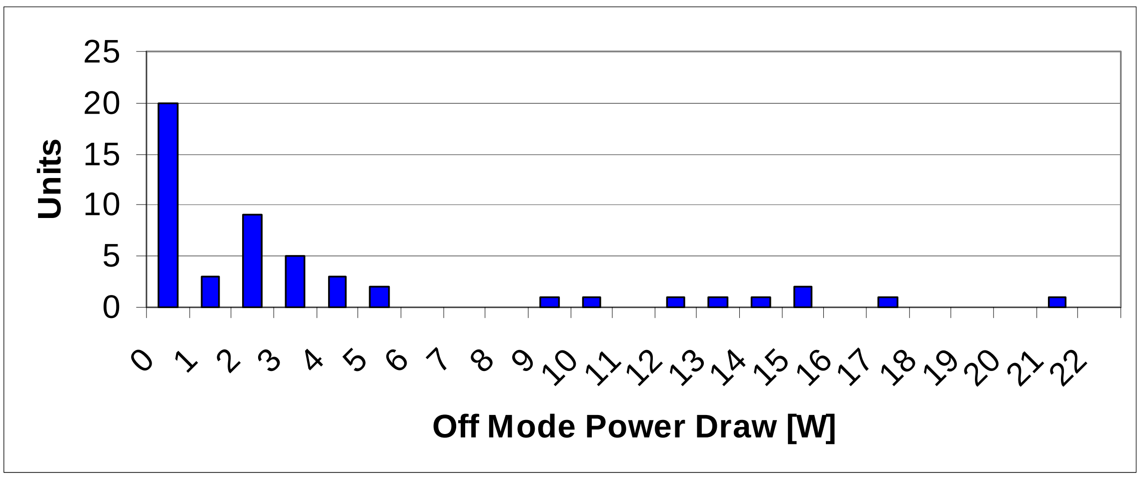

Figure 5-3: Distribution of Off Mode Power Draw for Compact Audio Systems Using 1 W Increments

The average off mode power draw of the measured sample was approximately 4 Watts. However, the majority of the measured units were manufactured in 2005 or 2006, and therefore older devices are not properly represented in the average. Unlike active mode power draw, the average off mode power draw does appear to be dependant on year of manufacture due largely to the EnergyStar® Program (see Figure 5-5). Therefore, a model was developed to account for the off mode power draw of older devices (see Table 5-4).

Table 5-4: Average Off Mode Power Draw Model

	1998	1999	2000	2001	2002	2003	2004	2005	2006
% EnergyStar® Rated	-	10%	17%	20%	31%	64%	13%	20%	30%
Compact Audio Unit Sales, EnergyStar® [millions]	-	1	2	2	2	4	1	1	2
Compact Audio Unit Sales, All [millions]	9	11	12	10	7	6	7	7	7
EnergyStar® Off Mode Requirement [W]	-	3	3	3	3	1	1	1	1
Estimated Off Mode Avg, EnergyStar® Units	-	2	2	2	2	2	0.6	0.6	0.6
Estimated Off Mode Avg, non- EnergyStar® Units	10	10	9	9	8	8	6	6	6
Estimated Annual Off Mode Average [W]	10	9	8	7	6	4	5	5	4

Nine years of compact audio sales, power estimates, and EnergyStar® penetration data were analyzed to capture the overall average off mode power draw. The sum of nine years of unit sales adds up to approximately the total installed base estimate[11]. Measurements of 19 compact audio systems by Rosen and Meier (1999) found an average off mode power draw of almost 10 Watts. The majority of the devices measured in their study were manufactured in 1999 and these values were used to estimate the off mode power draw in both 1999 and 1998. The 2006 non-EnergyStar® off mode power draw was estimated by averaging the current measured units that draw greater than 1 W. The 2006 average EnergyStar® unit was calculated by averaging the power draw of all the units on the current EnergyStar® "audio and DVD product list"[12]. We estimated the off mode power draw for 2000 through 2005 using a linear interpolation, modified[13] to take into account that the EnergyStar® criteria changed in 2003 for compact audio products[14]. The weighted average of the annual power draw estimates based on annual unit sales was calculated to be approximately 7 W.

The average idle mode power draw for the 20 compact audio systems measured by Rosen and Meier (1999) is approximately 85% of the average active mode power draw. Nordman and McMahon (2004) measured the idle power draw of 11 "audio minisystems", and the ratio of idle mode power to active mode power was approximately 50%, albeit primarily for smaller units in the 5 to 8 Watt active power draw range. Without additional idle mode power measurements, we assumed an average idle to active mode ratio of 70%, noting the uncertainty of this estimate.

[11] A more refined product retirement function (e.g., 2/3rd law) could have been employed, but we judged that it would not result in a more accurate off mode power estimate due to other uncertainties in the model.
[12] Downloaded from: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=HA .
[13] Using a straight linear interpolation results in a similar value for average off-mode power draw.
[14] Compact audio products launched after 1 January 2003 must draw 1W or less in off mode to qualify as EnergyStar®, while products launched before 1 January 2003 that drew 3W or less may continue as EnergyStar® products while they remain on the market.

The CEA Survey found that compact audio systems are used an average of 2.3 hours per day, or 840 hours per year. This estimate was taken from a second survey in which participants were asked specifically to also think about how much time they listened to television audio through their compact audio systems (in addition to listening to music)[15]. Respondents estimated that 40% of the active usage results from playing television sound through a compact audio system. Comparing the first and second survey results, it appears that some survey respondents failed to include this "TV time" in the first survey.

The survey results indicate that compact audio systems are "turned on" for 2 hours longer than they are "in active use". The term "turned on" refers to the sum of the time the audio system is in active mode and idle mode. Therefore, the idle mode usage is 2 hours per day, or approximately 730 hours per year. There is likely significant uncertainty associated with this estimate since many participants likely have a difficult time accurately estimating idle time, even if they do understand the terminology. They simply may not be aware of when their devices are in idle mode.

Table 5-5 shows the unit energy consumption by operating mode for compact audio systems. Active mode usage accounts for 24% of the energy consumption, and off mode account for an additionally 62%. Idle mode only accounts for 14% of the UEC, but is likely a lower bound given the uncertainty of the survey usage estimates.

Table 5-5: UEC for Compact Audio Systems

	Active	Idle	Off	Total	Comments and Sources
Power [W]	23	16	7		See text above
Usage [hr/yr]	840	730	7,190	8,760	CEA Survey
UEC [kWh/yr]	19	12	50	81	

5.3.1.3. National Energy Consumption

Multiplying the estimated installed base by the average UEC yielded an annual energy consumption (AEC) of 6.2 TWh for compact audio systems (see Table 5-6).

Table 5-6: 2005 AEC Summary for Compact Audio Systems

Installed Base [millions]	UEC [kWh/yr]	AEC [TWh]
76	81	6.2

5.3.2. Prior Energy Consumption Estimates

The current UEC estimate derived from surveyed usage data and measured power draw data is significantly lower than prior estimates (see Table 5-7).

[15] Rosen and Meier (1999) concluded that TV viewing increased audio active mode usage significantly.

Table 5-7: Prior Compact Audio System Energy Consumption Estimates

Source		Current	EIA (2001)	Rosen and Meier (1999)	ADL (1998)	Sanchez et al. (1998)	Floyd and Webber (1998)
Year of Estimate		2006	2001	1998	1997	1995	
Installed Base [millions]		76	37	50	55	53	
Power Draw [W]	**Active**	23		22	15	15	34
	Idle	16		20			
	Off	7		9.8	11	11	9
Annual Usage [hours]	**Active**	840		876	365	365	
	Idle	730		1,577			
	Off	7,190		6,307	8,395	8,395	
UEC [kWh/year]		81	81	113	94	94	
AEC [TWh/year]		6.2	3.0	5.6	5.2	5.0	

The current installed base estimate indicates growth in household penetration as well as the number of units per household with at least one device relative to prior estimates. The penetration estimate of 44% is similar to prior estimates of 40%. The number of systems per household may have increased because many households may not retire older systems when they purchase a new system if the older device still works. Also, smaller and less expensive compact systems are available.

The analysis conducted by Rosen and Meier (1999) is the only prior estimate to account for usage resulting from playing TV sound through the compact audio system. The current active usage estimate is comparable to that estimate.

Rosen and Meier assumed that compact audio systems spend 25% of the time not in active mode in idle mode because owners neglected to turn them off. There were, however, no data to support this assumption. Although an improvement over this prior assumption, the current estimate of idle mode usage based on survey data also may have significant uncertainty. For example, survey respondents might not accurately recall the time that compact audio systems spend in idle mode because they may not pay much attention to the time that units spend in that mode. Nonetheless, barring metered data from a statistically significant and representative sample of households, occupant responses are superior to rough estimates based on researchers' experience. The current data suggests that compact audio systems are in idle mode 10% of the time they are not active.

Figure 5-4 plots the active mode power of compact audio systems versus the year of manufacture from the CEA measurements and those reported in Rosen and Meier (1999). 1999, 2005, and 2006 are the only years with significant sample sizes and the data from these years indicate that a large range of products have been available for the past decade. These data do not produce a clear trend in active mode power draw.

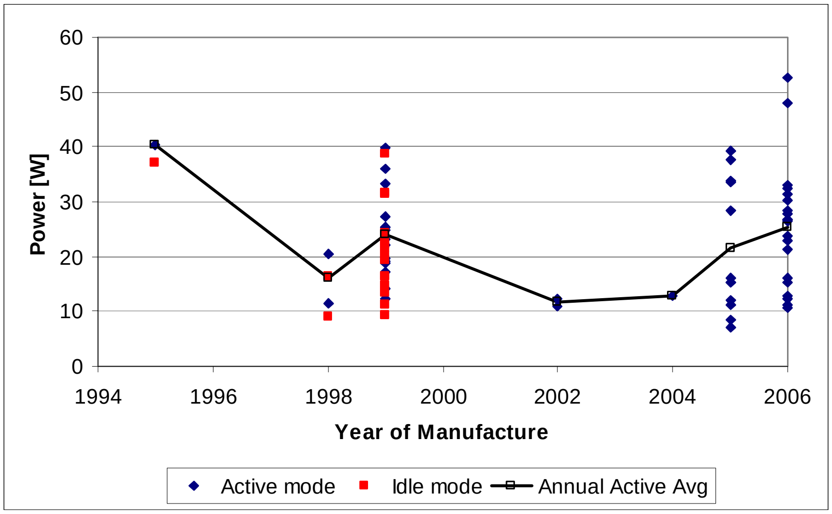

Figure 5-4: Active and Idle Mode Power Draw Measurements for Compact Audio Systems by Year of Manufacture

Figure 5-5 plots the off mode power draw versus year of manufacture from current measurement data and from Rosen and Meier (1999). Again, many years lack sufficient sample sizes needed to discern trends. Data from units manufactured in 1999, 2005, and 2006 show a broad range of off mode power requirements. The averages from these years show a downward trend in off mode power draw from approximately 10 W down to 4 W. \

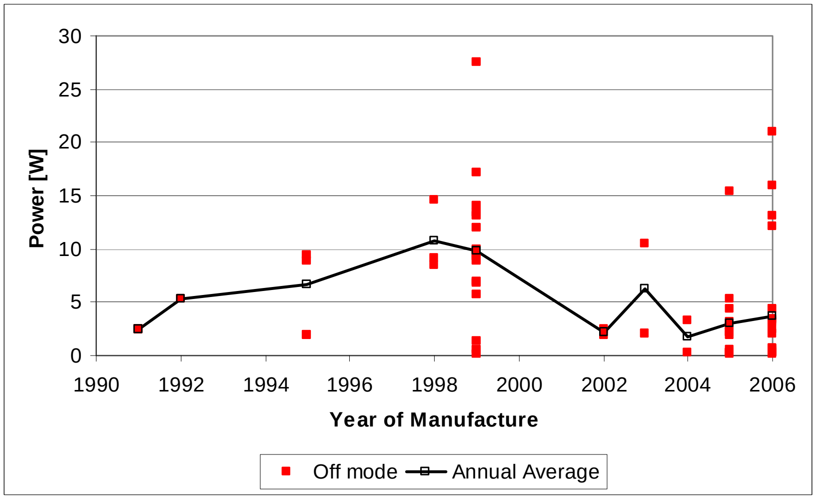

Figure 5-5: Off Mode Power Draw Measurements for Compact Audio Systems by Year of Manufacture

This decrease in off mode power draw reflects the sizeable portion of products that have met the EnergyStar® off mode power draw levels (see Figure 5-6). The first EnergyStar® specification – 3W or less in off mode – came into existence in 1999 and was subsequently reduced to 1W or less in 2003 (EnergyStar 2006).

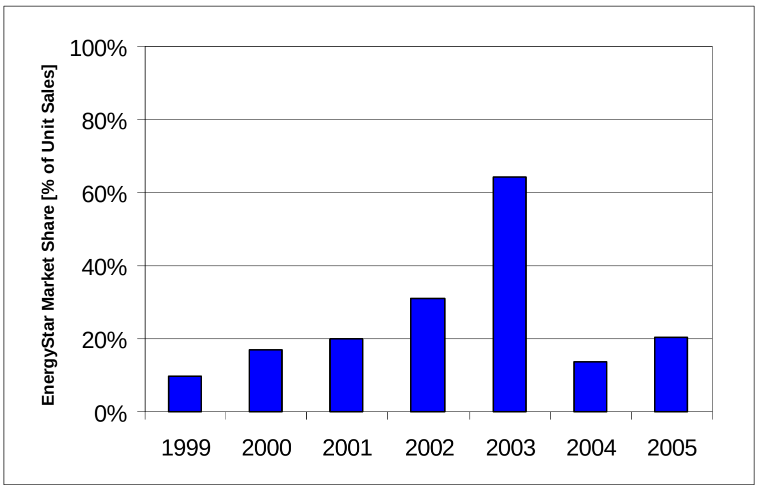

Figure 5-6: Market Penetration of EnergyStar® Compact Audio Systems (EPA 2006)

5.3.3. References

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5.4. Cordless Telephones

5.4.1. Current Energy Consumption

This analysis uses the installed base, typical usage patterns, and average power draw estimates by operating mode to calculate the AEC of cordless telephones in the U.S. in 2006. The cordless telephone category consists of both standard cordless telephones, as well as cordless phones with integrated telephone answering devices (TADs). A further breakdown of cordless phones into standard and spread spectrum technology (SST) is applied for additional energy analysis accuracy. Cordless phones may be sold with multiple handsets, but this analysis does not specifically account for this factor.

5.4.1.1. Installed Base

Survey data from CEA (2005a) estimates that there were 179 million cordless telephones in the U.S. in 2005 and 83% of households own at least one cordless telephone. About 32% of these units have an integral TAD (Bates 2006), while approximately 30% of all cordless telephones (including combination units) feature SST (CCAP 2005; see Table 5-8). Our analysis assumes that all of these values did not change appreciably between 2005 and 2006.

Table 5-8: Installed Base of Cordless Telephones

	Standard Installed Base [millions]	SST Installed Base [millions]	Penetration [% of Households]
Cordless Telephones	92	31	83%
Cordless Telephones w/ Integrated TAD	32	25	

As this estimate reflects the total number of cordless telephone handsets, it somewhat overestimates the number of cordless phone base stations because some cordless phone packages have multiple handsets per base station. Unfortunately, we did not find data for the number of base stations, nor the prevalence of base stations with multiple handsets. According to Bates

(2006), base stations with multiple handsets only became common within the past couple of years, which limits the impact of this effect on the installed base.

5.4.1.2. Unit Energy Consumption

Cordless phones can be characterized by four operating modes:

- *Active* – The handset is in use
- *Handset Removed* – The handset is not in use, and is not in the base (Prior studies also refer to this mode as "no-load")
- *Maintenance* – The handset is attached to the base, but is fully charged
- *Charging* – The handset is attached to the base and charging

The usage estimates for this analysis come from limited survey data and anecdotal evidence obtained by LBNL (Rosen et al. 2001) and, therefore, has appreciable uncertainty. Our analysis assumes that usage for each mode is the same for standard cordless telephones and those with integrated TADs. Additionally, this estimate also assumes that cordless telephone usage patterns have not changed over the last five years, even though recent growth in mobile telephones may have affected usage patterns in cordless phones. On the other hand, power draw measurements (see below) show that cordless phone power draw varies relatively little by mode, and therefore UEC will not change significantly with changes in usage patterns.

Table 5-9: Cordless Telephone Usage by Mode

	Active	Handset Removed	Maintenance	Charging
Usage [hrs/yr]	350	2,015	5,695	700

This usage estimate indicates that the average cordless phone spends 65% of the time in maintenance mode, or attached to the base fully charged. Another 23% of the time cordless phones are unattached from the base in handset removed mode.

The power draw estimates come from limited measurement data. Because of the various options available on cordless phones, including integrated TAD, SST, and multiple handsets, a relatively large sample size would be needed to accurately capture the average power draw by mode of the installed base. The available data indicate that the power draw does not vary significantly between operating modes and that the average power draw has not changed significantly in the past five years (Rosen et al. 2001, McAllister and Farrell 2004, measurements by four major cordless phone manufacturers of their best-selling units in 2006).

The EnergyStar® program has a specification for cordless phones (see Table 5-10). Figure 5-7 indicates that the historical penetration of EnergyStar® units as a percentage of annual sales has not followed a discernable pattern. Only cordless phone/TAD combination units show a steady improvement in EnergyStar® penetration.

Table 5-10: Cordless Telephone Energy Requirements (EnergyStar® 2006)

	Version 1.0 Standby Mode Requirements *(Effective January, 2002 – October, 2006)*	Version 2.0 Requirements *(Effective November, 2006)*
Cordless Telephones	3.3 W	2 W
Cordless Telephones with SST	3.6 W	2 W
Combination Cordless Telephones/TADs	4 W	2.5 W
Combination Cordless Telephones/TADs with SST	5.1 W	2.5 W
Additional Handsets	Additional 1.5 W	Additional 1 W

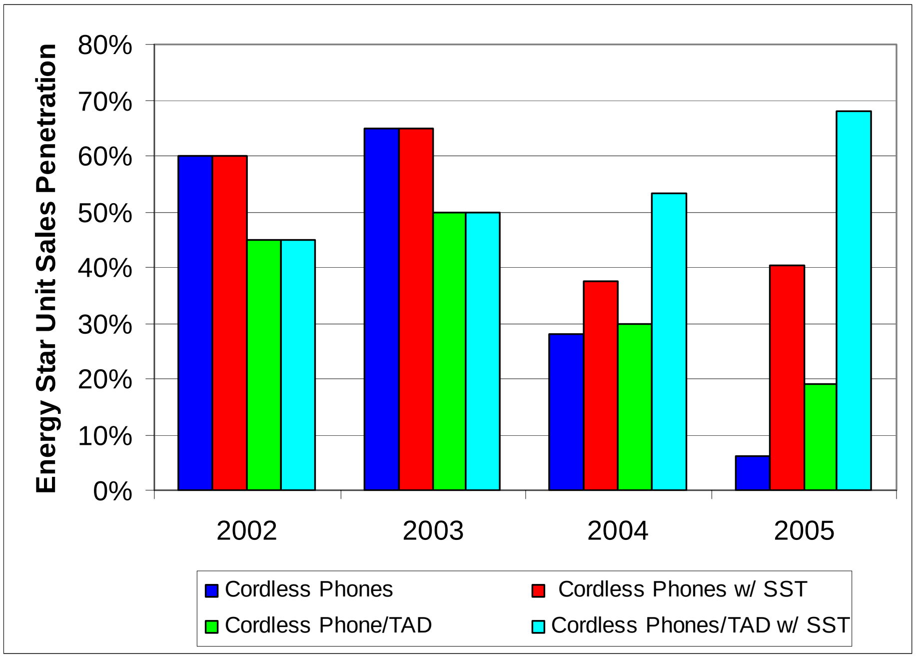

Figure 5-7: Cordless Telephone Energy Star Unit Sales Penetration (EPA 2006)

The maintenance mode power draw data from the EnergyStar® product list suggest that cordless phones with SST draw less power in maintenance mode than the average standard cordless phone, despite the higher EnergyStar® power draw specifications for SST (see Table 5-11). SST represents the latest in cordless phone technology and the lower power draw levels may reflect design advances that could reduce power draw.

Table 5-11: Average Maintenance Mode Power Draw of EnergyStar® Compliant Cordless Telephones (EnergyStar® 2006)

	Standard [W]	w/ SST [W]	Overall Energy Star Average [W]
Cordless Phone	3.0	2.5	2.7
Cordless Phone/TAD	3.5	2.7	2.9

Table 5-12 presents the average power draw of cordless telephones by operating mode for standard cordless phones and those with integral TADs. The estimates are taken from prior research as well as limited current measurements by manufacturers. The four largest cordless phone manufacturers provided maintenance mode and handset removed mode power draw data for 11 and six best-selling (for 2006) cordless phones and cordless phones/TADs, respectively (see Appendix D for a summary of the power draw measurements). We calculated the overall mean using the average power draw values for the units of each manufacturer. Subsequently, we estimated the mean for the entire installed base by assuming that the 2006 models represented half of the installed base and that the values reported in McAllister and Farrell (2004) and Rosen et al. (2001)[17] represented the other half of the installed base for stand-alone phones and units with integral TADs, respectively. The lower of the two averaged values given in Table 5-12 represent the measurements of 2006 models. The active mode and charging mode power draw estimates come from previous research, but do not affect UEC as much because of the relatively low annual usage in these modes.

Table 5-12: Power Draw by Mode of Cordless Phones

Device Type	% Installed Base	Active [W]	Handset Removed [W]	Maintenance [W]	Charging [W]	Comments and Sources
Cordless Telephones	68%	3.1	2.3 = 0.5*(2.1+2.4)	3.1= 0.5*(2.8+3.4)	4.0	Active and Charging from Rosen et al. (2001)
Cordless Telephones w/ Answering Machines	32%	3.9	2.8 = 0.5*(2.4+3.1)	3.8 = 0.5*(3.1+4.4)	4.4	
Weighted Average	100%	3.4	2.4	3.3	4.1	

The combination of the sheer range of units in the installed base and their features that affect power draw, and limited measurement data, the current power draw suggests that the estimates have appreciable uncertainty. Upon comparison to the EnergyStar® product averages, however, e.g., taking them as lower limits on the average values for the entire installed base, the estimated power draw levels appear reasonable.

[17] Both have limitations. McAllister and Farrell (2004) reports values for 11 units in households, but did not differentiate between units with and without integral TAD. Rosen et al. (2001) does present separate power draw values for stand-alone units and those with integral TAD. Their data are, however, older and, based on sales data since 2000, are for units that almost certainly represent only a small portion of the current installed base.

Table 5-13 presents the average power draw, usage, and UEC by usage mode. The average UEC was calculated to be 26 kWh/yr for cordless telephones and 31 kWh/yr for cordless phones with integrated TADs.

Table 5-13: Unit Energy Consumption of Cordless Phones

		Active	Handset Removed	Maintenance	Charging	Total
Power Draw [W]	w/o TAD	3.1	2.3	3.1	4	
	w/ TAD	3.9	2.8	3.8	4.4	
Usage [hrs/yr]		350	2,015	5,695	700	
UEC [kWh/yr]	w/o TAD	1.1	4.5	18	2.8	26
	w/ TAD	1.4	5.5	21	3.1	31

5.4.2. National Energy Consumption

Based on the current estimated installed base, the annual energy consumption of all cordless phones was calculated to be 5 TWh per (see Table 5-14).

Table 5-14: AEC Summary for Cordless Telephones

Device Type	UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
Cordless Telephones	26	122	3.2
Cordless Telephones with Answering Machines	31	57	1.8
TOTAL	28	179	5.0

5.4.3. Prior Estimates

Tables 5-15 and 5-16 compare the current estimates of cordless phone energy consumption with prior estimates for both stand-alone and combination units.

Table 5-15: Prior Energy Consumption Estimates for Stand-Alone Cordless Phones

Source		Current Estimate	Rosen et al. (2001)	McAllister and Farrell (2004)*	CCAP (2005)	EIA (2001)*	Nordman and McMahon (2004)
Estimate Year		2006	2000		2005	2001	
Installed Base [millions]		122	87.0		212	82	
Power Draw [W]	Active	3.1	3.1				
	Handset Removed	2.3	2.3	2.4		2.9	
	Maintenance	3.1	3.4	3.4	3	3.9	3
	Charging	4	3.4	4			
Annual Usage [hours]	Active	350	350	0		0	
	Handset Removed	2,015	2,015	876**		1,489	
	Maintenance	5,694	5,694	7,008**		7,271	
	Charging	701	701	876**		0	
UEC [kWh/year]		26	28	29	45	26	
AEC [TWh/year]		3.2	2.4		7.2	2.1	

*McAllister and Farrell (2004) and EIA (2001) only present data for cordless phones, i.e., they do not distinguish between stand-alone cordless phones and those with integral TADs.
**Usage estimated from plots provided in reference.

Table 5-16: Prior Energy Consumption Estimates for Cordless Phones with Integrated TADs

Source		Current Estimate	Rosen et al. (2001)	CCAP (2005)
Estimate Year		2005	2000	2005
Installed Base [millions]		57	35	76.9
Power Draw [W]	**Active**	3.9	3.9	6.1
	Handset Removed	2.8	3.1	5.2
	Maintenance	3.8	4.4	
	Charging	4.4	4.4	
Annual Usage [hours]	**Active**	350	350	5,694
	Handset Removed	2,015	2,015	3,066
	Maintenance	5,694	5,694	
	Charging	701	701	
UEC [kWh/year]		31	35.7	50.7
AEC [TWh/year]		1.8	1.3	3.9

Relative to Rosen et al. (2001) and EIA (2001), the current study indicates that the residential installed base of cordless phones has increased by at least 40% for stand-alone cordless phones and 60% for cordless phones with integral TAD. This is not surprising, given the dramatic increase in cordless phone unit sales over this period, particularly for units with integral TAD (see Figure 5-24 in Section 5.10). On the other hand, CCAP (2005) estimates a higher installed base than the current estimate. The current estimate comes from CEA Survey data and is approximately equal to the sum of stand-alone and integral TAD cordless telephone unit sales for the past three and five years, respectively (CEA 2005a). We assume that the survey result yields a more accurate estimate than an installed base estimate based on sales data coupled with a lifetime assumption, e.g., the approach that appears to have been used to develop the CCAP (2005) estimates. In addition, the CCAP (2005) estimates also include cordless phones used in the commercial sector, which are not considered in the current analysis of residential CE energy consumption.

In general, current and prior power draw estimates by mode agree relatively well.

5.4.4. References

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5.5. DVD Players

5.5.1. Current Energy Consumption

This section describes the number of DVD players, typical usage patterns, and average power draw estimates in an effort to calculate the energy consumption of DVD players in the U.S. in 2006.

5.5.1.1. Installed Base

The DVD player analysis includes all stand-alone DVD players and recorders, as well as DVD/VCR combination units. Portable DVD players, and DVD players integrated with home computers, televisions, or HTIB are excluded from this study. Survey participants may have included DVD players outside the category boundaries, and therefore sales data was used to estimate the installed base.

Sales data from 1999 to present indicate that there are 120 million DVD players installed in households. According to the current survey data, 74% of U.S. households owned at least one DVD player, and therefore households with DVD players owned an average of 1.4 units based on 115 million households (see Table 5-17). CEA sales data indicate that approximately 10 million installed DVD players have recording capability. Additionally, approximately 35 million of the installed DVD players are DVD/VCR combination units.

Table 5-17: DVD Player Installed Base

Type	Installed Base [millions]	Penetration [% HH]	Comments and Sources
Stand-alone	75	N/A	Installed base from sales data (CEA 2006)
Stand-alone + Record	10	N/A	
DVD + VCR	35	N/A	
TOTAL	120	74%	Penetration from CEA Survey

5.5.1.2. Unit Energy Consumption

Home video products can be characterized by three operating modes as described by Rosen and Meier (1999):

- *Active* – Device is playing (or recording)
- *Idle* – The system is on but no motor functions are being performed
- *Off* – The power has been switch off by the user, but the system remains plugged in.

A separate "record" mode could be added for DVD players capable of recording to a disk or internal hard drive. However, according to current CEA measurements, the average recording power draw was only 1 W higher (5%) than the average active mode power draw of devices capable of recording, and therefore the record mode was lumped together with the active mode.

As part of this project, CEA measured the active mode and off mode power draw of about 35 DVD players that were identified by major manufacturers as better-selling models. Appendix C explains the measurement procedure used. The majority of current power draw measurements made by CEA are primarily for devices manufactured in 2006 (two devices are from 2005). Using only measurements from these units would underestimate the overall average power draw since most older DVD players manufactured from 1999 through 2004 are still in households and tend to have higher power requirements. In addition, DVD/VCR combination units are not included in the current measurements, and limited prior measurements by Nordman and McMahon (2004) suggest that they draw more power than standard DVD players. An analysis of the measured devices is presented below, along with an adjusted overall average power draw estimate to account for older devices in the installed base, as well as combination units.

Figure 5-8 plots the off mode power distribution for the measured units with and without recording capability. The median off mode power draw for measured units without recording capability was approximately 0.7 W, and the mean off power draw was 1.1 W. The measured DVD players with recording capability drew an average of 2 W in off mode.

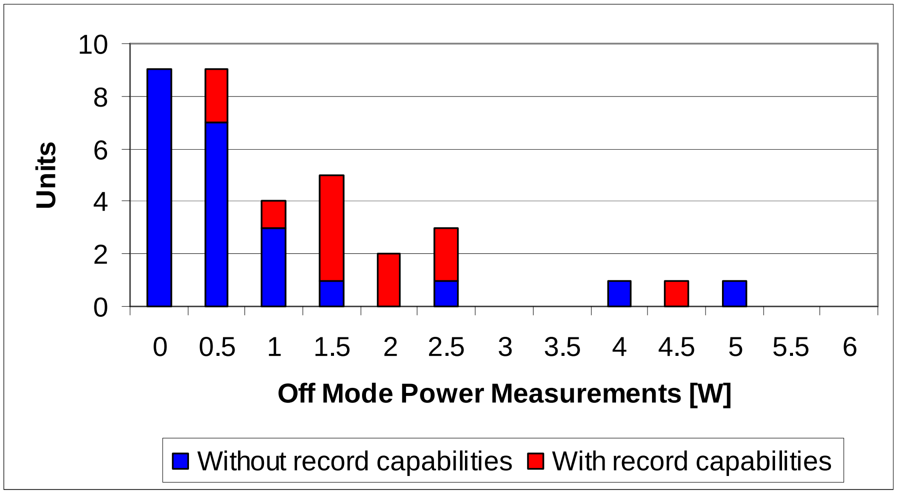

Figure 5-8: Distribution of Off Mode Power Draw Measurements of DVD Players

As stated above, the overall average power draw of installed DVD players needs to include older devices and combination units, which typically draw more power than newer and standard devices. To calculate an overall average, we considered the EnergyStar® annual market share data (from EPA 2006), as the EnergyStar® program uses a maximum off mode power draw criterion for DVD players[18]. To estimate the average power draw values for EnergyStar® and non-EnergyStar® units, we took into account the criteria levels for each year, power draw data in the EnergyStar® product databases, and measurements from Rosen and Meier (1999) and CEA (for recent units). Tables 5-18 and 5-19 show the annual estimated average power draw for stand-alone DVD players and combination units, respectively, based on EnergyStar® sales penetration data (EPA 2006).

[18] DVD products launched after 1 January 2003 must draw <=1W standby for EnergyStar®, while products launched before 1 January 2003 that drew <=3W may continue as EnergyStar® products while they remain on the market.

Table 5-18: Average Annual Off Mode Power Draw for Stand-Alone DVD Players

	1999	2000	2001	2002	2003	2004	2005	2006
% EnergyStar®	34%	47%	59%	71%	72%	52%	32%	40%
DVD Units, EnergyStar® [millions]	1	3	8	9	9	5	4	5
DVD Units, All [millions]	4	7	13	13	13	10	12	12
Estimated EnergyStar® Off Mode Power Draw Level [W]	3	3	3	3	1	1	1	1
Estimated Off Mode Average Power Draw, EnergyStar® Units	2	2	2	2	1.5	1	0.6*	0.5**
Estimated Off Mode Average Power Draw, non-EnergyStar® Units***	4***	4	4	4	4	3	2.5	2.5**
Annual Off Mode Average [W]	3.3	3.1	2.8	2.6	2.2	2.0	1.9	1.7

* Average value from EnergyStar® product list
** Average value from CEA measurements
***Approximated based on Rosen and Meier (1999) and CEA measurements

Table 5-19: Average Annual Off Mode Power Draw for DVD/VCR Combination Devices

	1999	2000	2001	2002	2003	2004	2005	2006
EnergyStar® Market Share [%]				18%	18%	18%	0%	0%
DVD/ VCR Combo Units, EnergyStar® [millions]	0	0	0	0	1	2	0	0
DVD/VCR Combo Units, All [millions]	0	0	0	0	6	10	10	10
EnergyStar® Off Mode Power Draw Level [W]	4	4	4	4	4	4	1	1
Estimated Off Mode Average Power Draw Level, EnergyStar® Units [W]	-	-	-	-	2	2	1.5	1.5
Estimated Off Mode Avg. Power Draw Level, non-EnergyStar® Units [W]	-	-	-	-	5	5	4.5	4.5
Estimated Annual Off Mode Power Draw Average [W]	-	-	-	-	4.5	4.5	4.5	4.5

These data yield a weighted average off mode power draw of 2.3 Watts for standard DVD players and 4.5 Watts for combination units.

Figure 5-9 plots the active mode power distribution for the units measured by CEA. The measured DVD recorders drew an average of 20 W in active mode, compared to an average 10W by standard DVD players.

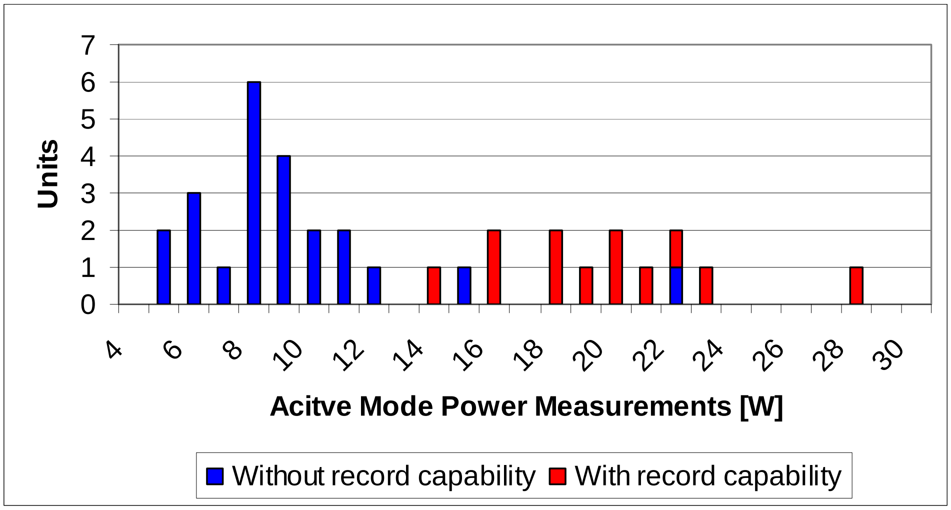

Figure 5-9: Distribution of Active Mode Power Draw of DVD Players Using 1 W Increments

Unfortunately, there was a dearth of data for the active mode between the 2006 CEA measurements and the late 1990s measurements reported in Rosen and Meier (1999). To capture the overall average active mode power draw, we assumed that active mode power draw varied linearly over the time period between those two studies, i.e., values for the period 1999 and 2005 represent a linear interpolation between those two sources. In addition, we found only one measurement of combination unit power draw, i.e., one unit of indeterminate vintage that drew 16W (Nordman and McMahon 2004). Consequently, we developed a rough estimate for the active mode power draw of combination units based on active mode power draw values for VCRs and DVD players. On the other hand, the uncertainty associated with this estimate will not significantly impact the overall energy consumption calculation because active mode accounts for only a small portion of annual usage and UEC (see below). Table 5-20 summarizes the active mode power draw estimates.

Table 5-20: Active Mode Power Draw Estimates for DVD products

	1999	2000	2001	2002	2003	2004	2005	2006	Weighted Avg.
DVD Player Active Mode [W]	17	16	15	14	13	12	11	10	13
DVD/VCR Combo Active Mode [W]	-	-	-	-	18	16	14	12	15

Very few measurements were available for idle mode power draw. Measurements of idle mode power draw for four DVD players indicate that idle mode power draw is approximately 75% of active mode draw (Nordman and McMahon 2004). This ratio was used to estimate idle mode power draw in this analysis for all years of products.

Usage estimates by mode come from the CEA Survey. The average DVD player was used for 270 hours per year, or about 5 hours per week. Since a demographically representative sample of households was surveyed, the usage estimate represents a weighted average of DVD players and DVD recorders. On one hand, it is likely that DVD recorders spend more time in active and idle modes than DVD players due to the extra functionality. On the other, the relatively small installed base of DVD recorders limits the impact of using a weighted average for usage on the total AEC estimate. The CEA Survey did not collect specific usage data for combination units, and, therefore, we approximated the active usage for combination devices by summing the usage of the average DVD player and VCR, or approximately 420 hours per year.

Table 5-21 shows the energy consumption by mode for DVD players. Only 12% of the energy consumption of the average DVD player comes from the active use of the device, while 27% of the energy is consumed in idle mode, i.e., when the devices remain on when not used. The remaining 61% of energy is consumed when DVD players are off.

Table 5-21: UEC for DVD Players

		DVD Player Usage Mode				
		Active	Idle	Off	Total	Comments and Sources
Power Draw [W]	Stand-alone	13	10	2.3		Idle mode power draw estimated based on Nordman and McMahon (2004)
	Stand-alone w/ record	20	15	2		
	DVD/VCR	15	11	4.5		
Usage [hr/yr]	Stand-alone	270	900	7,590	8,760	Based on CEA Survey
	Stand-alone w/ record	270	900	7,590	8,760	
	DVD/VCR	420	900	7,440	8,760	
UEC [kWh/yr]	Stand-alone	3.5	8.8	17.5	30	
	Stand-alone w/ record	5.4	14	15	34	
	DVD/VCR	6.3	10.1	33.5	50	
	Weighted Average	4.5	9.6	22	36	

5.5.1.3. National Energy Consumption

Table 5-22 summarizes the total annual energy consumption of DVD players, DVD recorders, and DVD/VCR combination units based on the UEC and the installed base for each product type.

Table 5-22: AEC Summary for DVD Players

DVD Type	UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
Stand-alone	30	75	2.3
Stand-alone w/ record	34	10	0.3
DVD/VCR combo	50	35	1.8
TOTAL	36	120	4.4

5.5.2. Prior Energy Consumption Estimates

DVD player sales only became significant in the late 1990s, hence there are few prior estimates of energy consumption (see Table 5-23).

Table 5-23: Prior DVD Player Energy Consumption Estimates

Source		Current	Rosen and Meier (1999)	CCAP (2005)	Nordman and McMahon (2004)
Year of Estimate		2006	1998	2006	2003
Installed Base [millions]		120	3	133	
Power Draw [W]	**Active**	15	17	16	16
	Idle	11	15	14	12
	Off	2.9	4.1	2.7	1.6
Annual Usage [hours]	**Active**	270	350	351	
	Idle	900	2,102	841	
	Off	7,590	6,307	7,568	
UEC [kWh/year]		37	64	38	
AEC [TWh/year]		4.4	0.2	5.0	

The current calculations yield similar UEC and AEC estimates to those made by CCAP (2005) for 2006. The average off mode power draw from Nordman and McMahon is lower than the current estimate, but suffers from a small sample size and does not include DVD/VCR combination units. The power draw estimates given by Rosen and Meier (1999) are understandably higher since older DVD products typically require more power.

Figure 5-10 through Figure 5-12 show trends in home video power draw by plotting past measurements of VCRs and current measurements for DVD players. Though not a true "apples to apples" comparison, the apparent power draw trends are of interest considering that sales of DVD players have largely replaced sales of VCRs.

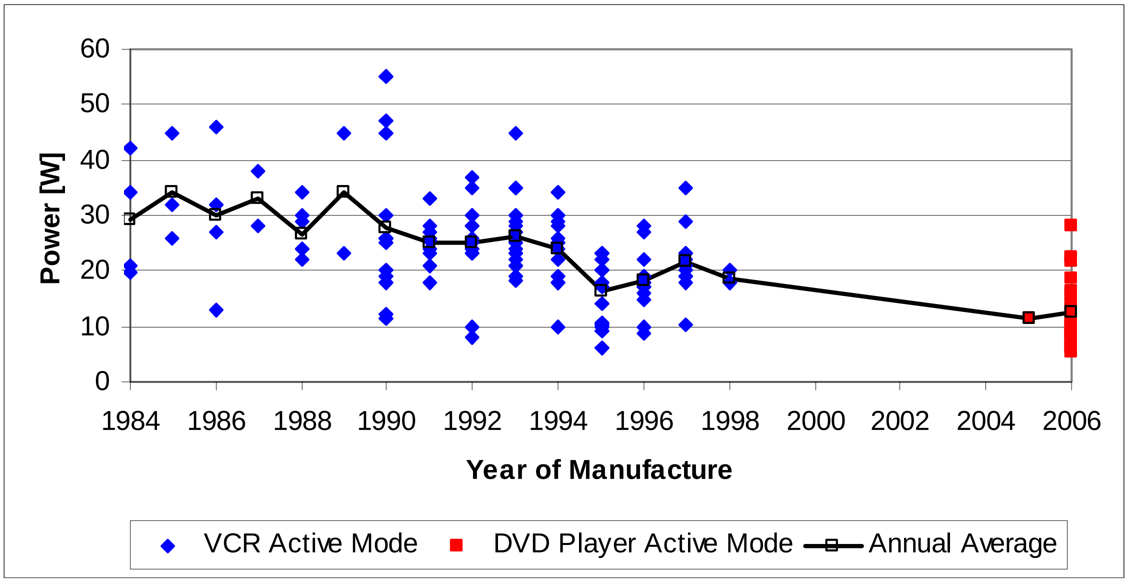

Figure 5-10: Active Mode Power Draw Measurements of Home Video Products by Year of Manufacture

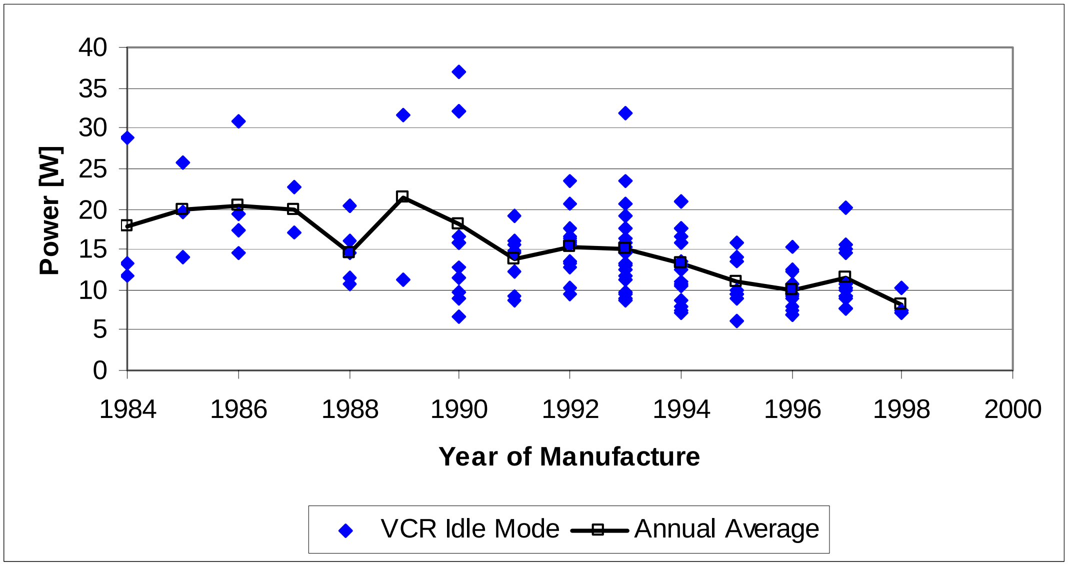

Figure 5-11: Idle Mode Power Draw Measurements of VCRs by Year of Manufacture (from Rosen and Meier 1999)

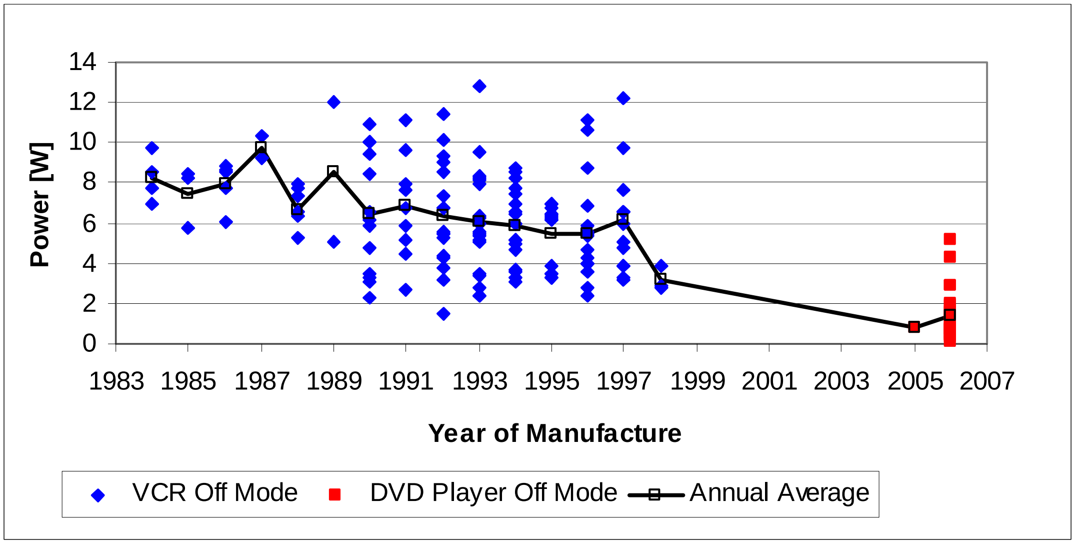

Figure 5-12: Off Mode Power Draw Measurements of Home Video Products by Year of Manufacture

While some yearly averages are skewed by small sample sizes, the general power draw trends are clear. Gradual improvements have decreased the power draw of VCRs over time in each mode, and similar trends are likely valid for DVD players since they became a mainstream product circa 1999.

Most notably, manufacturers have produced and sold large quantities of products that meet the EnergyStar® off mode power draw level. Figure 5-13 shows the unit sales penetration of EnergyStar® rated DVD players. The EnergyStar® criteria for stand-alone DVD players changed from 3 Watts to 1 Watt in January, 2003, which appears to have reduces the portion of stand-alone products that met the requirement. The sale of DVD/VCR combination units became significant in 2002, although few units met the EnergyStar® criteria of 4 Watts in off mode. In July, 2005 the requirement dropped to 1 Watt, and very few units met that standard.

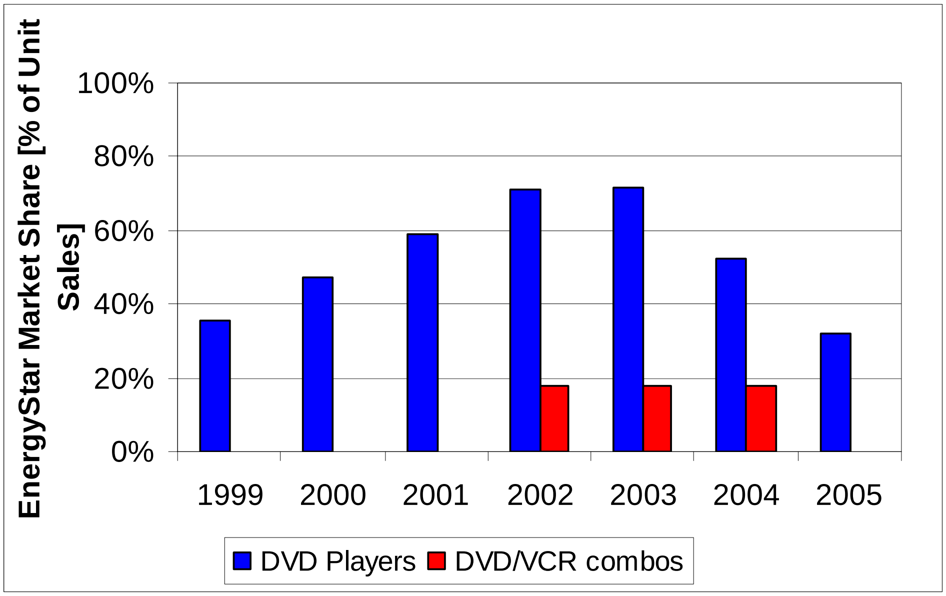

Figure 5-13: DVD Player EnergyStar® Market Share Data[19] (EPA 2006)

The idle mode usage in the current estimate is significantly lower than the estimate used by Rosen and Meier (1999). They made a rough estimate that home video devices spend 25% of the time they are not in active mode in idle mode because owners neglect to turn them off. Subsequently, a survey of about 300 people in the UK inquired if "when you get home tonight is your VCR off or on," and 60% of respondents responded affirmatively, suggesting that the idle time may be as high as 60% of the time not in active mode (Harrison 2006). The CEA Survey does not support these estimates, but indicates that devices spend about 11% of time not in active mode in idle mode. One concern about the current estimate is that survey participants may not be able to accurately estimate idle usage of home video products in their homes. Nonetheless, barring metered data from a statistically significant and representative sample of households, occupant responses are superior to rough estimates based on researchers' experience.

5.5.3. References

CCAP, 2005, "CCAP-ELECTRONICS.XLS," Climate Change Action Plan Spreadsheet, EnergyStar® Program, April.

CEA, 2006, Personal Communication, J. Bates, Director of Research, Consumer Electronics Association, October.

[19] Data were not available for the 2002 and 2003 EnergyStar® market share combination units. We assumed that they had the same market share as in 2004.

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5.6. Home Theater in a Box (HTIB)

5.6.1. Current Energy Consumption

A home theater in a box (HTIB) is a group of devices that are all packaged together including: an A/V receiver with or without an integrated DVD player, two or more speakers, a subwoofer, and generally an integrated radio tuner (see Figure 5-14). When connected with a television larger than 27 inches, the combined system is called a home theater system. This analysis includes all HTIB, but does not include all home theater systems, since home theater systems could be made up of individually purchased audio and video components.

Figure 5-14: Example of a Home Theater in a Box (HTIB) System (Source: JVC)

5.6.1.1. Installed Base

According to CEA sales data including year to date data for 2006, there is an estimated 25 million HTIB in the U.S (CEA 2006, CEA 2005), as shown in Table 5-24. Approximately 17%

of households own at least one HTIB system, and these households own an average of 1.3 systems.

Table 5-24: 2006 HTIB Installed Base

Installed Base [millions]	Penetration	Comments and Sources
25	17%	CEA sales data

The CEA Survey indicates that there are 35 million HTIB in the U.S. This estimate is higher than what sales data support, and we theorize that survey participants were not clear about the definition of a HTIB, and counted A/V equipment sold as individual components as HTIB. Since HTIB only came to market in sizeable numbers around 2000, we estimate that few HTIB have been retired and the sum of the unit sales should closely approximate the installed base.

5.6.1.2. Unit Energy Consumption

HTIB systems can be characterized by three operating modes as follows:

- *Active* – Audio and/or video is being played or recorded through the HTIB system
- *Idle* – The system is on, but no audio or video function is being performed
- *Off* – The power has been turned off, but the system remains plugged in

Active mode could be subdivided into multiple modes depending on whether a DVD is playing, the radio is playing, or the sound from the television is playing through the HTIB. In addition, active mode power draw can vary depending on the content being played or recorded. Further refinement of the active mode does not, however, significantly affect the energy consumption of component stereo systems (Rosen and Meier 1999) and HTIB power draw measurements provided by CEA do not suggest a large difference in power draw for units with and without a DVD player.

The active mode power draw estimates come from measurement data collected by the CEA of HTIB identified by major HTIB manufacturers as their best-selling units. One system had two speakers, while the rest contained six, and nine of the 13 systems had an integral DVD player. None of the units measured had a separate external power supply to power the subwoofer. Approximately half of the systems had a known manufacturing date of 2005 or 2006, and we assumed that the others were of similar vintage since all systems were acquired new. Figure 5-15 shows the distribution of the active power required by the measured units; all measurements were made while a DVD played[20].

[20] The nine systems with integral DVD players had an average active mode power draw of 38 W, while the units without a DVD player averaged 40 W.

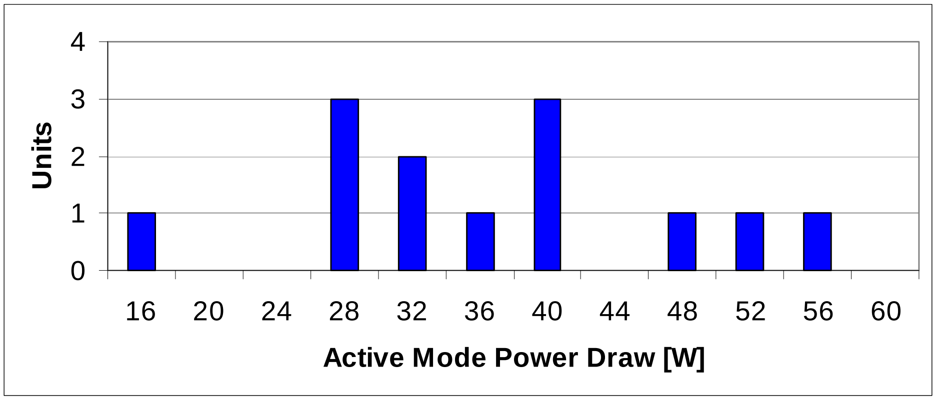

Figure 5-15: Distribution of Active Mode Power Draw of HTIB (4 W increments)

As with many audio systems, HTIB have a relatively wide range of active power draw values due to the wide variety of functions and speaker capabilities. Assuming that the sample is representative of the installed base, the overall average active power draw equals 38 Watts. Listening volume also affects the active mode power draw but a prior study suggests that, within a reasonable listen volume range, the volume setting has limited impact on active power draw (Rosen and Meier 1999).

All but one of the measured HTIB drew less than 1 Watt in off mode, and 70% of the measured systems drew less than 0.5 Watts. The overall sample mean equaled 0.6 Watts (see Figure 5-16).

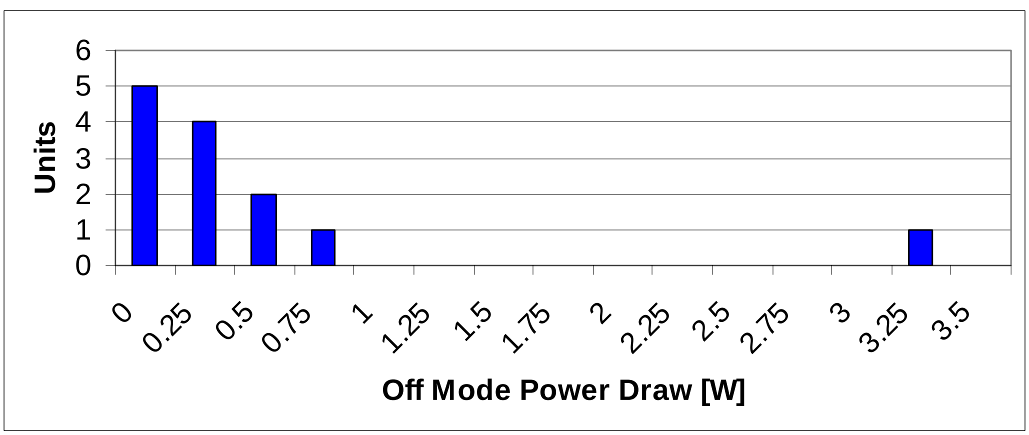

Figure 5-16: Distribution of Off Mode Power Draw of HTIB (0.25 W increments)

Rosen and Meier (1999) reported that the idle mode power draw for a "receiver based component stereo system", which includes a CD player component, was approximately 4 Watts less than the active mode power draw[21]. We used the same offset in power draw for HTIB since idle mode power draws were not measured.

The CEA Survey suggests that HTIB spend 4.3 hours per day in active mode, or 1,580 hours per year. Respondents estimated that 56% of the active usage results from playing television sound through an HTIB[22]. This estimate was taken from a second survey in which participants were asked specifically to also recall how much time they listened to television audio through their HTIB (in addition to listening to music)[23]. Comparing the first and second survey results, it appears that some survey respondents failed to include this "TV time" in the first survey.

In addition, the survey results indicate that HTIB systems spend two more hours per day "turned on" than they spend "in active use". The term "turned on" refers to the sum of the time the audio system is in active mode and idle mode. Therefore, the idle mode usage equals two hours per day, or 730 hours per year. There is likely significant uncertainty associated with this estimate since many participants likely have a difficult time accurately estimating idle time, even if they do understand the terminology. They simply may not be aware of when their devices are in idle mode.

Table 5-25 shows the unit energy consumption by operating mode for HTIB. Active mode usage accounts for 68% of the energy consumption and idle mode accounts for an additional 28%. Off mode energy consumption only accounts for 4% of the UEC, even thought HTIB spend nearly 75% of the time in this mode.

Table 5-25: UEC Calculations for HTIB Systems

	Mode				
	Active	**Idle**	**Off**	**Total**	**Comments and Sources**
Power [W]	38	34	0.6		• Active and off mode from current measurements • Idle mode 4 W less than active mode (Rosen and Meier 1999)
Usage [hr/yr]	1580	730	6450	8760	CEA Survey data
UEC [kWh/yr]	60	25	4	89	

[21] We considered using a percentage increase, but the measurements in Rosen and Meier (1999) indicate that an offset more accurately models the power draw difference.
[22] This information came from a 2nd, more targeted survey (subsequently discussed in this paragraph).
[23] Rosen and Meier (1999) concluded that TV viewing increased audio active mode usage significantly.

5.6.1.3. National Energy Consumption

Based on an installed base of 25 million units, we estimate that HTIB consume 2.2 TWh (see Table 5-26).

Table 5-26: 2006 AEC Summary for HTIB

Year	UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
2006	89	25	2.2

5.6.2. Prior Energy Consumption Estimates

We could not find any prior estimates of HTIB energy consumption. Table 5-27 compares the current HTIB analysis with prior analyses of component audio systems, which may include separate component receivers, CD players, tape players, radio tuners, and speakers. The components may or may not be from the same manufacturer.

Table 5-27: Prior Energy Consumption Estimates for HTIB

Source		Current	Rosen et al. (1999)*	EIA (2001)*	Nordman and McMahon (2004)**
Year of Estimate		2006	1998	2001	2003
Installed Base [millions]		25	74	36	
Power Draw [W]	**Active**	38	47		28
	Idle	34	43		27
	Off	0.6	3		2.3
Annual Usage [hours]	**Active**	1,580	1,664		
	Idle	730	1,402		
	Off	6,450	5,694		
UEC [kWh/year]		89	156	55	
AEC [TWh/year]		2.2	12	2	

*Estimate is for all component audio systems
**Measurements of audio receivers

The current installed base can not be compared with prior estimates for component stereo systems. HTIB are a relatively new product category (i.e. significant unit sales since around

2000), and the HTIB installed base excludes component stereo systems that don't fit the HTIB definition. HTIB sales have grown briskly over the last 5 years (CEA 2006) and are likely replacing some older component stereo systems.

The usage estimates for HTIB and component stereos can, however, be compared directly. The current active mode estimate agrees fairly well with that of Rosen and Meier. Both estimates take into account the time that TV sound plays through the audio system. On the other hand, the idle usage estimates differ substantially. Rosen and Meier assumed that component stereos spend 20% of the time not in active mode in idle mode, based on a brief (30 participant) survey of LBNL employees. The current estimate of idle mode usage is based on a much larger and statistically representative survey, an improvement over the LBNL source, but still may have significant uncertainty. As discussed earlier, survey respondents might not accurately recall the time that HTIB spend in idle mode because they probably do not pay much attention to the time that units spend in that mode. Nonetheless, barring metered data from a statistically significant and representative sample of households, occupant responses are superior to the brief survey conducted by Rosen and Meier.

The current active power draw of HTIB is similar to the average power draw of stand-alone component A/V receivers measured by Rosen and Meier (approximately 35 Watts). Figure 5-17 plots the active mode power requirements of stand alone A/V receivers measured by Rosen and Meier and HTIB measured for the current analysis in 2006.

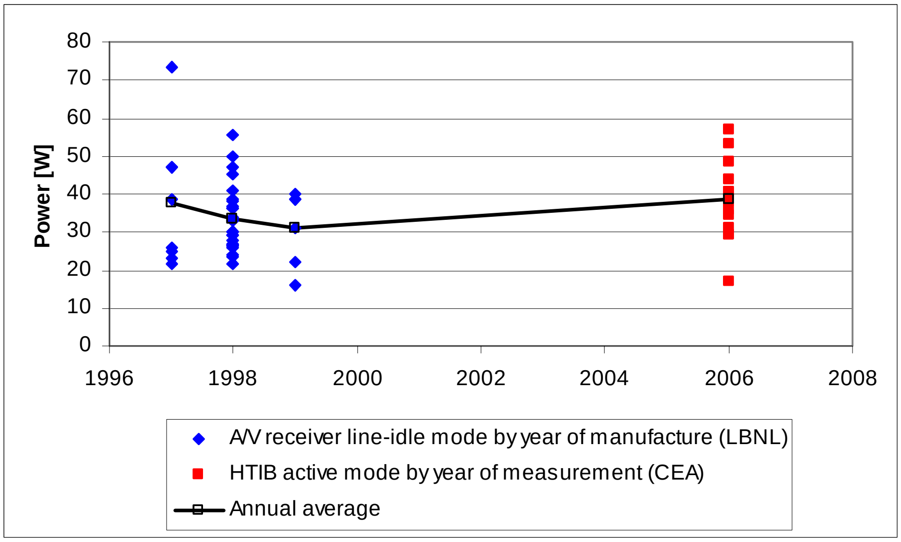

Figure 5-17: Active Mode Power Requirements of Older A/V Receivers and Recently Measured HTIB

The added power requirements of other stand-alone stereo components (i.e., CD player, tape player, and tuners) increased the average system power draw to the 47 Watts listed. Since HTIB integrate DVD/CD players and tuners into a single box, they likely reduce active mode power draw relative to component stereos.

The average off mode power draw estimate for HTIB is lower than prior estimates. Even when compared to stand alone A/V receivers measured by Rosen and Meier (see Figure 5-18), the current HTIB exhibit lower off mode power draw values. This trend may be do to the relatively the recent designs of HTIB systems (i.e. newer electronic components) that meet the current EnergyStar® Program specification of 1W or less for home audio products.

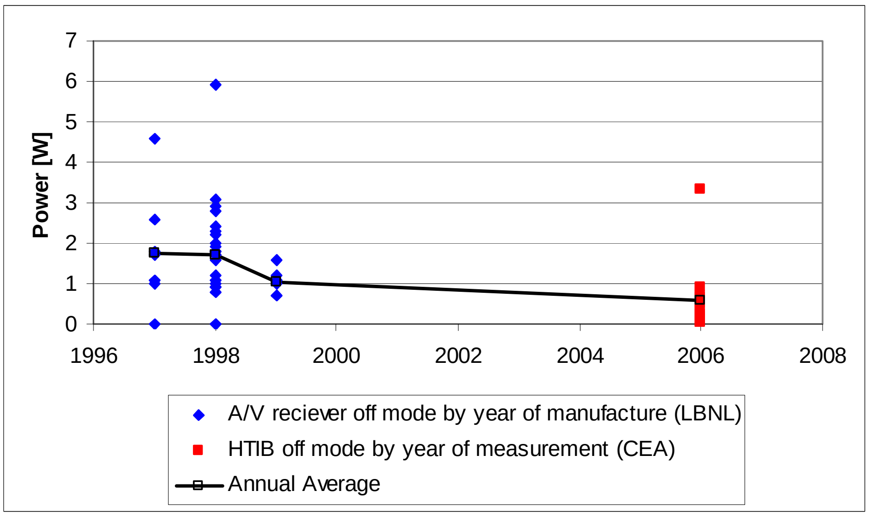

Figure 5-18: Off Mode Power Requirements of Older A/V Receivers and Recently Measured HTIB

5.6.3. References

CEA, 2005, "U.S. Consumer Electronics Sales and Forecasts 2000-2005," Consumer Electronics Association (CEA) Market Research, January.

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5.7. Monitors

5.7.1. Current Energy Consumption

5.7.1.1. Installed Base

The current analysis includes stand-alone computer monitors, i.e., those used with desktop PCs. Assuming that each desktop PC has one monitor, a total of 90 million desktop PCs (see Section 5.8) yields an estimate of 90 million monitors (see Table 5-28). Similarly, about 64% of U.S. households have at least one desktop PC and, hence, at least one monitor. Laptops can be used with docking stations and stand alone monitors, but it is assumed at this time that this will not significantly affect the estimated installed base.

Table 5-28: Installed Base of Monitors (based on TIAX 2006)

Installed Base [millions]	Penetration	Comments and Sources
90	64%	Assumes one monitor for every desktop PC; see Section 5.8

Based on installed base data from iSuppli (2005), we used three categories of monitors to characterize the residential installed base[24]. 17-inch (cathode ray tube) CRT monitors make up approximately 54% of the installed base, 17-inch liquid crystal display (LCD) monitors make up 28%, and 15-inch LCD screens make up the remaining 18%.

5.7.1.2. Unit Energy Consumption

Computer monitors can be characterized by three operating modes as follows:

- *Active* – Device is turned on and displaying an image
- *Sleep* – The reduced power state that the computer monitor enters after receiving instructions to do so (e.g., instructed by computer). The monitor returns to full operation capability upon sensing a request from a user (e.g., user moves the mouse or presses a key)
- *Off* – The monitor is plugged in but turned off. An image will not return unless the monitor is turned on using the power switch

Some monitors have two sleep modes, with one sleep mode typically being a lower power "deep" sleep. This analysis only considers the lower power sleep mode because we assume that most of the time spent in a sleep mode would occur during extended periods of sufficient duration for the monitor to enter – and spend much of the time in – the deep sleep mode.

[24] In practice, the installed base does contain smaller quantities of larger CRT- and LCD-based displays, as well as smaller (15-inch) CRTs.

We calculated the average power for monitors using a weighted average of the three key monitor categories used to represent the installed base (see the prior subsection). Table 5-29 presents the results by operating mode, assuming that monitor size does not correlate with usage[25].

Table 5-29: Power Draw of Monitors by Mode

Monitor Size	% Installed Base	Active	Sleep	Off
CRT – 17-inch	40%	61	2	1
LCD – 15-inch	15%	20	1	1
LCD – 17-inch	35%	31	1	1
LCD – 19-inch	10%	35	1	1
Average	100%	42	1	1

The average usage by mode for monitors comes from models developed by TIAX. The models use survey data to create monitor daily weekday and weekend usage patterns (see TIAX 2006 for details of the survey and the process for translating the survey results into usage patterns for individual monitors). In addition, the survey results suggest that monitors associated with PCs that have high-speed internet access spend slightly more time (~6%) in active mode than those associated with PCs with dial-up access[26]. As data indicate that high-speed internet access grew from approximately 50% in the 2005 TIAX Survey[27] to 56% in 2006 (J.D. Power 2006), we adjusted all usage values to reflect this increase.

Table 5-30 summarizes the power draw, usage, and UEC by usage mode. The average monitor consumes 91 kWh per year, 91% of which is consumed in the active mode. Monitors consume 2% and 7% of their UEC in sleep mode and off mode, respectively.

Table 5-30: Monitor Average Power Draw and Usage by Mode (based on TIAX 2006)

	Active [W]	Sleep [W]	Off [W]	Comments and Sources
Power Draw [W]	42	1	1	• Average values based on iSuppli (2005) sales data and projections: 40% 17-inch CRT, 15% 15-inch LCD, 35% 17-inch LCD, and 10% 19-inch LCD • EnergyStar (2006) and Roberson et al. (2002) for power draws
Usage [hrs/yr]	1,865	875	6,020	TIAX Survey "Day Off" usage pattern, adjusted to reflect higher penetration of high-speed internet access
UEC [kWh/yr]	78	1	5	

[25] For example, usage data for TVs indicate that larger TVs are more likely to be the primary TVs in homes and, as such, operate in active mode for more hours per day than smaller TVs (see Section 5.11.1.2).
[26] In contrast, PCs with broadband access spend approximately 25% more time in active mode; see Section 5.8.1.2.
[27] The 2005 J.D. Power & Associates survey estimated high-speed internet access penetration at 44% (J.D. Power 2006).

5.7.1.3. National Energy Consumption

Based on an installed base of 90 million units, monitors consume 7.6 TWh per year.

Table 5-31: AEC Summary for Monitors

UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
85	90	7.6

5.7.2. Prior Energy Consumption Estimates

In general, the current monitor UEC is similar to estimates from prior studies (see Table 5-32).

Table 5-32: Prior Estimates of Monitor Energy Consumption

		Current	TIAX (2006)	CCAP (2005)	Nordman and Meier (2004)	Kawamoto et al. (2001)
Year of Estimate		2006	2005	2005	2001	1999
Installed Base [millions]		90	89[28]		68	54.5
Power Draw [W]	**Active**	42	45	64	85	85
	Sleep	1	2	3.4	5	5
	Off	1	1	1.3	0.5	0.5
Annual Usage [hours]	**Active**	1,865	1,860	1,442	1,170	626
	Sleep	875	880	894	488	104
	Off	6,020	6,020	6,424	7,102	8,130
UEC [kWh/year]		85	101		105	57
AEC [TWh/year]		7.6	9		7.2	3.1

On the other hand, this masks two important differences. First, the current study estimates appreciably higher annual active mode usage than prior studies (29% greater than CCAP and 59% greater than Nordman and Meier). Because the current usage estimate reflects the findings of a demographically-representative survey, improved usage data appear to account for a large portion of the difference. On the other hand, some of the increase appears to represent a real increase in usage driven by higher residential penetration of broadband access. Specifically, TIAX (2006) found that broadband internet access increases active mode usage by approximately 25 percent. Given that approximately 56% of households with one or more PCs had broadband connectivity in 2006, this effect increased active mode usage by approximately 13 percent.

[28] 65 million CRTs and 24 million LCDs.

Second, the installed base of residential monitors is undergoing a major transition from cathode ray tube (CRT) displays to LCDs (see Figure 5-19). In the size range of monitors, LCDs typically draw significantly (approximately 50%) less power in active mode than CRT-based displays, so this transition tends to decrease monitor UEC. Indeed, the current study estimates that LCDs account for a majority of residential monitors, whereas CCAP (2005) and Nordman and Meier (2004) estimate 24% and 0% shares of the installed base for LCDs.

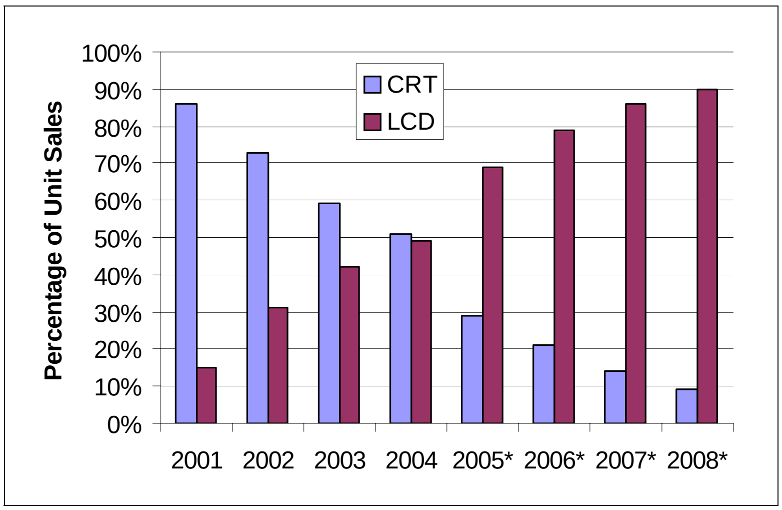

Figure 5-19: Historical and Projected* Monitor Sales, by Display Technology (from iSuppli 2005)

As the installed base of LCDs continues to grow at the expense of existing CRTs, monitor UEC will almost certainly continue to decrease, even as the screen size of the average LCD increases.

Figure 5-20 plots the active mode usage for 17-inch CRTs and 15- and 17-inch LCDs against the approximate year of manufacture[29]. Although the test procedures used for the three studies sites were not necessarily the same, the data indicate a downward trend for the active mode power draw of CRT monitors over time. Similarly, more limited data for LCDs (for the period 1998 through 2002) suggest that their active mode power draw has also decreased over time.

[29] All of the 2000 and earlier measurements come from Groot and Siderius (2000), which included year of manufacture for all units tested. The 2005 LCD measurements come from the EnergyStar(R) database as of late 2005 and likely include older LCDs. The 2001 measurements come from Roberson et al. (2002) and were assumed to be 2001; their precise year of manufacture is not known.

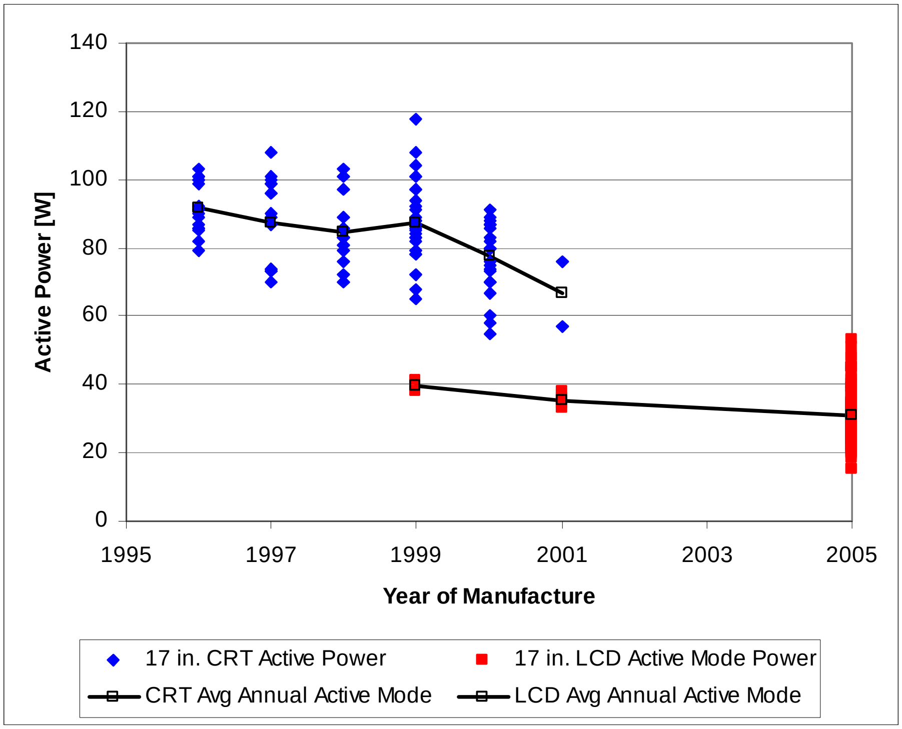

Figure 5-20: Monitor Active Mode Power Draw History (Roberson et al. 2002, Groot and Siderius 2000, EnergyStar® 2005)

Power measurements from monitors in sleep mode and off mode are shown in Figure 5-21 and Figure 5-22 respectively. Prior to the launch of the EnergyStar® program for monitors, most monitors did not have a sleep mode (Koomey et al. 1995).

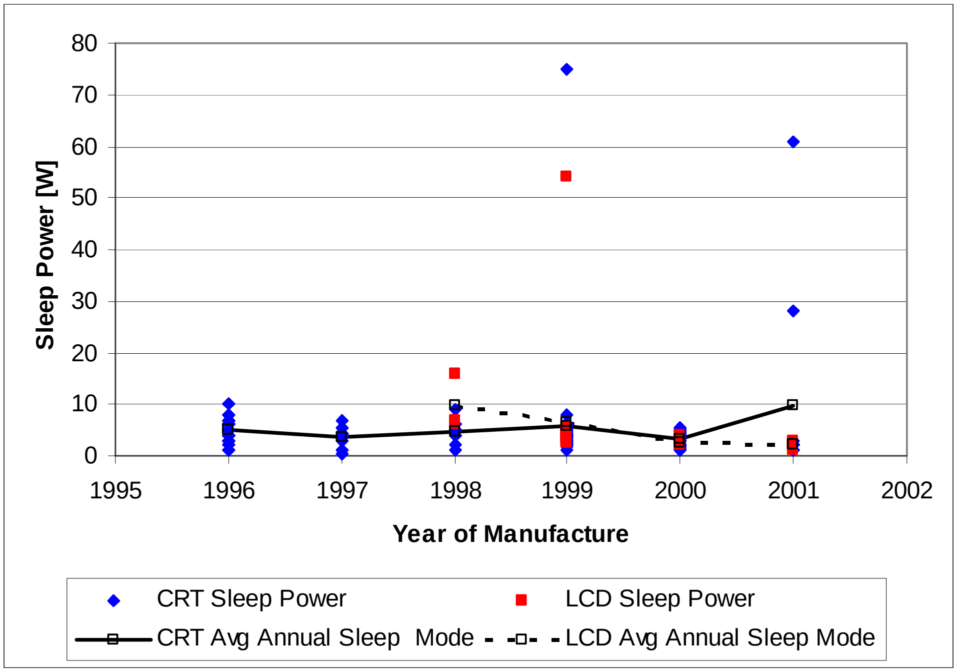

Figure 5-21: Monitor Sleep Mode Power Draw History

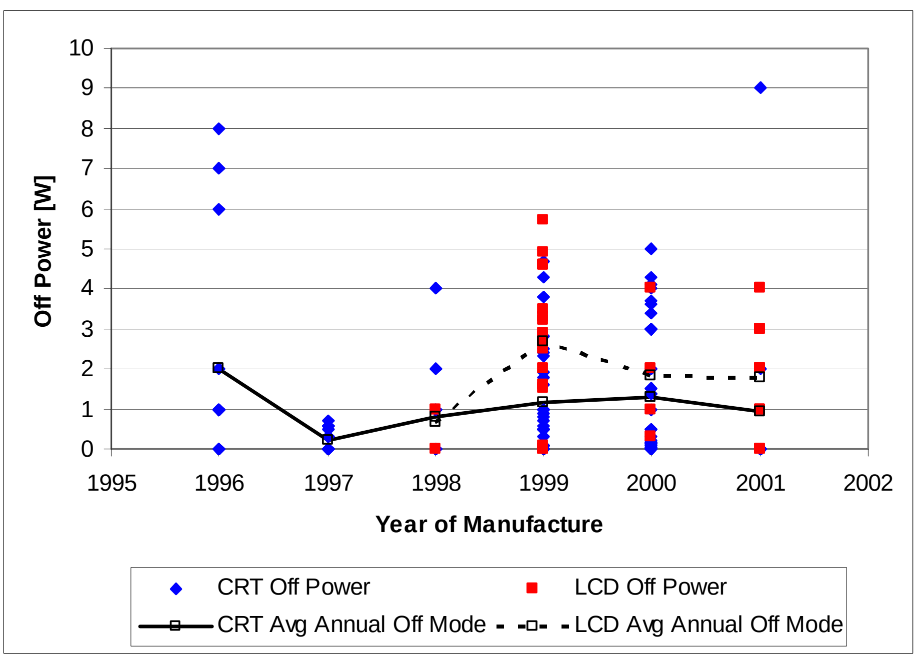

Figure 5-22: Monitor Off Mode Power Draw History

No clear trends for sleep and off mode power draw present themselves from these plots. Historically, the vast majority of monitors have met the voluntary power requirements set by the EnergyStar® program (as shown in Figure 5-23), which may be why no clear power trends are present during the relatively short time period plotted.

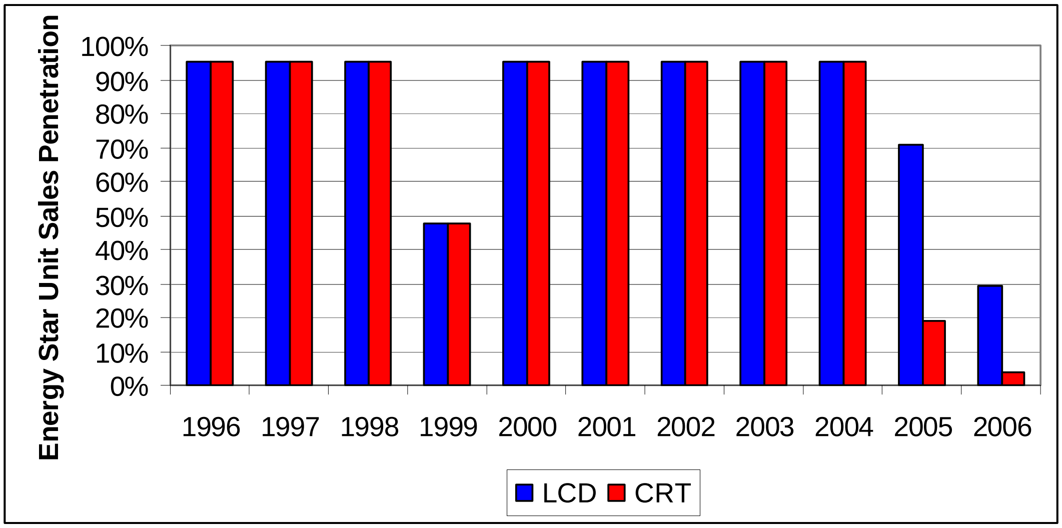

Figure 5-23: EnergyStar® Unit Sales Penetration Estimates and Projections for Monitors (CCAP 2004)

The dips in EnergyStar® sales penetration seen in 1999 and again in 2005 and 2006 mirror changes in the EnergyStar® program criteria (see Table 5-33).

Table 5-33: Energy Star Program Requirements History for Monitors

	1992	1995	1999	2005	2006
Active Mode	-	-	-	Max Power (W) = 38*<# *pixels*> + 30	< 1 Mpixel, max power (W) = 23 > 1 Mpixel, max power (W) = 28*<# *pixels*>
Sleep (idle)	30 W	30 W	15 W	4 W	2 W
Deep sleep	-	-	8 W	4 W	2 W
Off	-	-	-	2 W	1 W
Power Management Enabled when shipped	No	Yes	Yes	Yes	Yes

Power management (PM)-enabled rates also have a substantial impact on monitor UEC and AEC. A survey described in TIAX (2006) found monitor PM-enabled rates generally consistent with the 60% to 70% estimated in prior studies (Nordman and Meier 2004, Kawamoto et al.

2001). Although significantly higher than the PM-enabling rates for PCs, an appreciable energy savings potential remains for the sizeable minority of monitors that do not have PM enabled.

Starting in 2005, an active mode power requirement was implemented based on monitor resolution along with sleep and off mode requirements of less than 4 and 2 Watts respectively (EP, 2006). The requirements for each operating mode again tightened at the start of 2006. An EnergyStar®-qualified monitor with a typical resolution of 1.31 megapixels will have an active mode power draw of less than 80 W in 2005 and less than 37 W in 2006. (EPA 2006)

5.7.3. References

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5.8. Personal Computers

5.8.1. Current Energy Consumption

5.8.1.1. Installed Base

PCs, including both desktops and notebooks, account for the largest portion of residential IT energy consumption. The TIAX survey found that almost 70% of households had one or more PCs in March 2005 (TIAX 2006) and a survey conducted in the fourth quarter of 2005 found a penetration of 71% (Parks Associated 2006). Assuming that the number of PCs per household with at least one PC (about 1.6) did not change appreciably, U.S. homes have a total of 129 million PCs in use (see Table 5-34). Notebook PCs, also referred to as laptops, account for an increasing portion of total residential PCs. In fact, data indicate that notebook PCs had slightly higher retail[30] sales volume in 2005 (IDC 2006, Kanellos 2006).

Table 5-34: PC Installed Base

	Installed Base [millions]	Penetration[31]	Comments and Sources
Desktop	90	64%	TIAX (2006), EIA (2006), EIA (2001); see footnote
Laptop	39	25%	

Figure 5-24 depicts the distribution of the number of PCs in households for 2005.

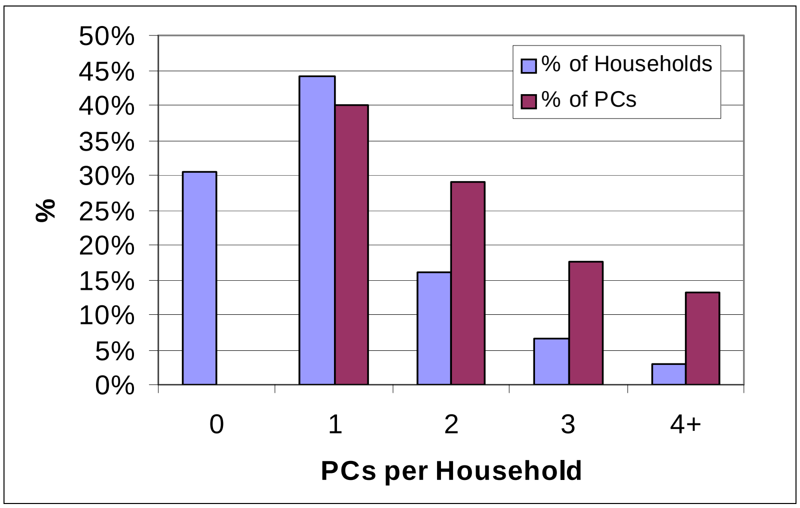

Figure 5-24: Distribution of Residential PCs (TIAX 2006)

[30] I.e., excluding direct sales and sales by resellers to corporations (Kanellos 2006).
[31] Approximate penetration estimates, based on the assumptions that: 1) the percentages of PCs with at least one desktop and one laptop PC both increased in proportion to the percentage of all households with any type of PC relative to the RECS (2001) data for the percentage of households with one or more desktop PCs, and 2) a 7:3 ratio of desktop to notebook PCs in the residential installed base [based on sales data and CEA 2005).

5.8.1.2. Unit Energy Consumption

PCs can be characterized by three operating modes as follows:

- *Active* – Device is being actively used (active-processing) or is not actively being used but remains on and has not entered sleep (active-idle)
- *Sleep* – Device is on and has entered a power saving mode
- *Off* [32] – Device is turned off but remains plugged in

Table 5-35 shows a summary of the average power draw, usage, and unit energy consumption by mode for desktop and laptop PCs. The active mode power draw values used are more typical for what the EnergyStar® program refers to as the active-idle mode, i.e., where the PC is on but is not actively being used and has not entered sleep mode. Prior studies suggest that the idle mode accounts for most active mode energy consumption by PCs (e.g., Herb et al. 2006).

Table 5-35: PC Unit Energy Consumption by Mode

		Active	Sleep	Off	Comments and Sources
Desktop	Power [W]	75	4	2	• Power draw values from EPA EnergyStar (2005b), Roberson et al. (2002) • Usage from TIAX (2006), based on TIAX Survey; adjusted for 2006 high-speed Internet access increase
	Usage [hr/yr]	2,954	350	5,456	
	UEC [kWh/yr]	224	1	11	
Notebook	Power [W]	25	2	2	
	Usage [hr/yr]	2,368	935	5,457	
	UEC [kWh/yr]	59	2	11	

We expect that the power draw values are relatively accurate and that the usage by mode estimates have greater uncertainty. Notably, the usage estimates were derived from responses to a phone survey about residential PC and monitor usage. Although almost certainly appreciably more accurate than prior estimates, the survey relied upon respondents' recollection of PC usage. In addition, obtaining meaningful information about PC power management enabling rates proved difficult (see TIAX 2006 for a more in-depth discussion of the survey).

In 2006, the penetration of high-speed internet access increased from approximately 50% in 2005 (TIAX 2006) to 56% (J.D. Power 2006). Because TIAX (2006) found that high-speed internet access increased PC active mode usage by about 25%, we adjusted the usage estimate to reflect the continued growth in high-speed access.

[32] Laptop PCs might spend an appreciable portion of the off mode time unplugged but we did not have data to accurately quantify the time an average residential laptop PC spends unplugged. During this period they would not draw power. The assumption that all of the off mode occurs while plugged in has a relatively small impact on laptop UEC, e.g., the assumption that laptops sped 50% and 100% of off mode time unplugged decreases device UEC by 4% and 8%, respectively (TIAX 2006).

Interestingly, the survey estimated that more than half of the time spent in active mode occurred when users were not actively using the PCs but when the PC remained on and did not enter a low-power mode.

5.8.1.3. National Energy Consumption

PCs consumed approximately 24 TWh of electricity in 2006 (see Table 5-36).

Table 5-36: AEC Summary for PCs

	UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
Desktop	237	90	21
Notebook	72	39	2.8

5.8.2. Prior Estimates

Relative to all prior studies except the primary source for the current estimate (TIAX 2006), the current study yields significantly higher estimates for residential PC unit and annual electricity consumption (see Table 5-37 and Table 5-38). This reflects continued growth in the installed base of both desktop and notebook PCs, an improved understanding of residential PC usage, and increased average power draw in active mode.

Table 5-37: Comparison of Current Desktop PC AEC Components with Prior Estimates

Source		Current	TIAX (2006)	CCAP (2005)	RECS (2001)	Nordman and Meier (2004)	Kawamoto et al. (2001)
Year of Estimate		2006	2005	2005	2001	2001	1999
Installed Base [millions]		90	85	108	66	68	54.5
Power Draw [W]	**Active**	75	75	58		50	50
	Sleep	4	4	NA		25	25
	Off	2	2	3		1.5	2
Annual Usage [hours]	**Active**	2,990	2,950	2,116		1,495	717
	Sleep	330	350	183		163	65
	Off	5,440	5,460	6,461		7,102	7,978
Power Management-enabled Rate		20%	20%	15%		20%	25%
UEC [kWh/year]		237	234	151	262*	90	49
AEC [TWh/year]		21	20	16	17.2*	6.1	2.7
*Includes monitors; based on ADL (1998)							

Table 5-38: Comparison of Current Notebook PC AEC Components with Prior Estimates

Source		Current	TIAX (2006)	RECS (2001)	Nordman and Meier (2004)	Kawamoto et al. (2001)
Year of Estimate		2006	2005	2001	2001	1999
Installed Base [millions]		39	36	16.6	17.3	16
Power Draw [W]	**Active**	25	25		15	15
	Sleep	2	2		3	3
	Off	2	2		0[33]	2
Annual Usage [hours]	**Active**	2,368	2,368		1,007	521
	Sleep	935	935		651	261
	Off	5,457	5,457		7,102	7,978
Power Management-enabled Rate		40%	40%			100%
UEC [kWh/year]		72	72	77		9
AEC [TWh/year]		2.8	2.6	1.3		0.14

The installed base of residential PCs has roughly doubled over the past decade, with notebook PCs growing faster than desktop PCs.

The TIAX (2006) study, the primary source for the current study, estimates that PCs spend significantly more time in active mode than prior studies. Most prior studies of residential IT energy consumption have used informed estimates for usage by mode (Nordman and Meier 2004, Kawamoto et al. 2001). One survey, the EIA Residential Energy Consumption Survey (RECS), asked respondents to estimate weekly PC usage and reported results in very broad time bands (e.g., 2-15 hours, 16-40 hours, 41+ hours; EIA 2001). Although these data were the best available prior to this study, they provide only a general feel for PC active mode usage and do not directly address time spent in off or sleep modes.

Due to the limited data about PC usage patterns, TIAX commissioned a phone survey in a prior study to develop a more up-to-date estimate of PC usage by mode. The phone survey posed a dozen questions to people in 1,000 demographically-representative households about the usage patterns for up to three computers per household. The respondents' answers to these questions were used as inputs into models to calculate the estimated weekday and weekend usage by mode. Consequently, we believe that the current study yields more accurate estimates for PC usage than earlier studies. Concurrently, the growth of residential broadband Internet connectivity – the percentage households with a PC with broadband Internet access passed 50% in 2005 (TIAX

[33] Disconnected.

2006) – also appears to have increased usage. Specifically, the survey found that broadband access increases PC active mode usage by approximately 25%.

The data also show that the current PC active mode power draw estimate is significantly (approximately 50%) higher than prior estimates. This reflects increased microprocessor power draw and, clearly, tends to increase PC energy consumption.

On the other hand, Table 5-39 indicates that the average sleep mode power draw of desktop[34] PCs has decreased dramatically since the mid 1990s, from approximately 30W to 4W. Prior to the launch of the EnergyStar® specification for PCs, most desktop PCs could not enter a low-power mode after a period of inactivity (Koomey et al. 1995). After the launch of the EnergyStar® program, this rapidly changed, i.e., by 1995 74% of all desktop PCs sold met the first EnergyStar® specification (see Table 5-39) and almost all units sold in 1999 met the specification (CCAP 2005). In response to the very high percentage of units that meet the specification, the EnergyStar® program has gradually reduced the allowable sleep mode power draw, with a 4W scheduled to come into effect in July, 2007 (see Table 5-39).

Table 5-39: Evolution of the EnergyStar® Computer Specifications for Sleep Mode Power Draw

Specification	Effective Date	Maximum Sleep Mode Power Draw [W]	Comment
1	December, 1994	30	EnergyStar® (2006a)
2	1 October 1995	30	PC must enter sleep mode after 15 to 30 minutes of inactivity (EnergyStar® 2006a)
3	1 July 1999	30[35]	Specification only revised monitor power levels (EnergyStar® 2006b)
	1 July 2000	15 / 20 / 25 / 30	For PCs with power supplies rated for: <200W, 200-300W, 300-350W, 350-400W[36] (EnergyStar® 2006b)
4	20 July 2007	*Active/Idle*: 50W ***Sleep*: 4W** *Off*: 2W	• EnergyStar® (2006c) • Includes higher active mode power draw levels for more powerful PCs • Includes minimum power supply efficiency requirements

Although the average sleep mode power draw has decreased, this has had a small impact on PC UEC because only a small portion of desktop PCs actually do, in practice, enter a sleep mode

[34] Notebook PC sleep mode power draw has always been relatively low, presumably because notebooks have always incorporated energy-saving features to maximize battery life when unplugged.
[35] According to EnergyStar® (2006b) (but not clearly noted in EnergyStar® 2006a), at some point the computer specification added language to specify that the maximum sleep power draw must equal 30W for a PC with a power supply rated at 200W or less, and 15% times the power supply rating for PCs with power supplies rated at 200+W.
[36] Per EnergyStar® (2006), PCs with power supplies rated for >400W must draw 10% of the rated power draw or less.

because most do not have the power management (PM) feature enabled. A reliable estimate for residential desktop PM-enabled rates does not exist, but the best estimates available suggest a rate between 15 and 20 percent.

5.8.3. References

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5.9. Set-top Boxes (STBs)

Set-top boxes (STBs) include traditional STBs used with televisions to receive and decode signals transmitted by cable and satellite video service providers and stand-alone hard disk drive-based personal video recorders (PVR). The most common STBs are cable boxes and satellite receivers leased by cable and digital broadcast satellite (DBS) service providers. STBs can offer a range of functions that may affect the overall energy consumption. Namely, HDTV capability and personal video recorder (PVR) functionality are offered by STBs. Stand alone PVRs (such as TiVo) are recording STBs not supplied by service providers. PVRs are also known as digital video recorders (DVRs).

5.9.1. Current Energy Consumption

5.9.1.1. Installed Base

Prior research and sales data were used to generate the current estimate of STB installed base and the breakdown of STB sub-categories. There were substantial inconsistencies between sales data and CEA Survey data that precluded the use of survey data for installed base estimates. Table 5-40 shows the current estimates.

Table 5-40: Detailed Installed Base Estimate for Set Top Boxes (in millions)

	Cable	Satellite	Stand Alone	Total
Analog STB	28	n/a	n/a	28
Digital STB	42	61	n/a	102
HD Digital STB	1.0	1.4	n/a	2
PVR Digital STB	4	6	1.5	12
HD PVR Digital STB	1.0	1.4	n/a	2
Total	77	70	2	148

Amann (2004) estimated that there were 30 million analog STBs in 2003. Kagan Research, LLC (2004) projected that less than 2 million subscribers would convert from analog to digital STBs from 2004 to 2006, which equates to just over 2 million STB units. Therefore, we estimate an installed base of approximately 28 million analog STBs. Kagan Research (2004) also projected that there would be approximately 48 million digital cable STBs, and approximately 1.5 units per subscriber household. Limited shipment data indicate that from 2001 to 2006 approximately 11% of DBS STBs shipped had PVR capability (CEA 2006). The same source suggests that 4% of DBS STBs offered HD[37]. We also applied these percentages to digital cable STBs to arrive at the breakdowns in Table 5-40.

In 2006, there were approximately 29 million digital broadcast satellite (DBS) subscribers based on an extrapolation of the Federal Communication Commission's estimate of 26 million in 2005 (FCC, 2006). According to an industry representative, each subscriber has an average of 2.4 STBs per DBS household, yielding 70 million total DBS STBs. As with the cable STBs, we estimate that 11% of the units provide DVR capability, and 4% are estimated to be HD compatible.

Stand-alone PVR STBs (dominated by TiVo products) account for approximately 1.5 million of the installed PVRs (Kagan Research 2004).

5.9.1.2. Unit Energy Consumption

STBs can be characterized by two operating modes:

- *Active*: The STB is plugged in and performs functions for the user, such as video signal processing, PVR recording or playing, and providing signals to multiple TVs
- *Off-Ready:* The STB is plugged in and switched off by the user. However, it continues to receive data from and/or send data to the service provider.

An additional Off-Sleep mode could be used to define a lower power mode when a STB is plugged in but neither provides user functionality nor exchanges data with the service provider. Typically, today's cable and satellite STBs do not have such a mode, but some stand-alone PVRs do.

Motorola and Scientific Atlanta dominate the U.S. cable STB market, accounting for approximately 55% and 40% of the market, respectively (Kagan Research 2004). Therefore, we used measurements of STBs from these two manufacturers to generate the average cable STB power draw values by mode. Kagan Research describes the more popular STBs based on functionality. Although measurements for all popular units were not available, we expect this method to provide a more accurate estimate than a straight average of all measurement data. Models for which power measurements were averaged are listed in Table 5-41 (CEA

[37] Lacking data, we assumed that 50% of the HD units have PVR capability

measurements 2006, CEA member measurements 2006, Foster, 2005). In general, PVR capability appears to increase unit power draw by approximately five Watts.

Table 5-41: Cable STB Power Draw Estimates by Function

Cable STB Functionality	Units Measured / Source	Active Power [W]	Off Power [W]
Analog STB	Foster (2005)	16	15.5
Digital STB	Units #9 and #13 (see Appendix D)	14	14
HD STB	Foster (2005)	21.5	20.5
PVR STB	Unit #10	26	21
HD DVR STB	Unit #11 and Foster (2005)	29	24

The two largest DBS service providers are DIRECTV and EchoStar (DISH Network). Measurement data for approximately 20 units were used to estimate the average power draw for DBS STBs.

Table 5-42 summarizes the average STB power draw by operating mode and STB functionality. Because STBs are constantly receiving, transmit, and/or recording service provider signals, they draw nearly the same power in off mode as they do in active mode. The stand-alone PVR category is dominated by TiVo products and, therefore, power draw estimates come from measurements of TiVo PVR systems[38].

[38] CEA did measure the power draw of three stand-alone PVR units besides the TiVo and found that they drew an average of 26W in “delayed watch” mode, 23W in “record + watch” mode, and 10W in “sleep” mode (see Appendix C for test methodology and mode definitions).

Table 5-42: Power Draw Summary for STBs

Operating Mode		Cable Active	Cable Off	Satellite Active	Satellite Off	Stand-alone DVR Active	Stand-alone DVR Off
Power Draw by Functionality and Operating Mode [W]	Analog STB	16	16	n/a	n/a	n/a	n/a
	Digital STB	14	14	13	13	n/a	n/a
	HD STB	22	21	21	18	n/a	n/a
	PVR STB	26	21	25	25	27	27
	HD DVR STB	29	24	42	40	n/a	n/a
	Weighted Avg.	16	15	15	14	27	27

The usage estimates come from the CEA Survey results (see Table 5-43). There are questions about survey participants' ability to accurately estimate STB on time. In particular, one might question why the stand-alone PVR on time is significantly lower than cable or satellite STB on time. In practice, because there is so little difference between on power and off power for most STBs[39], any errors in usage by mode estimates do not significantly affect the energy consumption calculations.

Table 5-43: STB Usage by Mode

	Cable		Satellite		Stand-alone PVR	
Active Usage	Active	Off	Active	Off	Active	Off
Off Usage	2,729	6,031	3,239	5,521	2,082	6,678

The analysis of televisions revealed that primary TVs, or the TVs used more often, were commonly larger units that drew more power in active mode. Following the same logic, we hypothesize that primary STBs would generally provide more functionality than STBs used less often and, therefore, draw more power. The survey usage data do suggest that STBs in households are used differently (see Table 5-44). However, since the survey did not provide an accurate breakdown of STB functionality, we could not verify this hypothesis.

[39] We found two exceptions. When units with a PVR are off, the PVR appears to stop spinning and power draw decreases by about 5W. In addition, measurements by CEA of three stand-alone PVR units that are not subscription based revealed that all drew substantially less (32, 44, and 91% less) power in a low-power mode than in active (watch + record) mode.

Table 5-44: Daily Usage of STBs by STB Priority

STB Priority	Daily Time in Active Mode [hrs]	
	Cable	Satellite
Primary	9.1	9.8
Second	6.0	8.1
Third	4.9	7.3
Fourth	4.3	7.3
Fifth	3.2	6.5
Sixth	3.2	0.0

Table 5-45 summarizes the unit energy consumption (UEC) for STBs using average power and usage estimates.

Table 5-45: UEC Summary for STBs

		Cable			Satellite			Stand-alone PVR		
		Active	Off	Total	Active	Off	Total	Active	Off	Total
UEC by Functionality and Operating Mode [kWh/yr]	Analog STB	44	93	138						
	Digital STB	38	84	123	43	70	113			
	HD STB	59	124	182	69	100	169			
	PVR STB	71	127	198	82	139	222	56	180	237
	HD DVR STB	79	145	224	137	223	360			
	Weighted Avg.	43	90	133	49	80	129	56	180	237

5.9.1.3. Annual Energy Consumption

Table 5-46 displays the annual energy consumption (AEC) for each STB category based on the estimated installed base and average UEC.

Table 5-46: Annual Energy Consumption of Set-Top Boxes (TWh/yr)

	Cable	Satellite	Stand Alone	Total
Analog STB	4	n/a	n/a	4
Digital STB	5	7	n/a	12
HD Digital STB	0	0	n/a	0.4
PVR Digital STB	1	1	0.4	3
HD DVR Digital STB	0	1	n/a	1
Total	10	9	0.4	**20**

5.9.2. *Prior Energy Consumption Estimates*

Table 5-47 presents prior estimates for STB energy consumption.

Table 5-47: Prior STB Energy Consumption Estimates

Source		Current	Foster (2005)	Davis Energy Group (2004)	Amann (2004)	Rosen et al. (2001)
Cable STB						
Year of Estimate		2006	2003	2003	2003	2000
Installed Base [millions]		77	35		65	49*
Power Draw [W]	**Active**	16	16		23	13
	Off	15	16	23	22	11
Annual Usage [hours]	**Active**	2,730	1,825	2,555		
	Off	6,030	6,935	6,205		
UEC [kWh/year]		134				103
AEC [TWh/year]		10				5.0
Satellite STB						
Source		Current	Foster (2005)	Davis Energy Group (2004)	Amann (2004)	Rosen et al. (2001)
Year of Estimate		2006	2003	2003	2003	2000
Installed Base [millions]		70	32		32	13
Power Draw [W]	**Active**	15			18	17
	Off	14		16	17	16
Annual Usage [hours]	**Active**	3,240		2,555		
	Off	5,520		6,205		
UEC [kWh/year]		129				140
AEC [TWh/year]		9				1.9
Stand Alone PVR						
Source		Current	Foster (2005)	Davis Energy Group (2004)	Amann (2004)	Rosen et al. (2001)
Year of Estimate		2006	2003			
Installed Base [millions]		1.5				
Power Draw [W]	**Active**	27	24			
	Off	27	24			
Annual Usage [hours]	**Active**	2,080				
	Off	6,680				
UEC [kWh/year]		237				
AEC [TWh/year]		0.4				

Relative to prior studies, the current study estimates an installed base for satellite STBs almost twice as large. This occurs for two reasons. First, the number of satellite subscribers has continued to grow rapidly, at 12% from 2004 to 2005 (FCC 2006). Second, our estimated number of STBs per subscriber is 60% greater (2.4 versus 1.5) than that used in prior estimates. Since our value comes from a major industry representative, we expect that it is valid.

In general, the current power draw values by mode estimates for STBs are similar to prior estimates. Two notable exceptions are the DEG (2004) and Amann (2004) estimates for cable STB power draw, which were substantially higher. The current cable STB power draw estimates take into account measurements for several of the more prevalent models in use today, so we expect that the current estimate is sound.

5.9.3. References

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5.10. Telephone Answering Devices (TADs)

5.10.1. Current Energy Consumption

This section describes the energy consumption of stand-alone telephone answering devices (TADs) in the U.S. in 2005. TADs are also referred to as answering machines. Answering machines integrated with corded telephones and answering services provided by telephone service providers are not included in this analysis. TADs that are integrated with cordless telephones are captured in the cordless telephone section.

5.10.1.1. Installed Base

CEA estimated that there were 103 million telephone answering devices in the U.S. in 2005 (CEA 2005). This estimate included integrated TAD/telephone units, as well as answering services. The CEA also estimated that there were 57 million TAD/cordless telephone combination units in 2005, leaving 46 million other answering systems. Recent sales data from CEA (2006) show that approximately 25 million stand-alone TADs have been sold in the last six years (Appliance Magazine [2005] estimates an average 6 year life for TADs). The same data also show that integrated TAD/telephone devices are quickly replacing stand-alone TADs. For this analysis, we estimate an installed base of 25 million stand-alone TAD devices, noting appreciable uncertainty in the estimate. Assuming one stand-alone TAD per owner household yields a penetration of 22% based on 115 million households (EIA 2006).

Table 5-48: Installed Base of Stand-Alone Answering Machines

	Installed Base [millions]	Penetration	Comments and Sources
Answering Machines	25	22%	CEA (2006), Appliance Magazine (2005)

5.10.1.2. Unit Energy Consumption

The energy consumption of TADs can simply be modeled using the following two operating modes:

- *Active* – Device is recording or playing
- *Standby* – The system is on but no motor functions are being performed

TADs likely spend the vast majority of the time in standby mode. Also, limited measurements indicate that the power draw of answering machines does not vary significantly by mode (Nordman and McMahon 2004). Most TADs are now digital, and therefore have no moving parts. For these reasons, we estimate that answering machines draw approximately 4 W continuously, yielding a UEC of 35 kWh/year (see Table 5-49).

Table 5-49: Unit Energy Consumption of TADs

Operating Mode	Active	Standby	Comments and Sources
Power Draw [W]	4	4.0	Power draw does not vary significantly with operated mode (Nordman and Meier 2004)
Usage [hours/year]	-	8,760	Devices assumed to draw 4 W continuously
UEC [kWh/year]	-	35	

5.10.1.3. National Energy Consumption

Based on the installed base and the calculated UEC values, stand-alone TADs consumed about 0.9 TWh in 2006 (see Table 5-50).

Table 5-50: AEC Summary for Answering Machines

UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
35	25	0.9

5.10.2. Prior Energy Consumption Estimates

Table 5-51 compares the current and several prior estimates for TAD electricity consumption.

Table 5-51: Prior Estimates of Stand-alone TAD Energy Consumption

Source		Current	CCAP (2005)	Nordman and McMahon (2004)	EIA (2001)	Rosen et al. (2001)	Sanchez et al. (1998)
Year of Estimate		2006	2005		2001	1999	1995
Installed Base [millions]		25	42		66	77	66.4
Power Draw [W]	**Active**		4	4			
	Standby	4.0	3.9	4.2		2.9	3.3
Annual Usage [hours]	**Active**		8,760				
	Off	8,760				8,760	8,760
UEC [kWh/year]		35	35		35	26	29
AEC [TWh/year]		0.9	1.5		2.3	2.0	1.9

Recent assessments of TAD UEC have arrived at similar values, which are approximately one-third greater than estimated developed in the late 1990s. This reflects an increase in standby power draw from around 3W to 4W. On the other hand, the AEC of stand-alone TADs has decreased significantly due to a decrease in their installed base. Specifically, sales data show combination cordless phone-answering machine units outsold stand-alone TADs by about 3.5 to 1 from 1996 through 2005 and have, to a large extent, supplanted stand-alone TADs (see Figure 5-25; from CEA 2006).

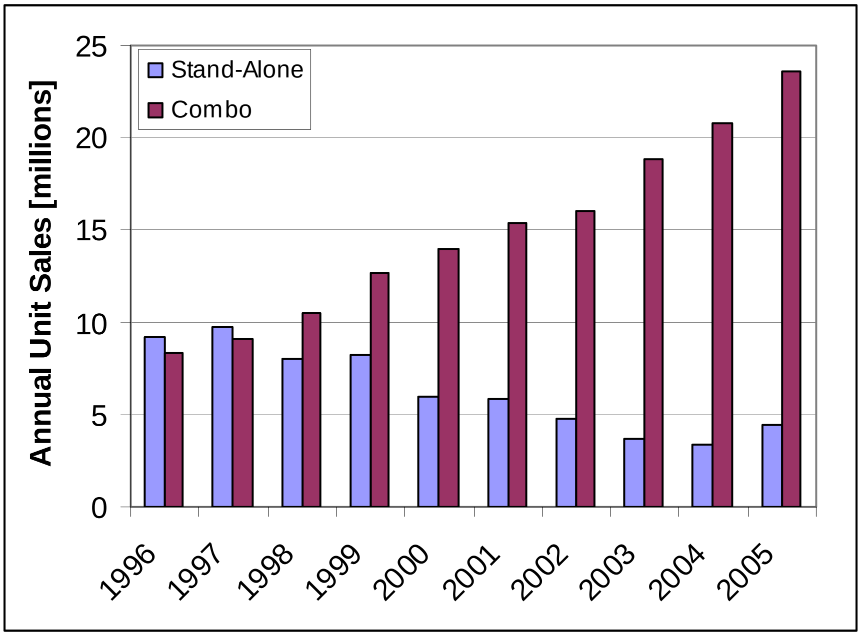

Figure 5-25: Annual Sales of Stand-Alone and Combo TADs (CEA 2006)

Voice message services and cell phones have likely also reduced the number of stand-alone TADs.

5.10.3. References

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5.11. Analog Televisions

5.11.1. Current Energy Consumption

This section describes the number of analog TVs in the U.S., typical usage patterns, and average power draw estimates in an effort to calculate the energy consumption in the U.S. in 2006. The majority of installed TVs are analog devices that display images in the standard-definition format using cathode ray tube (CRT) display technology[40]. This analysis includes analog TV-VCR and TV-DVD player combination units, but excludes digital televisions (DTVs). *An international effort is underway to develop a test procedure that accurately characterizes TV active mode power draw. This procedure is expected to be finalized in early 2007, at which point CEA members will provide power draw data for their best-selling units to TIAX for analysis. After analyzing that data, we will submit a new report that includes a new section analyzing DTV energy consumption.*

5.11.1.1. Installed Base

According to the current survey data, 89% of the 115 million U.S. households in 2006 (EIA 2006) own at least one analog television. The households owning at least one analog TV owned an average of 2.3 systems, for a total of approximately 237 million analog TVs in the U.S.

Table 5-52: Analog TV Installed Base

Installed Base [millions]	Penetration	Comments and Sources
237	89%	CEA Survey

Standard analog TVs account for approximately 86% of the 277 million total TVs in the U.S. Although the number of U.S. households and the number of televisions per household both continue to grow, the number of analog TVs has likely reached its peak as digital TVs (DTVs) become increasingly popular. Specifically, broadcast television will switch from analog to digital signals in 2009, ensuring the growth of DTVs and all TVs sold in and after March, 2007 and later must be DTVs (FCC 2006). Figure 5-26 shows the distribution of the number of analog TVs owned, based on current survey data.

[40] Bates (2006) indicated that just about all LCD TVs in the installed base are digital TVs.

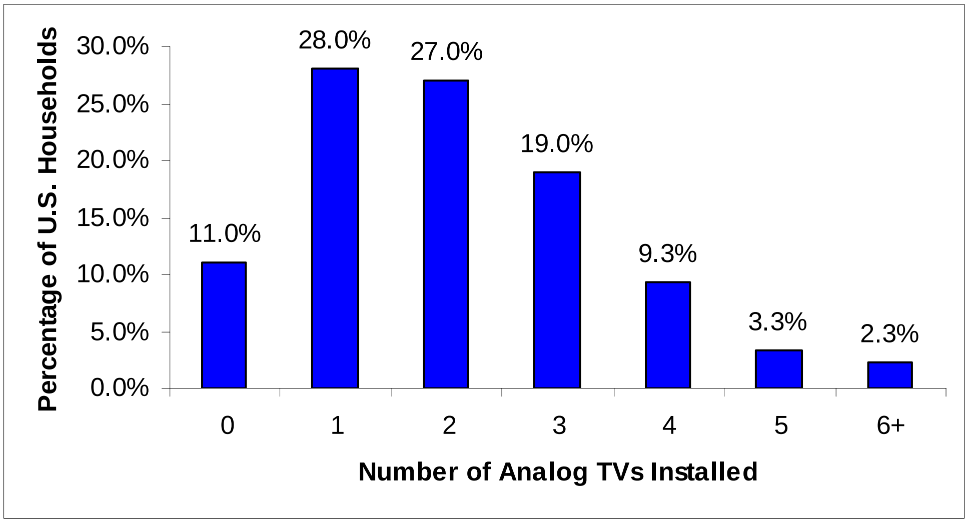

Figure 5-26: Distribution of Number of TVs per Household

5.11.1.2. Unit Energy Consumption

Televisions can be characterized by two operating modes:

- *Active* – Device is displaying image
- *Off* – The power has been switch off by the user, but the system remains plugged in

The majority of households own multiple television sets, which are likely to be of varying screen size. Furthermore, the survey found that larger TVs tend to be the primary televisions and, thus, are used more than other household TVs. To capture the effect of this fact on energy consumption, we analyzed the usage of each TV group (i.e., primary TV, secondary TV, etc.) separately, and calculated the AEC using the estimated installed base of TVs for each usage group.

The active mode power draw was estimated from measurement of 370 analog TVs (Rosen and Meier 1999). Although all the measured TVs were manufactured before 1999, analog CRT television is a mature technology and, therefore, we assumed that active mode power draw has not changed appreciably since the mid 1990s. We divided the power draw data into the same screen size groupings as were employed for the CEA Survey. Figure 5-27 plots the average power per screen area for each size group; all analog TVs over 40 inches are likely projection TVs.

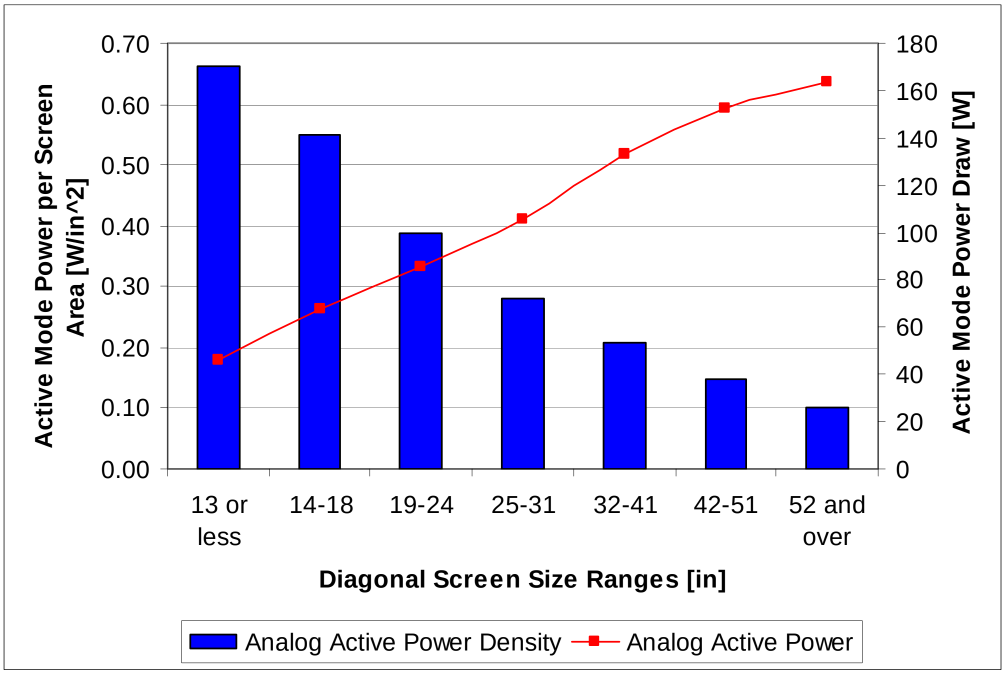

Figure 5-27: Analog TV Active Mode Power Draw per Screen Area and Absolute Power Draw for Screen Size Groups from CEA Survey[41] (based on Rosen and Meier 1999)

The usage survey asked participants to estimate the diagonal screen size of each TV in their household and Figure 5-28 shows the distribution of installed analog TV screen sizes. From this data, we calculated the average TV size and active mode power draw for each usage group.

[41] Note that screen size groups span different screen size ranges.

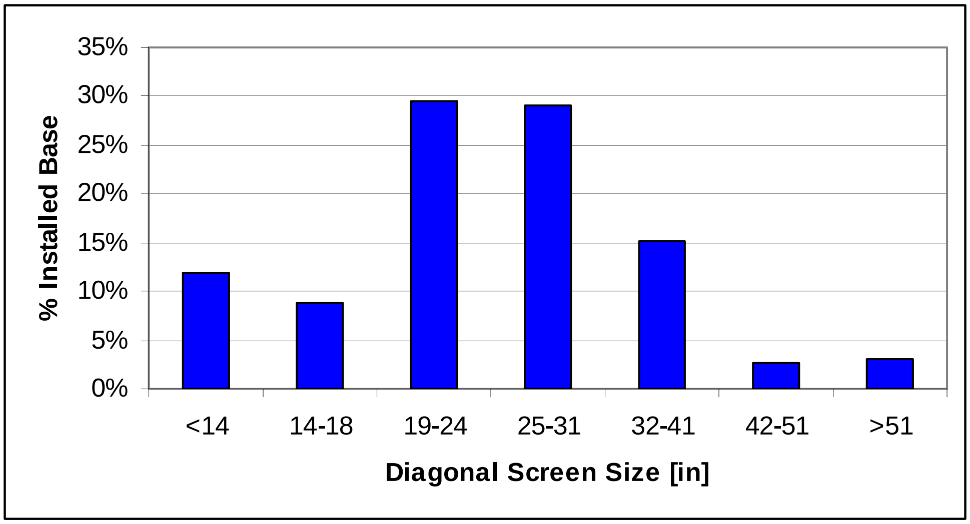

Figure 5-28: Analog TV Screen Size Distribution Based on Survey Results

In contrast to TV active mode power draw, which usually increases with screen size (assuming the same display technology), TV off mode power draw does not depend on screen size. Historical data shown in later in this section (see Figure 5-31) also indicate that the average off mode power draw did not vary significantly with year of manufacture between the years of 1984 and 1998. The overall average of the aforementioned 370 units measured was 5 W (Rosen and Meier 1999). This average would not, however, account for any effect that the EnergyStar® program, which established a maximum off mode power draw threshold in 1999, may have had on off mode power draw. Therefore, the average off mode power draw was estimated to be 4 W, which agrees with the estimate of Ostendorp et al. (2005). The active mode dominates (~88%) TV UEC; therefore a more complex approach to estimate the off mode power draw estimate would not significantly affect the overall energy consumption[42].

We used the responses from the current survey to estimate analog TV usage. Participants were asked how long each household TV was turned on the prior day. This captures the time the TV was used to watch broadcast television, as well as home video and time when TVs were on "in the background" with no one actively watching. As noted earlier, the survey enabled us to resolve usage for each TV usage group. Table 5-53 presents the estimates for power draw, usage, and energy consumption for the usage groups.

[42] In addition, very few data were available for TV-VCR and TV-DVD power draw.

Table 5-53: UEC Calculations for Analog TVs

Usage Group	% of Installed Base	Average Active Usage [hrs/day]	Average Screen Size [in]	Average Active Power [W]*	Average Off Power [W]**	UEC [kWh/yr]	AEC [TWh/yr]
Primary	43%	7.1	30	115	4	324	33
Second	29%	4.2	24	93	4	172	12
Third	16%	3.3	21	79	4	124	5
Fourth	7%	3.2	21	78	4	123	2
Fifth	3%	2.0	18	67	4	81	1
Sixth	1%	1.2	18	67	4	62	0
Total							53

*Calculated using measurement data from Rosen and Meier (1999)
**Average from measurement data from Rosen and Meier (1999) with estimated modification for recent EnergyStar® products

The results clearly indicate that the average primary household TV is larger, draws more power in active mode, and used significantly more often than other TVs in households. As a result, in general, the larger the TV in a household, the more time it spends in active mode. Capturing this trend in the energy consumption calculations increased the AEC for analog TVs by 5% relative to the assumption that average usage does not vary with screen size. Employing usage groups also enabled an accurate calculation of the average TV power draw.

The weighted average UEC (222 kWh/yr) is dominated by active mode energy consumption, accounting for approximately 88% of the total. There is a large range between the average primary TV (approximately 92% of UEC from active mode) and the average sixth TV (approximately 46% of the UEC from active mode).

5.11.1.3. National Energy Consumption

Table 5-54 summarizes the AEC calculations for analog TVs (and combination products).

Table 5-54: 2006 AEC Summary for Analog TVs

UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
222	237	53

5.11.2. Prior Energy Consumption Estimates

Table 5-55 summarizes prior estimates and relevant data for analog TV energy consumption.

Table 5-55: Prior Analog TV Energy Consumption Estimates

Source		Current	Rosen and Meier (1999)	Ostendorp (2005)	Sanchez et al. (1998)	ADL (1998)	Nordman and McMahon (2004)	EIA (2001)	Nielsen Media (2005)
Year of Estimate		2006	1998	2004	1995	1997	2004	2001	2005
Installed Base [millions]		237	212	234	191	229		243	
Power Draw [W]	Active	98[a]	75	100	77	60			
	Off	4	4.5	3.9	4	4	4.2		
Annual Usage [hours]	Active	1,882*	1,443	1,278	1,498	1,460			1,240**
	Off	6,878	7,317	7,483	7,262	7,300			7,520
UEC [kWh/year]		222	150	156	141	117		137	
AEC [TWh/year]		53	31.0	36.6	26.0	27		33	

*In current energy analysis, the usage and power were estimated for each TV usage group; for the purpose of comparison, however, the overall averages were calculated (i.e., not weighted for usage). On the other hand, the UEC and AEC values shown reflect the more complex model based on usage groups derived in Section 5.11.1.2.
**Broadcast TV only. Home video usage, video game system usage, and time with multiple TVs on simultaneously not included

The current power draw estimate is very similar to that of Ostendorp et al. (2005) but substantially higher than that of Rosen and Meier (1999), despite using the same data set. The reason for this discrepancy is that the current survey estimated that that average screen size is appreciably larger than that of Rosen and Meier, who used industry data for the size distribution of TVs from 1991 and 1992. Figure 5-29 (based on annual sales data from Bates 2006) reveals that the average TV size sold has grown from around 21 inches circa 1991 to almost 30 inches in 2005 (note: this includes both analog and digital TVs).

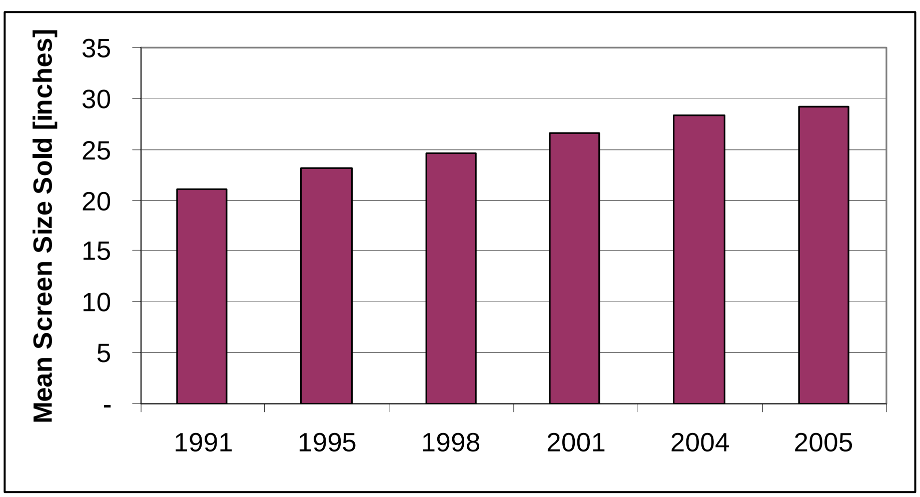

Figure 5-29: Television Average Screen Size (based on CEA 2006)

Historical data from Rosen and Meier (1999) indicate that active power draw for 27-inch analog TVs, a popular size, appears to not have changed significantly between 1988 and 1996 (see Figure 5-30; sufficient data were not available after this period). Although the data suggest an apparent decrease in active mode power draw may 1997 and 1998, this could well reflect insufficient sample size.

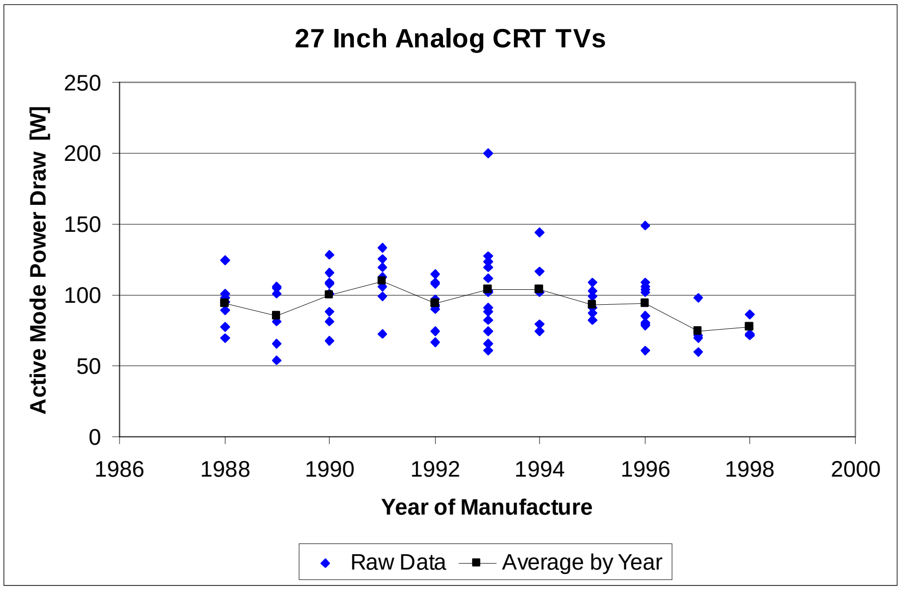

Figure 5-30: Historical Active Power Draw Data for 27-inch Analog TVs

Likewise, the average off mode power draw held fairly constant during the sampled time period, although the data range is large (see Figure 5-31).

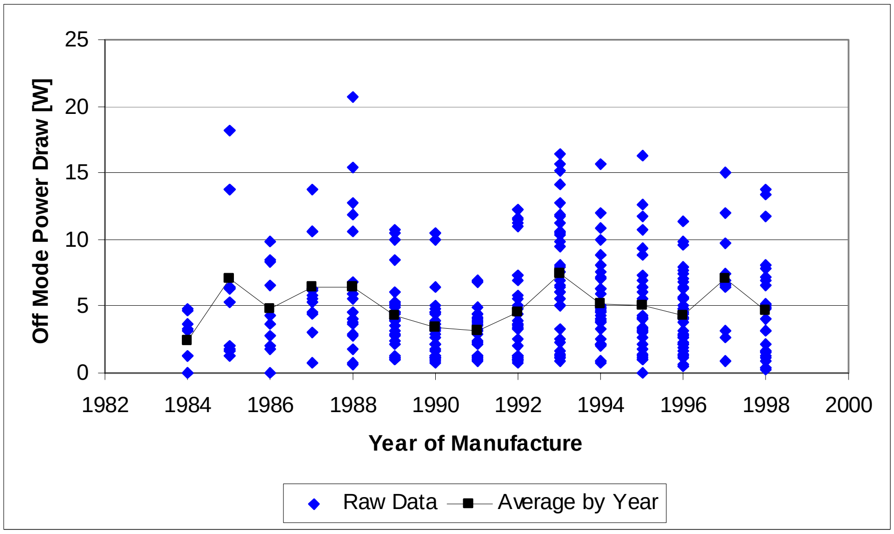

Figure 5-31: Historical Off Mode Power Draw Data for Analog TVs (Rosen and Meier 1999)

Although extensive measurements since 1998 are not available, we estimate that average off mode power draw has decreased since 1998 as significant portions of TVs sold have met the off mode power draw levels required by the EnergyStar® program (see Figure 5-32. However, EnergyStar® unit sales penetration has been fairly constant since 1999, so the average off mode power draw of the installed analog TVs may not have significantly decreased yet.

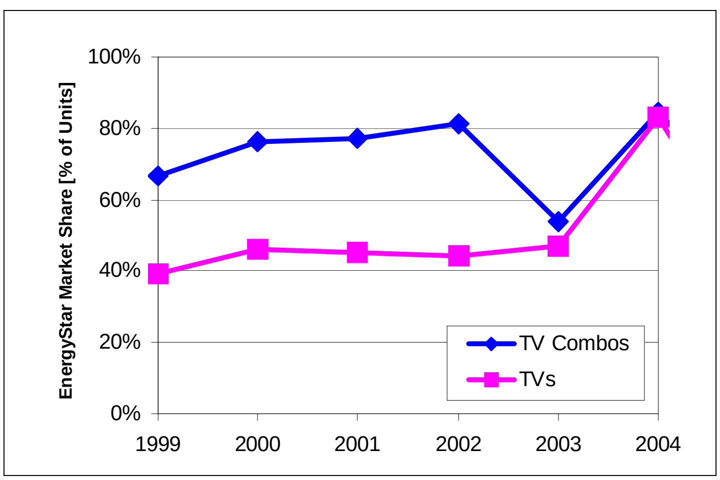

Figure 5-32: Historical EnergyStar® Market Share for Analog Televisions (EnergyStar® 2006)

Table 5-56 summarizes the historical EnergyStar® program requirements for TVs and combination units. Importantly, the maximum off mode power draw decreased for analog TVs on 1 July 2004 from 3W to 1W.

Table 5-56: TV EnergyStar® Criteria (EnergyStar 2006)

	Phase 1 Off Mode (7/1/2002)	Phase II Off Mode (7/1/2004)	Phase III Off Mode (7/1/2005)
Analog TVs	< 3 W	< 1 W	
TV/VCR Combo Units	< 6 W		< 1 W
TV/DVD and TV/VCR/DVD Combo Units	< 4 W		< 1 W

The current active mode usage estimate, derived from survey results, is substantially higher than past estimates, and is the foremost reason why the current analog TV AEC estimate is more than 40% higher than the next highest estimate. A survey-based approach has its limitations, most notably that the accuracy depends based on the participants' ability to accurately recollect TV usage for all of the TVs in their household. Ostendorp et al. (2005) used a similar survey-based approach to develop active mode usage estimates (based on their interpretation of U.S. Census bureau survey), while Rosen and Meier (1999) modified Nielsen viewing data to estimate usage. The following discussion explores the usage calculations further.

Figure 5-33 plots the increase of broadcast television viewing by households over the past two decades (Nielsen Media Research 2005) and indicates that households watched an average of 8.2 hours of broadcast television per day in 2005. As Rosen and Meier (1999) noted, this result does not include time spent watching home video, time spent playing video games, or time when multiple TVs are on simultaneously in a single home.

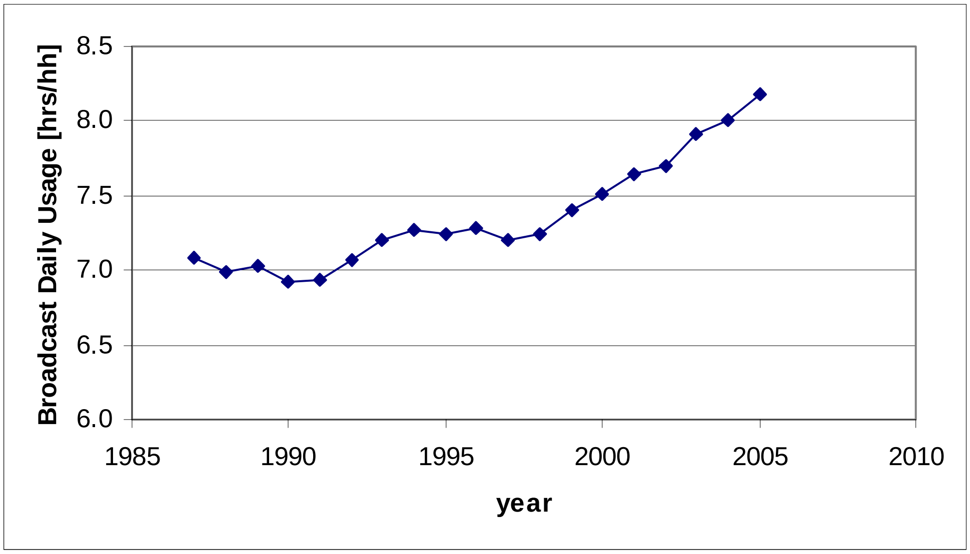

Figure 5-33: Nielsen Media Research (2005) Broadcast Television View Estimates per Household

As a check, the total TV usage was calculated from its components by summing the time watching television from Nielsen Media and the time watching home video and playing video game systems from the current survey. Table 5-57 shows the results of this alternative usage analysis.

Table 5-57: Secondary TV Usage Model

	Daily Usage per Unit [hours/day]	Units per TV (analog and digital)	% of TV Households w/ Multiple TVs[43]	Analog TV Active Usage	Comments
Television Viewing (analog + digital)	3.4	-	80%	3.7	8.2 hrs/hh broadcast TV viewing (Nielsen Media 2006) divided by 2.4 TVs/hh (analog and digital) from current survey
Simultaneous Viewing	3.8				Households with multiple TVs have 2 TVs on simultaneously 12% of the time (Rosen and Meier 1999, from Media Dynamics 1998)
DVD viewing	0.7	0.51		0.35	DVD usage, DVD units, and total TVs from survey results
VCR viewing	0.4	0.38		0.15	VCR usage and units, and total TVs from survey results
Video game viewing	1.2	0.23		0.28	Video game system usage and units, and total TVs from survey results
Total				4.5	Sum of television, home video, and video game systems

There is significant uncertainty associated with the estimate of time television is being viewed on multiple TVs in a household simultaneously. Lacking newer data, we used the 12% value from the 1998 source cited in Rosen and Meier (1999), which yields a total estimate of 4.5 hours per TV per day. This is 15% lower than the survey average result of 5.2 hours per day, but 4.5 hours per day, or 1,640 hours per year, exceeds the estimates of Ostendorp et al. (2005) and Rosen and Meier (1999) by about 14 and 28 percent, respectively.

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[43] That is, percent of TVs capable of simultaneous viewing.

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5.12. Video Cassette Recorders (VCRs)

5.12.1. Current Energy Consumption

This subsection characterizes the energy consumption of stand-alone VCRs only; combination DVD-VCRs and TV-VCRs are incorporated into the DVD and TV sections, respectively.

5.12.1.1. Installed Base

VCRs have recently passed their market penetration peak. Appliance Magazine saturation statistics indicate that 94% of all U.S. households owned at least one VCR from 2000-2002 (Appliance Magazine 2005b). Since then the market penetration has dropped and the CEA Survey suggests that VCRs are installed in 79% of homes. The same survey also estimates that households with VCRs owned an average of 1.6 units, which translates to approximately 141 million VCRs in the U.S. in 2006 based on 115 million households (EIA 2006). This total includes, however, 35 million DVD-VCR combination units that are included in the DVD player energy consumption analysis. Consequently, approximately 105 million stand-alone VCR units remain.

[44] Date of document not noted in document, download year shown.

Table 5-58: 2006 VCR Installed Base

Installed Base [millions]	Penetration	Comments and Sources
105	79%	CEA Survey, less number of DVD-VCR combo units

5.12.1.2.Unit Energy Consumption

Home video products can be characterized by 3 operating modes as described by Rosen and Meier (1999):

- *Play/Record* – Tape is recording or playing
- *Idle* – The system is on but no motor functions are being performed
- *Off* – The power has been switch off by the user, but the system remains plugged in.

To calculate the overall average power of installed VCRs, a model was generated to incorporate data from the past 10 years (see Table 5-59). Older power draw estimates come from measurements made by Rosen and Meier (1999), while estimates for newer products were derived from extrapolation of historical trends, as well as EnergyStar® market share data. The overall average is weighted based on annual sales data going back to 1996[45] (CEA 2005, Appliance 2005a). Using this method, the average active mode and off mode power draws were calculated to be 16 Watts and 4.5 Watts respectively. Based on the values reported in Rosen and Meier (1999) and Nordman and McMahon, the average VCR idle mode power draw was taken to be approximately 75% of the active mode draw, or 12 Watts.

Table 5-59: VCR Average Power Model

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
VCR Unit Sales, All [millions]	17	17	18	23	24	15	14	6	2	1	1
EnergyStar® Market Share [%]	-	-	-	85%	94%	95%	91%	97%	85%	98%	98%
Energy Star Off Mode Power Draw Requirement [W]	-	-	-	4	4	4	4	4	1	1	1
Estimated Off Mode Average, EnergyStar® Units	-	-	-	3.5	3.5	3.5	3.0	3.0	1.0	1.0	1
Estimated Off Mode Average Power Draw, non-EnergyStar® Units	6	6	6	7	7	6	6	6	5	5	5
Estimated Annual Off Mode Average Power Draw [W]	6.0	6.0	6.0	4.0	3.7	3.6	3.3	3.1	1.6	1.1	1.1
Estimated Annual Active Mode Average Power Draw [W]	20	19	18	18	17	16	15	14	14	13	12

[45] The sum of the stand-alone VCRs over this period approximately equals the installed base estimate for these devices. We decided not to employ a more complex retirement model to describe the installed base, as we believed that this refinement would lead to a marginal increase in the accuracy of the AEC calculation.

Current survey data indicate that VCRs are used an average of 156 hours per year, or approximately 3 hours per week. Survey participants also responded that their VCR players sit in idle mode an average of 15 hours per week, or 10% of the time not in active mode.

Table 5-60 summarizes the UEC calculations by mode for VCRs. 75% of the energy consumption occurs while in off mode, idle mode energy consumption accounts 20% of the UEC, while only 5% of the UEC occurs in active mode.

Table 5-60: UEC for VCRs

	VCR Usage Mode			
	On	Idle	Off	Total
Power [W]	16	12	4.5	
Usage [hr/yr]	156	793	7,811	8,760
UEC [kWh/yr]	2.5	10	35	47

5.12.1.3. National Energy Consumption

Overall, stand-alone VCRs consume about 5 TWh per year.

Table 5-61: 2006 AEC Summary for VCRs

UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
47	105	5.0

5.12.2. Prior Energy Consumption Estimates

Table 5-62 compares the current estimate of VCR energy consumption and its components with prior estimates.

Table 5-62: Prior Energy Consumption Estimates for VCRs

Source		Current	Rosen and Meier (1999)	Sanchez et al. (1998)	ADL (1998)	EIA (2001) (VCRs and DVD Players)	Nordman and MacMahon (2004)
Year of Estimate		2005	1998	1995	1997	2001	
Installed Base [millions]		105	129	135	123	162*	
Power Draw [W]	**Active**	16	17	15.7	15.7		17
	Idle	12	13.5	10.7	10.7		13
	Off	4.5	5.9	5.4	5.6		5
Annual Usage [hours]	**Active**	156	240	262	264		
	Idle	793	2,429	1,256	1,259		
	Off	7,811	6,091	7,242	7,237		
UEC [kWh/year]		47	71	57	57	70	
AEC [TWh/year]		5.0	9.1	7.6	6.9	11	

[a]*Covers both VCRs and DVD players. There were approximately 10-15 million DVD players installed in 2001 based on sales data

Although DVD players now dominate home video sales and stand-alone VCR sales dropped substantially after 2000 (currently ~5% of their levels in 2000; CEA 2005), the installed base has not significantly dropped since that time. VCRs and DVD players currently coexist in households and the survey suggests that VCRs are used less than DVD players. Owners will unlikely retire VCRs, however, as long as they are still working. Many of the recent VCR sales (2003-present) have been in the form of DVD/VCR combination products. Because combination video products are included in the DVD player analysis, the installed base of stand-alone VCR units has dropped relative to previous analyses.

Figures 5-34 through 5-36 show power measurements of VCRs by operating mode plotted against the year of manufacture (Rosen and Meier, 1999). Recent DVD player power measurements are also plotted for comparison. Although limited sample size may skew the data in places, the overall trend is clear: as the technology matured, the power draw in each operating mode dropped. An EnergyStar® specification exists for VCRs, and most of the current sales are EnergyStar® products. Due to the low sales levels of VCRs in recent years, the current average power draw of installed VCRs has not significantly changed from prior estimates.

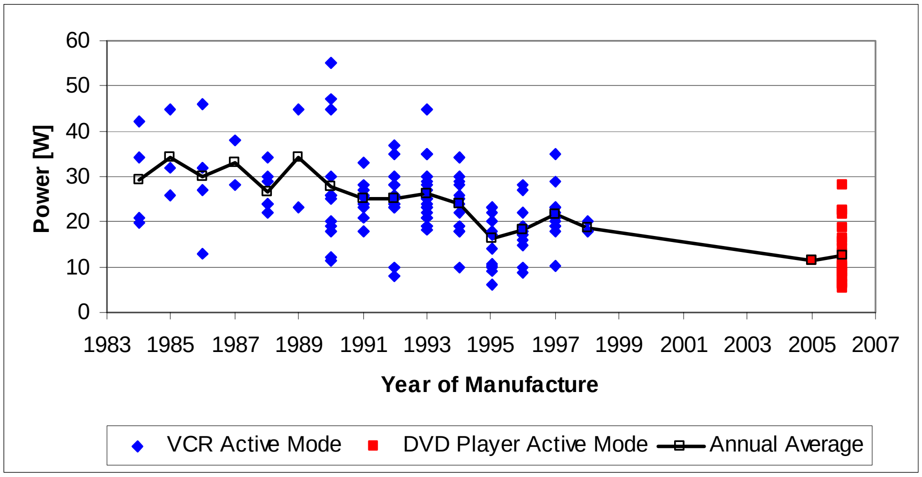

Figure 5-34: Active Mode VCR and DVD Power Measurements by Year of Manufacture

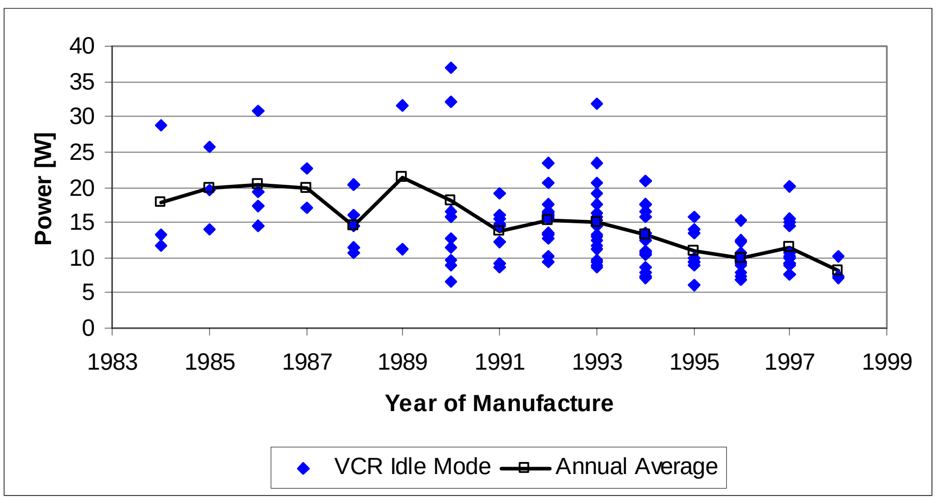

Figure 5-35: Idle Mode VCR Power Measurements by Year of Manufacture

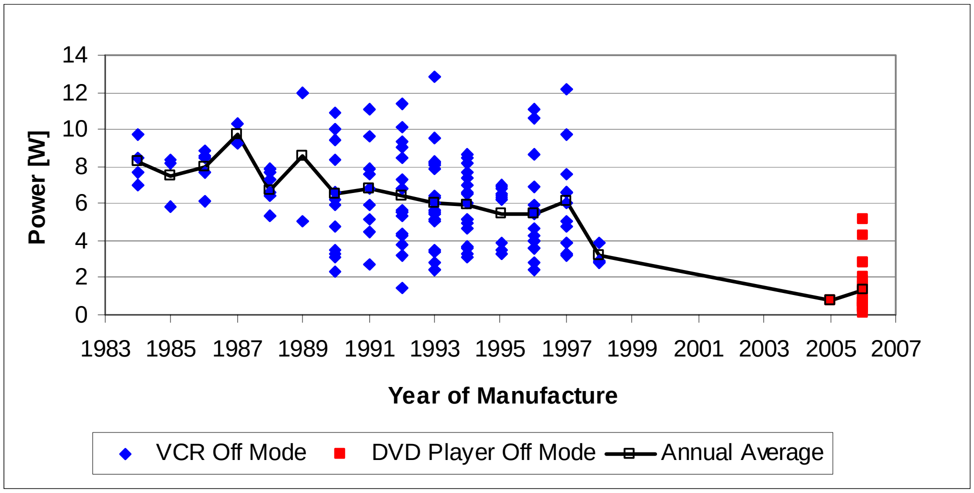

Figure 5-36: Off Mode VCR and DVD Power Measurements by Year of Manufacture

As noted, the current active mode usage estimate is lower than previous estimates, presumably because DVD player usage has supplanted a portion of VCR usage. The idle mode usage is lower than all previous estimates, and significantly lower than that of Rosen and Meier (1999) and used by EIA (2001). Rosen and Meier made a rough estimate that home video devices spend 25% of the time they are not in active mode in idle mode because owners neglect to turn them off. Based on an unofficial survey of company employees, another source stated that idle time may be as high as 60% of the time not in active mode. (Harrison 2006) The current survey data does not support these estimates and indicates that devices are in idle mode only approximately 9% of the time not spent in active mode. One concern about the current estimate is that survey participants may not be able to accurately recall and estimate idle usage of home video products in their homes. Nonetheless, barring metered data from a statistically significant and representative sample of households, occupant responses are superior to rough estimates based on researchers' experience.

5.12.3. References

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5.13. Video Game Systems

5.13.1. Current Energy Consumption

This section describes the number of stand-alone video game systems in the U.S., typical usage patterns, and average power draw estimates in an effort to calculate the energy consumption in the U.S. in 2006. Handheld game consoles, such as the Sony PSP and Nintendo DS, are not included in this analysis.

5.13.1.1. Installed Base

According to survey data, 36% of U.S. household owned at least one video game system and households owning at least one system have an average of 1.5 systems. Based on 115 million household in 2006 (AEO, 2006), this yields an installed base estimate of 64 million video game systems in the U.S. in 2006, excluding handheld gaming appliances.

Table 5-63: 2005 Video Game System Installed Base

Installed Base [millions]	Penetration	Comments and Sources
64	36%	CEA (2006) survey

5.13.1.2. Unit Energy Consumption

Home video products can be characterized by the following three operating modes:

- *Active* – The system is on and a game is being played
- *Idle (Pause)* – The system is on and the game is paused
- *Off* – The power has been switch off by the user, but the system remains plugged in.

Another "idle" mode exists when a game console is turned on but no game disks are in the drive. This power draw is referred to as the "dashboard" power draw by DX Gaming, and limited measurements show its value to be 75% to 95% of the active mode draw (DX Gaming 2006). However, CEA industry experts maintain that game consoles are more likely to be in a "pause" idle mode than a "dashboard" idle mode; therefore, we used the pause idle power draw estimates for the UEC calculations.

Three companies dominate the video game system industry: Sony, Nintendo, and Microsoft. DFC Intelligence claims that there are 35 million Sony Playstation 2 systems, 14 million Microsoft Xbox systems, 10 million Nintendo GameCube systems, and 2.5 million Microsoft Xbox 360 systems installed in homes (USA Today 2006). The sum of these estimates is nearly equal to the total installed base estimate from the current survey. Therefore, for the purpose of estimating the overall average video game system power draw, we assumed that these four systems exclusively comprise the installed base. Table 5-64 displays the installed base breakdown and current power draw measurements by mode for these four products. CEA staff performed the power draw measurements[46].

[46] DX Gaming reported power draw measurements for the four units measured. Their results are generally similar to the values measured with the notable exception of the PS2, i.e., they measured 30 and 23W, respectively, for the active and idle modes. This could reflect different generations of the PS2. Unfortunately, this source did not provide information about the equipment used to measure power draw.

Table 5-64: Video Game System Installed Base Break Down and Power Draw by Mode

	% of Installed Base	Active Power Draw [W]	Idle (Pause) Power Draw [W]	Off Power Draw [W]
PlayStation 2	57%	18	17	0.2
Xbox	23%	68	68	2.0
GameCube	16%	21	20	0.9
Xbox 360	4%	173	168	2.2
Weighted Average	**100%**	**36**	**36**	**1**

Active mode power draw may vary depending on the game played and the number of players involved. The current measurements were taken for only one game per console and, consequently, could differ from the average power draw represented by actual playing patterns for the entire country.

The current usage estimate comes from the current survey results. On average, survey participants played video games for a little over one hour per day. Participants also estimated that game consoles spent approximately 1.5 hours per day in idle mode, with the remaining time spent in off mode. Table 5-65 summarizes the average power draw, usage, and UEC by mode for video game systems.

Table 5-65: UEC Calculations for Video Game Systems

	Mode				
	Active	Idle (Pause)	Off	Total	Comments and Sources
Power [W]	36	36	0.8		CEA Measurements
Usage [hr/yr]	405	560	7,795	8,760	CEA Survey data
UEC [kWh/yr]	15	20	6	41	

5.13.1.3. National Energy Consumption

Video game systems consume about 2.6 TWh per year (see Table 5-66).

Table 5-66: 2006 AEC Summary for Video Game Systems

UEC [kWh/yr]	Installed Base [millions]	AEC [TWh]
41	64	2.6

5.13.2. Prior Energy Consumption Estimates

Table 5-67 summarizes prior estimates of video game system energy consumption.

Table 5-67: Prior Energy Consumption Estimates for Video Game Systems

Source		Current	Rosen et al. (2001)	Sanchez et al. (1998)
Year of Estimate		2006	1999	1995
Installed Base [millions]		64	54	64
Power Draw [W]	**Active**	36	8	20
	Idle	31	n/a	n/a
	Off	0.8	1	2
Annual Usage [hours]	**Active**	406	175	365
	Idle	558	n/a	n/a
	Off	7,796	8,585	8,395
UEC [kWh/year]		36	10	24
AEC [TWh/year]		2.4	0.5	1.5

Active mode power draw has increased significantly for newer models, contributing to the higher estimated UEC relative to prior estimates. Each generation of video game systems brings a new level of graphics and faster processing speeds. Figure 5-37 illustrates the growth in active mode power draw over the past two decades.

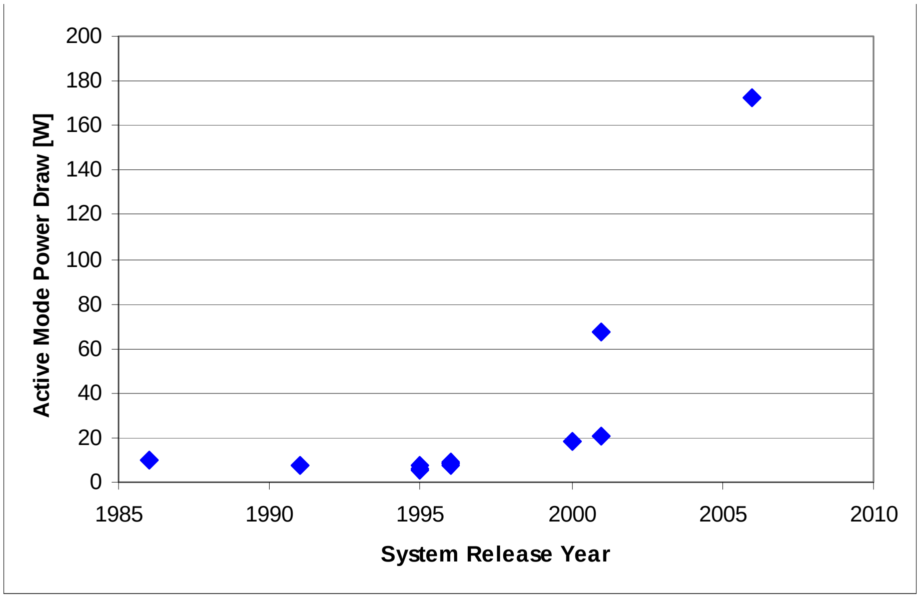

Figure 5-37: Historical Data for Video Game System Active Mode Power Draw

The latest generation of video game systems, Microsofts's Xbox 360, Sony's PlayStation 3, and Nintendo's Wii, all offer high definition graphics and internet capabilities. Only the Xbox 360, which came out by July 2006, is plotted in Figure 5-37. The current analysis does not, however, capture the energy impact of these newest systems.

The off mode power draw for video game systems exhibits no distinctive trend over the last 15 to 20 years; it appears to have remained steady at an average of approximately 1 Watt (see Figure 5-38).

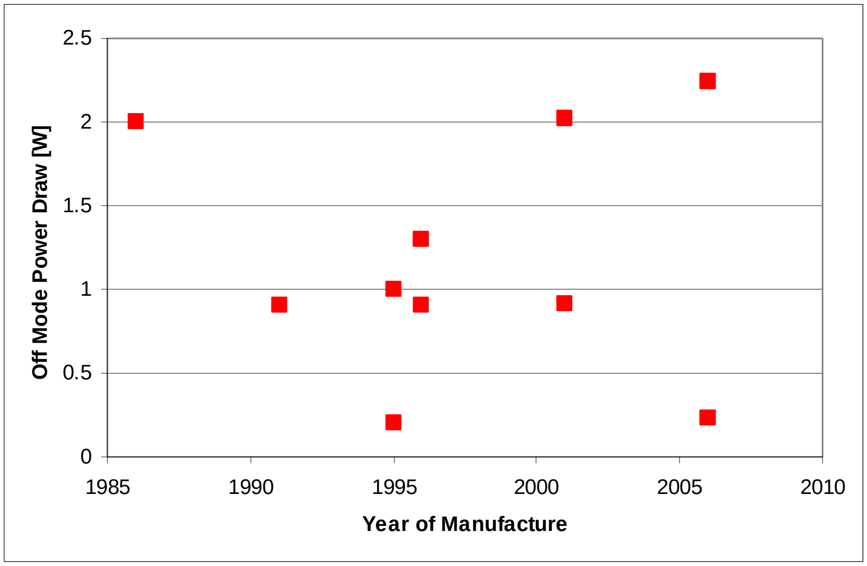

Figure 5-38: Historical Data for Video Game System Off Mode Power Draw

Prior estimates did not account for idle mode energy consumption, or considered it insignificant, resulting in a significant reduction in the UEC estimates. The current active mode usage is also higher than prior estimates, further increasing UEC. The growth in video game system usage appears reasonable.

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5.14. Other Products

Although the scope for this project could not support developing more refined estimates for the energy consumed by all CE products, we did develop preliminary estimates for the AEC of all products. Table 5-68 summarizes these preliminary estimates for other products; Appendix A contains the details of the assumptions underlying the AEC estimates.

Table 5-68: Estimates for the Energy Consumption of Other CE Products

Product	UEC [kWh]	Installed Base [millions]	AEC [TWh]
Caller ID Equipment	9	29	0.3
Camcorder	2.3	64	0.1
CD Boombox	17	95	1.6
Component Stereo	115	50	5.8
Digital Camera (rechargeable)	7.2	3.7	0.03
Facsimile Machine	6.3	70	0.4
Modem (Cable and DSL)	53	46	2.4
Pager	3.5	14	0.05
Portable Audio (MP3 Players)	5.6	23	0.1
Printer	30	88	2.8
Radios (home, including clock radios)	15	145	2.2
Mobile Telephone	3.5	200	0.7
TOTAL		830	17

6. Conclusions

TIAX carried out a study to characterize the electricity consumption of consumer electronics (CE) in U.S. residences. This included a bottom-up assessment of CE electricity consumption in 2006, characterization of energy consumption trends, and comparison of current electricity consumption estimates with prior estimates. The current study does not, however, include the energy consumed by digital televisions (DTV). An international effort is underway to develop a test procedure that accurately characterizes TV active mode power draw; this procedure is expected to be finalized in 2007. Subsequently, TIAX will synthesize power draw measurements for best-selling DTVs to characterize DTV annual electricity consumption (AEC). These findings will be integrated into an updated version of this report, anticipated to be completed in Spring of 2007. All subsequent references to CE energy consumption exclude DTV energy consumption.

We characterized the energy consumption of sixteen CE devices in detail (see Table 6-1). In addition, we developed preliminary estimates for the AEC of thirteen more devices.

Table 6-1: List of Consumer Electronics and Devices Analyzed in Detail

Answering Machine
Cable Set-top Box
Compact Audio
Cordless Telephone
Desktop Personal Computer (PC)
Digital Versatile Disk (DVD) Player
Digital Versatile Disk (DVD) Recorder
Home Theater in a Box (HTIB)
Monitor
Notebook Personal Computer (PC)
Personal Video Recorder (PVR)
Satellite Set-top Box (STB)
Television, Analog
Television, Digital (DTV)
Video Game System
Video Cassette Recorder (VCR)

Overall, excluding DTV, CE consumed about 147 TWh of electricity in U.S. homes in 2006. This represents about 11% of U.S. residential electricity consumption (see Figure 6-1) and 4% of total U.S. electricity consumption (EIA 2006).

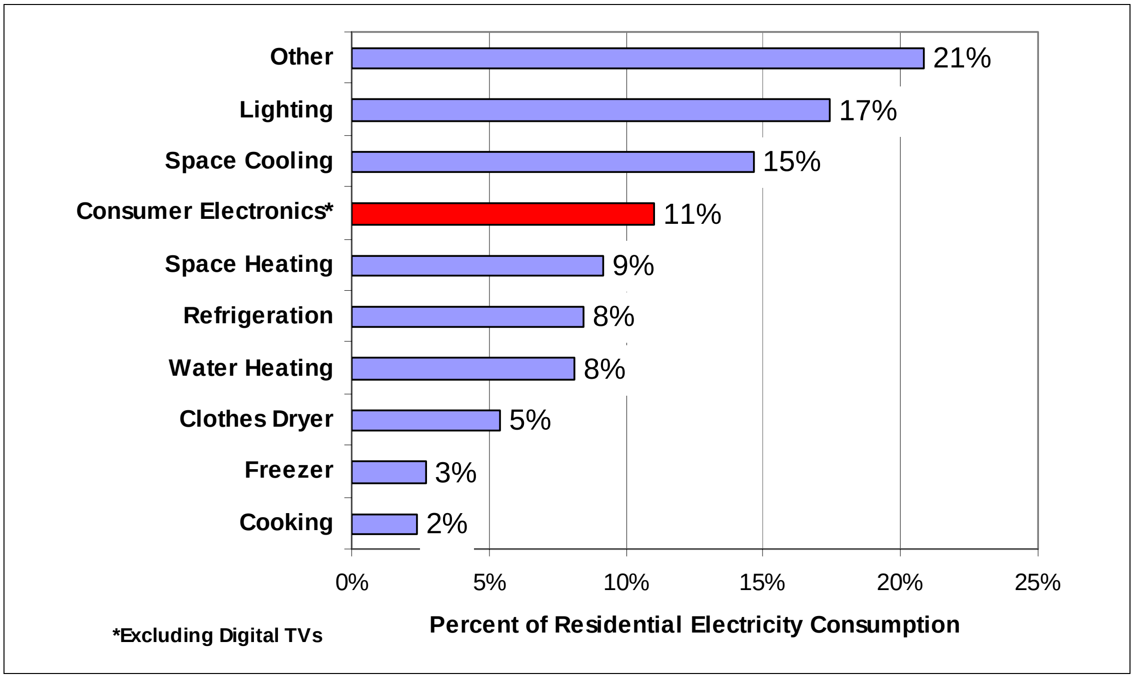

Figure 6-1: U.S. Residential Electricity Consumption in 2006

In primary energy[47] terms, residential CE consumed about 1.6 quads of primary energy, or 7.3% and 1.6% of residential and total U.S. primary energy consumption, respectively (see Figure 6-2).

[47] Primary energy, as opposed to site energy, takes into account the energy consumed at the power plant to generate the electricity. On average, each delivered kWh of electricity in the U.S. in 2006 was estimated to consume 10,815 Btus to generate (i.e., including transmission and distribution losses; EIA 2006).

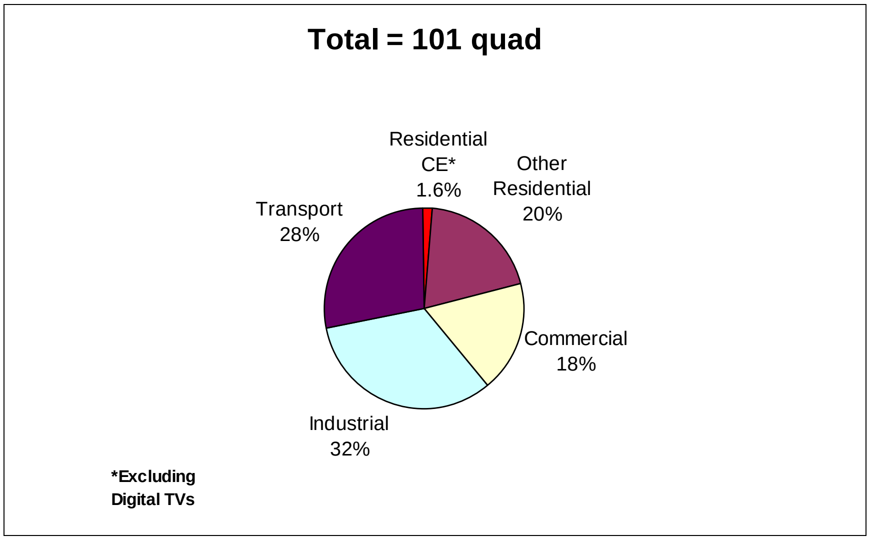

Figure 6-2: U.S. Primary Energy Consumption in 2006

A few products account for a large portion of total CE energy consumption. Specifically, analog TVs accounted for 36% of the total, PCs and monitors 21%, and set-top boxes, including cable, satellite, and stand-alone units, 13% (see Figure 6-3). Although "other" units represent about 40% of the estimated 2.1 billion CE devices in use in U.S. residences, we estimate that they account for only about 11% of CE AEC.

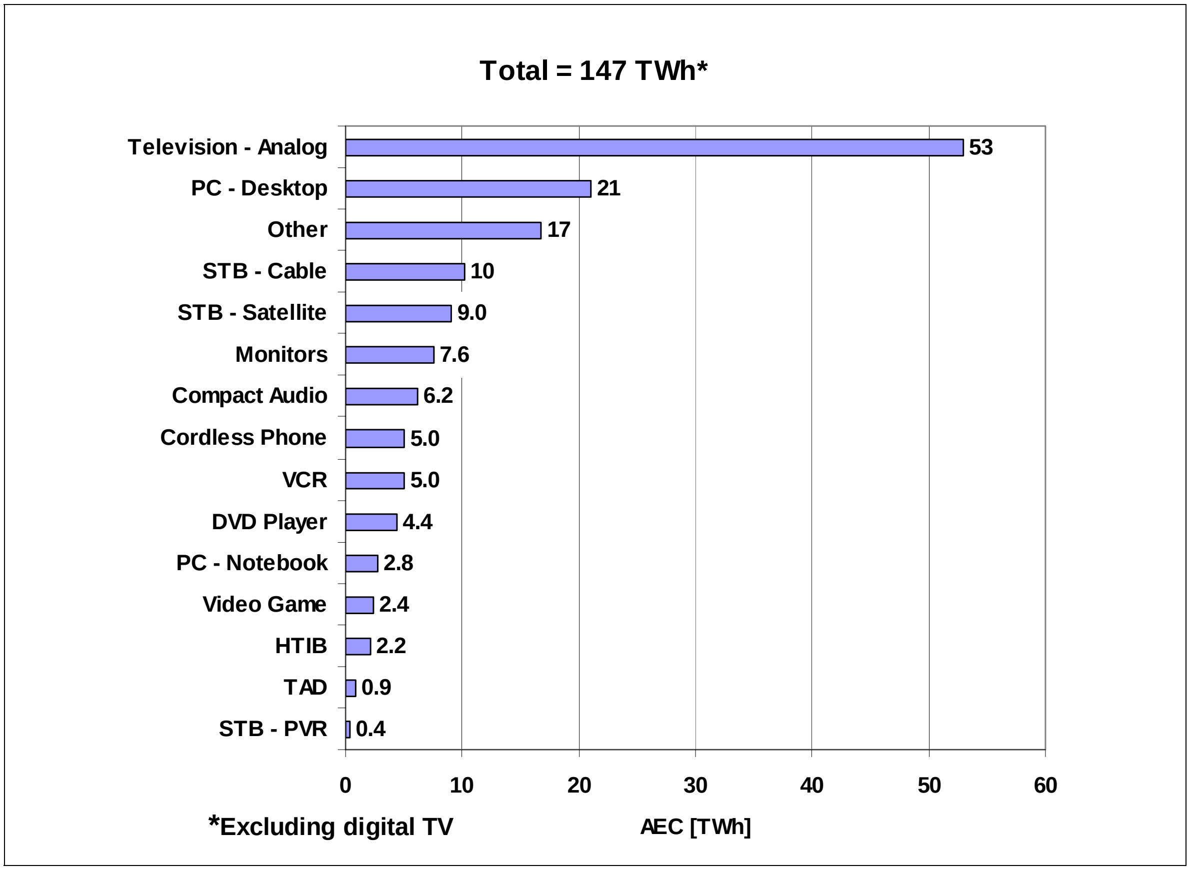

Figure 6-3: Residential CE Energy Consumption in 2006

The average unit electricity consumption (UEC) of CE also varies significantly between device types. For example, the devices with the highest UEC, desktop PCs, stand-alone PVRs, and analog televisions, consumed about an order of magnitude more electricity per unit than the device with the lowest UEC, cordless phones (see Figure 6-4).

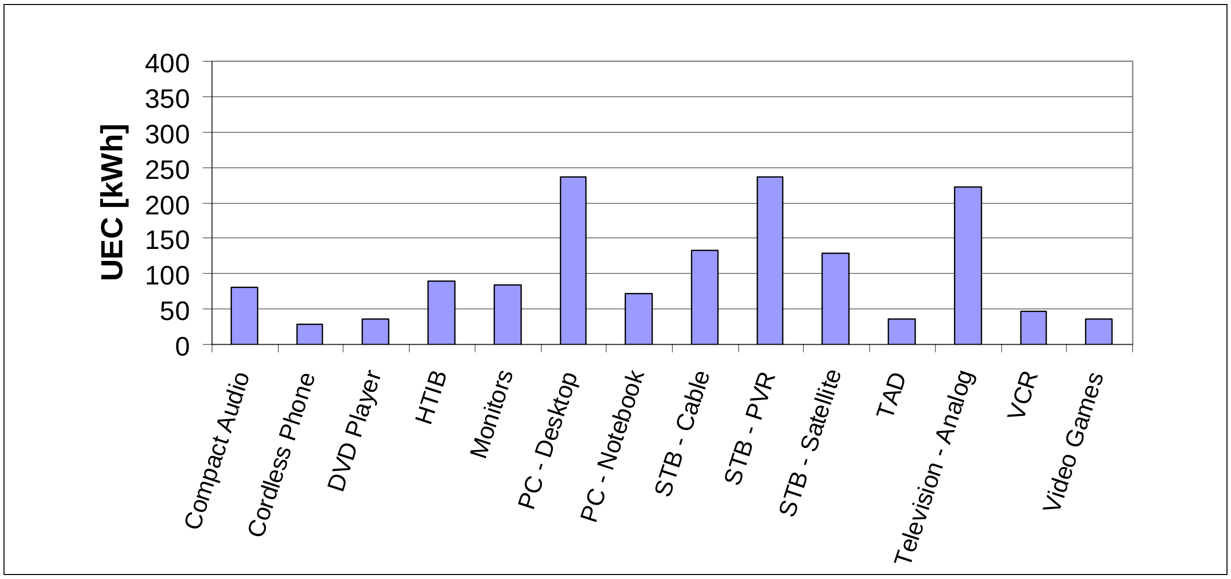

Figure 6-4: Unit Energy Consumption (Per Year) of Devices Selected for Further Analysis

The active mode dominates CE energy consumption and accounts almost 70% of the total AEC of the products analyzed in further detail (see Figure 6-5). Off mode accounts for about one quarter of total AEC, while the idle (8%) and sleep (<1%) are much smaller portions of total AEC.

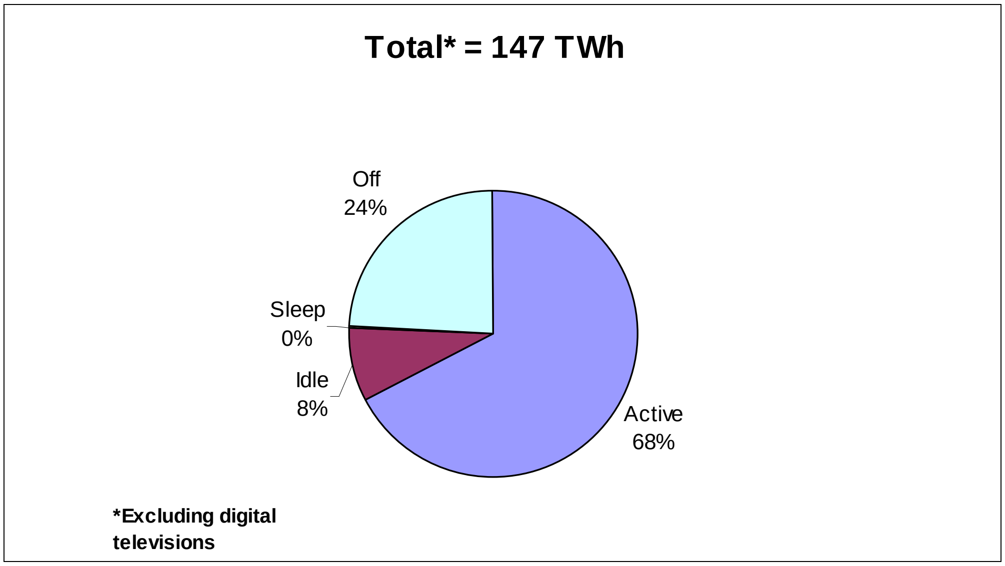

Figure 6-5: Residential CE AEC by Mode (for Devices Analyzed in Further Detail)

In practice, the UEC breakdown by mode varies greatly from one device type to another (see Figure 6-6). For example, the active mode energy consumption dominates (>80% of UEC) for monitors, PCs, and analog televisions, while the off mode consumption accounts for the majority of compact audio, DVD player, VCR, and set-top box UEC. The idle mode energy consumption is most important for cordless phones and telephone answering devices (TADs), devices that remain on all of the time but are only actively used a small portion of that time.

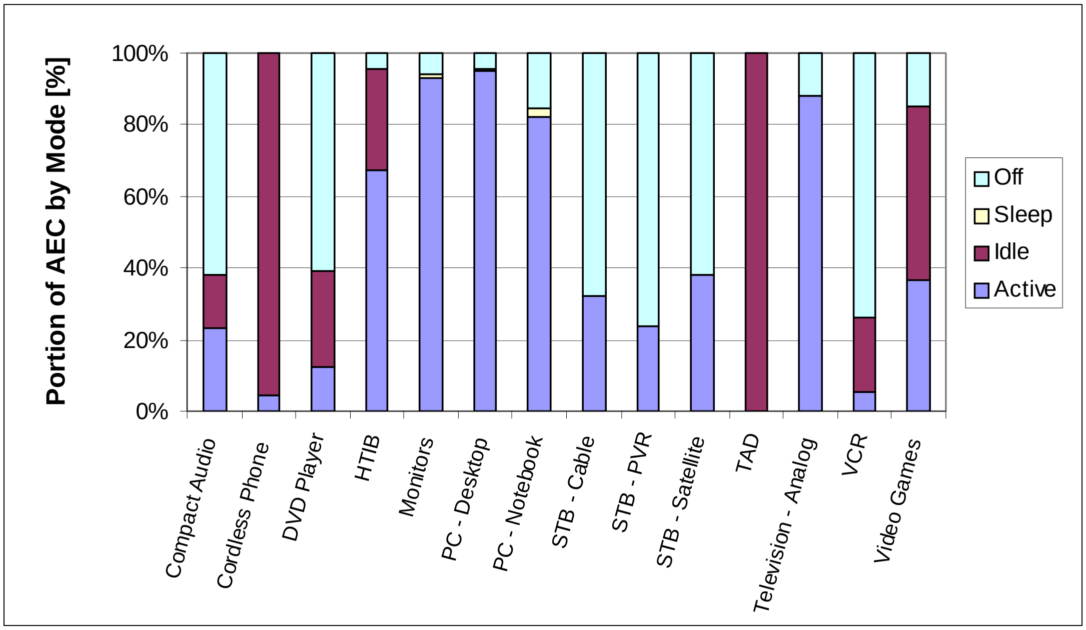

Figure 6-6: UEC by Mode for Devices Analyzed in Further Detail

Key Trends

Without question, the electricity consumption of residential CE has grown appreciably over the past five to ten years. Due to data challenges with prior studies (discussed below), we found it, however, difficult to develop a precise estimate for the magnitude of the increase of CE energy consumption. With this important caveat in mind, relative to prior estimates made five (EIA 2001) and nine (Sanchez et al. 1998, ADL 1998) years ago, the current estimate is approximately 2 and 2.5 times greater, respectively.

Nonetheless, several key trends have had major impacts on all three key factors that impact CE electricity consumption: installed base, power draw by mode, and usage by mode. The installed base of CE products continued to grow over time, with some products experiencing dramatic growth over the past decade and new products coming to market. The estimated installed base of the products shown in Figure 6-7 has approximately doubled since 1997.

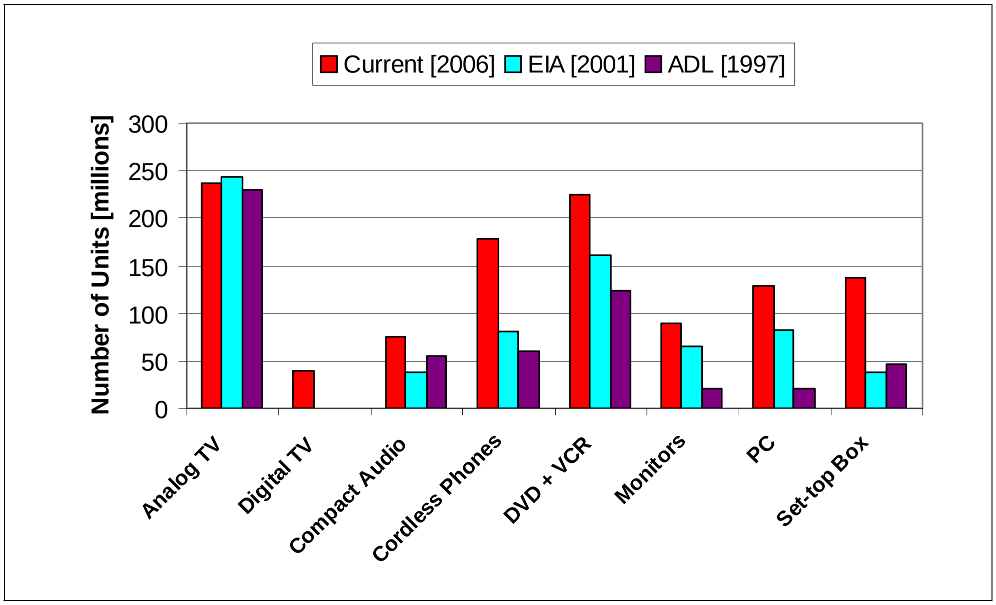

Figure 6-7: Comparison of Current and Prior Estimates for the Installed Base of Selected CE Products

The power draw characteristics of some CE products have changed appreciably. The trend for the active mode power draw of CE products, which accounts for about two-thirds of CE energy consumption, varies appreciably from one product to another (see Table 6-2). All of these trends have occurred while the performance and range of features offered in CE products has generally increased.

Table 6-2: Power Trends in CE Products' Active Mode Power Draw

Increase	• ***TVs*****:** Growth in screen sizes • ***Video Game Systems***: Increased processing power • ***PCs***[48]**:** Increased processing power
Decrease	• ***Monitors*****:** Market move to LCDs • ***VCR***: Not fully clear, likely technological progress
Ambiguous	• ***Cordless Phones*****:** Generally down for basic units, inclusion of answering functionality and multiple handsets increase power draw • ***Set-top Boxes*****:** Although basic unit power draw has generally decreased, power draw has increased in units with PVR and HD functionality

[48] The average power draw of both desktop and notebook PCs has grown. On the other hand, notebook PCs account for an increasingly larger portion of the installed base and this, in turn, has decreased the average growth rate in *total* (i.e., desktop and notebook combined) PC active power draw. Overall, the UEC of *all* PCs plus monitors has decreased over time due to the greater market share of notebook PCs and LCD monitors.

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In contrast, the average sleep and off (also referred to as standby) mode power draw for most CE products has decreased over the past decade, as manufacturers have produced products that meet the maximum power draw criteria established by the EnergyStar® program. In general, the decrease in off mode power draw of typical new units has been greater than the change in the average installed base off mode power draw shown in Figure 6-8. Furthermore, the average sleep mode power draw of desktop PCs (not shown in Figure) has decreased dramatically, from about 25W circa 1996 to approximately 4W. The trend for set-top boxes, which do not currently have an EnergyStar® specification, is less clear. Generally, there is only a slight difference between the active mode and off mode power draws. The power draw of simple STBs in both modes has generally declined. However, the recent rise in popularity of STBs with HD and PVR capability is causing an increase in both active and off mode power draw.

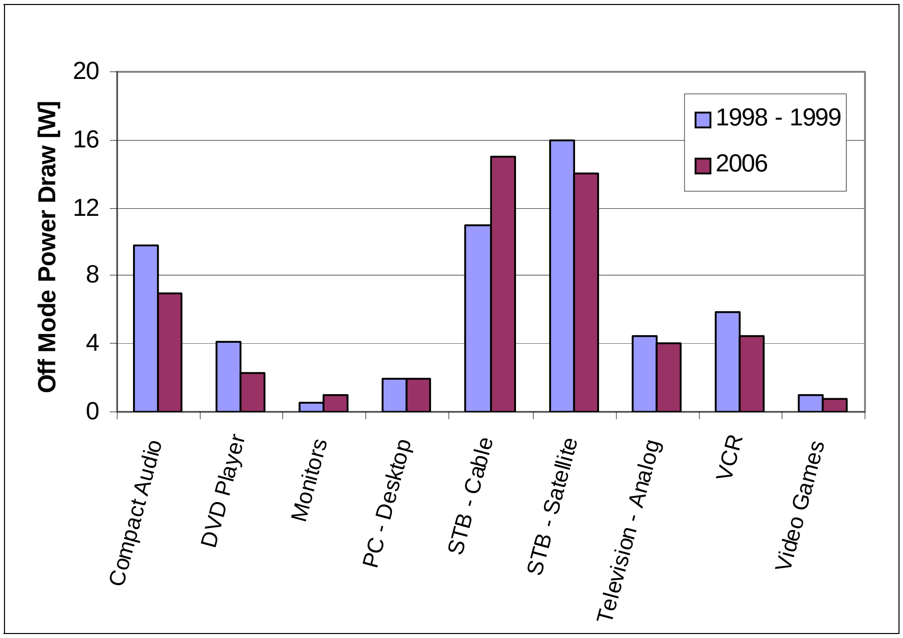

Figure 6-8: Comparison of Off Mode Average Power Draw Estimates for the Installed Bases of CE Products in 2006 and 1998/1999 (Rosen and Meier 1999a,b, Rosen et al. 2001)

Potential changes in CE usage are most challenging to assess. Relative to prior studies, the current study estimates that many products spend significantly more time per year in both active and off modes and, hence, less time in idle/sleep modes. It is not, however, completely clear what portion of these changes are real and what portion reflects the availability of new data characterizing CE usage by mode. Specifically, this study draws extensively from a consumer phone survey developed by the CEA with input from TIAX and outside reviewers to generate more refined and up-to-date estimates for the usage of CE products. The survey posed several questions to 2,000 demographically-representative households about the usage, quantity, and characteristics of ten CE products for (up to) the five most-used devices per product type, per household.

Prior estimates for annual time spent in active mode for TVs, video products, and audio products were developed using credible methodologies and data. Thus, the active mode usage estimates should be generally comparable. Taking this to be the case, this study suggests analog TVs, PCs, and monitors spend appreciably more time in active mode than in the past (see Figure 6-9). As active mode power draw for analog TVs, PCs, and monitors is much greater than in other modes, increased usage tends to significantly increase device UEC and total AEC. Indeed, increased active mode usage account for most of the growth in analog TV UEC relative to Ostendorp et al. (2005).

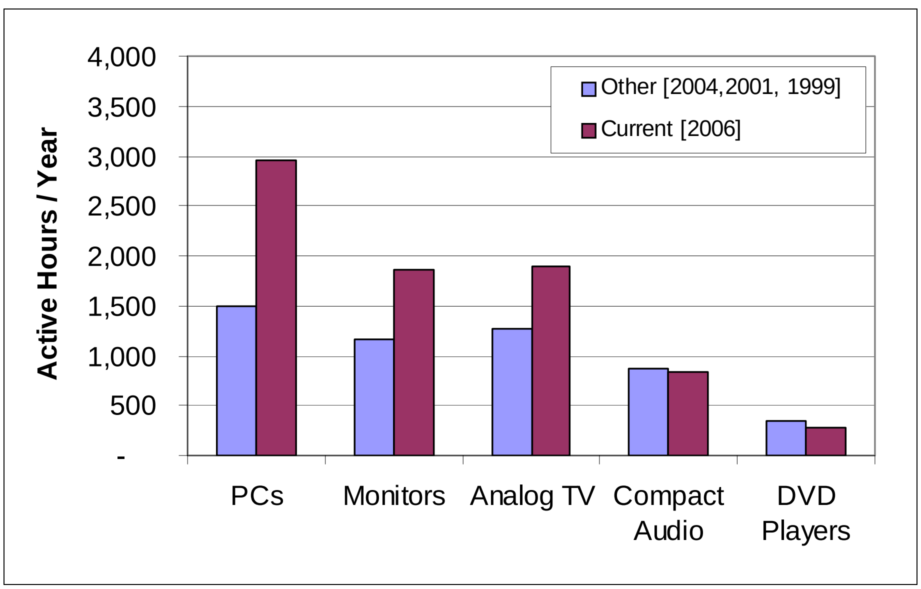

Figure 6-9: Current and Prior Active Mode Usage Estimates for Selected CE (Nordman and Meier 2004, Rosen and Meier 1999a, 1999b, Ostendorp et al. 2005)

Apparent decreases in active mode usage for compact audio and DVD players have, however, relatively little impact on their UEC values because energy consumed in idle and off modes dominate their UECs. In the case of PCs and monitors, this study uses estimates of usage derived from a recent targeted survey that are more accurate than prior estimates (see TIAX 2006b).

Unfortunately, developing meaningful comparisons of current and prior estimates of idle and off mode usage for audio and video products is more challenging. Prior estimates subtracted the active mode usage from the total number of hours in a year and dividing the remaining time between idle and off modes based upon, in essence, personal estimates (Rosen and Meier 1999a, 1999b). For all audio and video products, the survey yielded lower estimates for time spent in idle mode and higher estimates for time spent in off mode than prior estimates. Although we think that the survey-based estimates represent an improvement over prior estimates, we believe that the idle-off split values presented still may have significant uncertainty because some portion of survey respondents may not be aware of whether they have turned off audio and video devices or left them on. The probability of this scenario increases for units that the respondents' personally operate less frequently (i.e., when the respondent answers for a household with multiple occupants).

For some products, namely cable STBs, PVR STBs, satellite STBs, TADs, and, to a lesser extent, cordless phones, power draw by mode does not vary appreciably. As a result, these products are relatively insensitive to the allocation of time by usage mode.

Finally, portable devices account for more than 22% of all residential CE products, but less than 4% of CE AEC, with notebook PCs and CD boomboxes representing more than 80% of the AEC. Products such as mobile phones, digital cameras, and other rechargeable electronics have a large installed base, but consume relatively little energy.

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Appendix A – Details of AEC Calculations for Other Consumer Electronics Products

The following six tables summarize the data used to calculate the AEC of CE products not selected for further analysis. In general, these estimates have a higher degree of uncertainty than those analyzed in the body of the report. Please note that some usage sums may not sum to 8,760 hours due to either rounding or time spent disconnected.

Table A-1: Other Products Power Draw by Mode [Watts]

Product	Active	Recharging	Sleep / Idle Maintenance	Off / No-Load
Caller ID Equipment	1^	N/A	N/A	N/A
Camcorder	N/A	9.6	0.4	0.4
CD Boombox	5.0 / 5.9 / 8.6*	N/A	4.0 / 5.8**	1.8
Component Stereo	43	N/A	43	3
Digital Camera	N/A	3.0	0.4	0.4
Facsimile Machine	#	N/A	10	0
Modem (Cable and DSL)	6	N/A	N/A	N/A
Pager	N/A	3.7^	0.5^	0.25^
Personal Digital Assistant (PDA)	N/A	4.7	0.61	0.58
Portable Audio (MP3 Players)	N/A	3.7	0.6	0.3
Printer	14	N/A	6	3
Radios (home, including clock radios)	2.0	N/A	N/A	1.7##
Mobile Telephone	N/A	3.7	0.5	0.25

^Notably high uncertainty noted for this value
*For Tuner/Line, Tape, and CD.
**For Tape / CD
Nordman and Meier (2004) included additional energy for imaging in lieu of an active mode power draw value
Energy Efficient Strategies (2006) reported an average off mode power draw of 1.5 for radios, and noted that they found 36% of radios unplugged and 11% were turned off via a hard off switches

Table A-2: References for Other Products Power Draw by Mode

Product	Active	Recharging	Sleep / Idle Maintenance	Off / No-Load
Caller ID Equipment	CCAP (2005)			
Camcorder	McAllister and Farrell (2004)			
CD Boombox	Rosen and Meier (1999b)			
Component Stereo	Rosen and Meier (1999b)			
Digital Camera	N/A	McAllister and Farrell (2004), Foster Porter et al. (2006)		
Facsimile Machine	Nordman and Meier (2004)			
Modem (Cable and DSL)	TIAX (2006b)			
Pager	Assumed same as cellular telephone			
Personal Digital Assistant (PDA)	McAllister and Farrell (2004)			
Portable Audio (MP3 Players)	McAllister and Farrell (2004)			
Printer	TIAX (2006b)			
Radios (home, including clock radios)	Rosen and Meier (1999b)	N/A	N/A	Rosen and Meier (1999b), Nordman and McMahon (2004)
Mobile Telephone	N/A	McAllister and Farrell (2004), Ecos (2005)		

Table A-3: Other Products Annual Usage by Mode [hours/year]

Product	Active	Recharging	Sleep / Idle Maintenance	Off / No-Load
Caller ID Equipment	8,760^	N/A	0	0
Camcorder	***			
CD Boombox*	263 / 263**	0	1,139	4,468
Component Stereo	1,580	N/A	730	6,450
Digital Camera	***			
Facsimile Machine	##	N/A	6,987	1,773
Modem (Cable and DSL)	8,760	N/A	N/A	N/A
Pager	N/A	265	1,050	7,445
Personal Digital Assistant (PDA)	***			
Portable Audio (MP3 Players)	***			
Printer	52	N/A	1,606	7,102
Radios (home, including clock radios)	131	N/A	N/A	8,629
Mobile Telephone	N/A	265	1,050	7,445

^CCAP (2005) characterizes the one mode for caller ID equipment as the active mode
*30% of time estimated spent disconnected
**For Line / CD-Tape
***Not shown in McAllister and Farrell (2004)
#Assumed same as cellular telephone
Nordman and Meier (2004) included additional energy for imaging in lieu of active mode power usage

Table A-4: References for Other Products Annual Usage by Mode Estimates

Product	Active	Recharging	Sleep / Idle Maintenance	Off / No-Load
Caller ID Equipment	CCAP (2005)			
Camcorder	N/A			
CD Boombox	Rosen and Meier (1999b)			
Component Stereo	CEA Survey			
Digital Camera	N/A			
Facsimile Machine	Nordman and Meier (2004)			
Modem (Cable and DSL)	TIAX (2006b)			
Pager	Assumed same as Cellular Telephones			
Personal Digital Assistant (PDA)	N/A			
Portable Audio (MP3 Players)	N/A			
Printer	TIAX (2006b)			
Radios (home, including clock radios)	Rosen and Meier (1999b)			
Mobile Telephone	Estimated from McAllister and Farrell (2004)			
*CCAP (2005) characterizes the one mode for caller ID equipment as the active mode.				

Table A-5: UEC and Installed Base Estimates for Other Products

Product	UEC [kWh]	Installed Base [millions]	AEC [TWh]
Caller ID Equipment	9	29	0.3
Camcorder	2.3*	64	0.1
CD Boombox	17	95	1.6
Component Stereo	119	50	6.0
Digital Camera (rechargeable)	7.2*	6.6	0.05
Facsimile Machine	6.3	70	0.4
Modem (Cable and DSL)	53	46	2.4
Pager	3.5	14	0.05
Personal Digital Assistant (PDA)	6.1*	21	0.1
Portable Audio (MP3 Players)	5.6	23	0.1
Printer	30	88	2.8
Radios (home, including clock radios)	15	145	2.2
Mobile Telephone	3.5*	219	0.8
	TOTAL	870	17
*UEC from McAllister and Farrell (2004)			

Table A-6: References for Installed Base Estimates for Other Products

Product	Source(s)
Caller ID Equipment	CCAP (2005)
Camcorder	CEA (2005b)
CD Boombox	CEA (2005b)
Component Stereo	Rosen and Meier (1999b) and CEA (2006)
Digital Camera (rechargeable)	CEA (2005b), CCAP (2005)
Facsimile Machine	Nordman and Meier (2004)
Modem (Cable and DSL)	Based on number of households with broadband access (see the "Personal Computers" section)
Pager	Installed Base: CEA (2005a) UEC: Assumed same as Cellular Phones
Personal Digital Assistant (PDA)	CEA (2005b)
Portable Audio (MP3 and CD Players)	CEA (2005b)
Printer	TIAX (2006b)
Radios (home, including clock radios)	Rosen and Meier (1999b) scaled to number of households in 2006 (EIA 2006)
Mobile Telephone	CTIA (2006), CEA (2005a)

Appendix B – CEA Usage Survey

The following is the script used by the consumer research company that performed the usage survey.

E1 How many of each of the following products do you, or does someone in your household, CURRENTLY have plugged into an electrical outlet? [READ AND ROTATE ITEMS. RECORD NUMBER FROM 0-10 FOR EACH, -1 FOR DON'T KNOW/NOT SURE]

A. TV, NOT including any high-definition TVs
B. High-definition TV, also called HDTV
C. Digital video recorder, such as TiVo, that is NOT part of a DVD player, cable or satellite set-top box
D. Satellite television set-top box
E. Cable television set-top box
F. Home DVD player, NOT including a DVD drive on a computer
G. VCR
H. Video game console, such as an Xbox, PlayStation, or GameCube
I. Home theater in a box system, where the speakers and A/V receiver all came in one package
J. Shelf stereo system, also called a mini or compact stereo system

FOR E2-E5, ASK FOR UP TO 5 FOR EACH ITEM OWNED

For the remaining questions, please think in terms of the product you use most often, second most often, etc.

[ASK IF ANY IN E1D (1-10)]
E2 Is the [INSERT] satellite television set-top box that you own . . . [READ LIST. RECORD AS MANY AS APPLY]

01 Capable of receiving and displaying high-definition television signals
02 Have a digital video recorder included
• DON'T KNOW/NOT SURE

A. Primary
B. Second
C. Third
D. Fourth
E. Fifth

[ASK IF ANY IN E1E (1-10)]

E3 Is the [INSERT] cable television set-top box that you own . . . [READ LIST. RECORD AS MANY AS APPLY]

01 Capable of receiving and displaying high-definition television signals
02 Have a digital video recorder included
99 DON'T KNOW/NOT SURE

A. Primary
B. Second
C. Third
D. Fourth
E. Fifth

[ASK IF ANY IN E1F (1-10)]

E4 Is the [INSERT] DVD player that you own . . . [READ LIST. RECORD AS MANY AS APPLY]

01 Capable of recording programs onto a DVD disc
02 Capable of recording programs onto an internal hard drive, like a TiVo does
99 DON'T KNOW/NOT SURE

A. Primary
B. Second
C. Third
D. Fourth
E. Fifth

[ASK IF ANY IN E1A (1-10)]

E5 What is the approximate screen size of the [INSERT] TV that you own, that is not a high-definition TV? If you are not sure, please use your best estimate. [DO NOT READ LIST. PROBE WITH ANSWER LIST BEFORE ACCEPTING DON'T KNOW]

01 13 INCHES OR SMALLER
02 14 INCHES TO LESS THAN 19 INCHES
03 19 INCHES TO LESS THAN 25 INCHES
04 25 INCHES TO LESS THAN 32 INCHES
05 32 INCHES TO LESS THAN 42 INCHES
06 42 INCHES TO LESS THAN 52 INCHES
07 52 INCHES OR LARGER
99 DON'T KNOW/NOT SURE

A. Primary
B. Second
C. Third

D. Fourth
E. Fifth

[ASK IF ANY IN E1B (1-10)]

E6 What is the approximate screen size of the [INSERT] high-definition TV that you own? If you are not sure, please use your best estimate. [DO NOT READ LIST. PROBE WITH ANSWER LIST BEFORE ACCEPTING DON'T KNOW]

01 13 INCHES OR SMALLER
02 14 INCHES TO LESS THAN 19 INCHES
03 19 INCHES TO LESS THAN 25 INCHES
04 25 INCHES TO LESS THAN 32 INCHES
05 32 INCHES TO LESS THAN 42 INCHES
06 42 INCHES TO LESS THAN 52 INCHES
07 52 INCHES OR LARGER
99 DON'T KNOW/NOT SURE

A. Primary
B. Second
C. Third
D. Fourth
E. Fifth

FOR E7 SERIES, ASK FOR EACH PRODUCT IN E1A-J [1-10].
ASK IN SEQUENCE BY PRODUCT FOR PRIMARY, TURNED ON/IN ACTIVE USE, SECOND, TURNED ON/IN ACTIVE USE, ETC (UP TO FIFTH)
BEFORE MOVING ON TO NEXT PRODUCT.
ANSWER FOR TURNED ON (1) CAN NOT BE LESS THAN ANSWER FOR IN ACTIVE USE (2)

Next, I am going to ask you a couple of questions about how you and those in your household use each of the products you currently have plugged into an electrical outlet. I am going to use two terms that I will define for you.

The first term is "turned on". "Turned on" means that the device power is in the ON mode regardless of whether someone is actually using it. For example, a DVD player is turned on when it is playing or recording, as well as when it is ready to play or record but is not actually playing or recording.

The second term is "active use". "Active use" means that the device is on AND being used by someone. For example, when a DVD player is in active use, someone is using it to watch a movie, listening to a CD or to record something.

E7 Now, thinking of the [INSERT a-e] [INSERT PRODUCT A-J] that you own, during the PAST 24 HOURS, how much time was it . . . If you are not sure, please use your best estimate. [DO NOT READ LIST. PROBE WITH ANSWER LIST BEFORE ACCEPTING DON'T KNOW]

01 ZERO MINUTES
02 1 MINUTE TO LESS THAN 15 MINUTES
03 15 MINUTES TO LESS THAN 30 MINUTES
04 30 MINUTES TO LESS THAN 1 HOUR
05 1 HOUR TO LESS THAN 2 HOURS
06 2 HOURS TO LESS THAN 3 HOURS
07 3 HOURS TO LESS THAN 5 HOURS
08 5 HOURS TO LESS THAN 7 HOURS
09 7 HOURS TO LESS THAN 10 HOURS
10 10 HOURS TO LESS THAN 14 HOURS
11 14 HOURS TO LESS THAN 24 HOURS
12 24 HOURS
99 DON'T KNOW/NOT SURE

[ASK FOR EACH PRODUCT OWNED, E1A-J (1-10)]

A. TV, NOT including any high-definition TVs
B. High-definition TV, also called HDTV
C. Digital video recorder, such as TiVo, that is NOT part of a DVD player, cable or satellite set-top box
D. Satellite television set-top box
E. Cable television set-top box
F. Home DVD player, NOT including a DVD drive on a computer
G. VCR
H. Video game console, such as an Xbox, PlayStation, or GameCube
I. Home theater in a box system, where the speakers and A/V receiver all came in one package
J. Shelf stereo system, also called a mini or compact stereo system

[ASK FOR UP TO 5 OWNED FOR EACH PRODUCT]

a. Primary
b. Second
c. Third
d. Fourth
e. Fifth

["IN ACTIVE USE" TO BE ASKED IF "TURNED ON" IS 02-99. ANSWER FOR "IN ACTIVE USE" CAN NOT BE GREATER THAN ANSWER FOR "TURNED ON"]

1 Turned on
2 In active use

Appendix C – Measurement Test Procedures

To support this project, the CEA carried out measurements of the power draw of several devices, including compact audio products, DVD players, HTIB, PVRs, cable and satellite set-top boxes, and video consoles. In an attempt to have the power draw data approach the characteristics of the units actually sold and used, the manufacturers asked to supply equipment for measuring were identified as manufacturers with major market shares for that product. Furthermore, the equipment request specifically asked manufacturer to provide their better-selling products

<u>Compact Audio</u>

Equipment:

- Electronic Product Design Inc. Single Phase Power Multimeter PLM1-LP
- Computer with Electronic Product Design Inc. Serial Software, Microsoft Excel and Microsoft Word
- Test CD with 15 minute tracks of a 1 kHz sine tone set apart at 1 dB increments (10 tracks total on two CDs)
- Fluke 179 True-rms Multimeter with Backlight and Temperature

Procedure:

Setup

1. Ensure test room ambient temperature is (23 ± 5) °C, in accordance with IEC 62301, section 4.2.
2. First plug the Single Phase Power Multimeter into a standard US 115V wall outlet. And set up the datalogger function to record every two seconds.
3. Then set up the compact audio system according to manufacturer instructions included in the box. All components should be attached as if it were to be set up in a home.
4. Next record the Brand, Model, Serial Number, date of Manufacture and features the system has.
5. Record the Supply Voltage and frequency.
6. Then plug the audio system into the Single Phase Power Multimeter output socket (which supplies power to the system through the wall outlet) and record the Default state into which the system went. Determine if the system has more than system has more than one standby state and record which features are enabled in the each standby mode. If there is a clock function set the time to some arbitrary time.

Standby Mode Power Measurement

7. Next turn the system into the on state and then into the Default Standby Mode. Allow the system remain in Standby for 5 minutes in order to let the power consumption stabilize
8. Start the datalogger function which will record the power usage in Watts, and the power factor of the audio equipment in Standby into a file on the computer. Data will be recorded every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
9. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for power and two decimal places for the power factor; record the values in the cumulative spreadsheet of all compact audio equipment.
10. Repeat steps 7-9 for additional Standby Modes such as Demo Mode or the Standby with or without the clock display.

On Mode Power Measurement

11. Find and record the impedance of the main speakers which is listed on the speakers. Use the formula $V_{RMS} = (P*\Omega)^{1/2}$ where P = .05 Watts and Ω is the impedance of the main speaker to calculate the V_{RMS}.
12. Attach the multimeter to the main speaker cables so the red probe is on the signal wire and the black probe is on the ground wire. Turn on the multimeter and set it to measure the V_{RMS} of the alternating current. Insert the test CD and start the 1 kHz sine tone. Adjust the volume or change tracks until the V_{RMS} measured is within 5 mV of the V_{RMS} calculated in step 11 or as close as you can get if the system has discrete volume levels. Allow the system to stabilize for 5 minutes after the proper volume level is achieved
13. Start the datalogger function which will record the power usage in Watts, and the power factor of the audio equipment in Standby into a file on the computer. Data will be recorded every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
14. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for power and two decimal places for the power factor; record the values in the cumulative spreadsheet of all compact audio equipment.

Cordless Phone

Use the EnergyStar® test procedure to measure power draw when the phone unit sitting in place with the fully charged handset in the cradle.

To measure the power draw in the mode where the handset is removed from the cradle but not in use and the base station continues to draw power, use a modified version of the EnergyStar® procedure. Manufacturers should perform testing using the same procedure and equipment detailed in the EnergyStar test procedure, with the exception of Section 5, "Test Criteria", clause 1. of Subsection C ("Test Method"). It currently reads:

> 1. Power the PUT. When rechargeable batteries are involved, the PUT must be fully charged (allow up to 24 hours). The PUT must be in an on-hook state. Cordless phones and combination units must have the handset on the cradle.

For the Handset Removed state, this is modified to:

> 1. Power the PUT. The PUT must be in an on-hook state. Cordless phones and combination units must have the handset removed from the cradle.

DVD Players and Recorders

Equipment:

- Electronic Product Design Inc. Single Phase Power Multimeter PLM1-LP
- Computer with Electronic Product Design Inc. Serial Software, Microsoft Excel and Microsoft Word
- Toshiba MD20Q41 Television / DVD Combination Serial Number: 98Z55818B
- Test DVD - footage of the 2006 CES. Moving Natural Images such as is seen on most TV programming. This was used over a static signal for its better representation of the complexity of MPEG compression and decompression in players and recorders.
- Input DVD player - Insignia IS-DVD040924 SN: 510117308
- Blank Philips 1-16x 4.7 GB DVD-Rs

Procedure:

Setup

1. Ensure test room ambient temperature is (23 ± 5) °C, in accordance with IEC 62301, section 4.2.
2. First plug the into a standard US 115V wall outlet. And set up the datalogger function to record every two seconds.
3. Then set up the DVD Player according to manufacturer instructions included in the box. Connect the DVD player to the test TV as if it were to be used in a home using the composite connections, and plug the TV into a standard wall socket and

turn the TV on and leave it in the on state for the rest of the experiment. Test the setup with a DVD to make sure it is hooked up properly.

4. Next record the Brand, Model, Serial Number, date of Manufacture and features the DVD player has.
5. Record the Supply Voltage and frequency.
6. Plug the DVD player into the Single Phase Multimeter output socket (which supplies power to the DVD player through the wall outlet) and record the Default state into which the system went. Determine if the system has more than one standby state and record which features are enabled in the each of the standby modes. If there is a clock function set the time to some value so that it is keeping track of the time.

Standby Mode Power Measurement

7. Next turn the DVD player into the on state and then back into the Default Standby Mode. Allow the system remain in Standby for 5 minutes in order to let the power consumption stabilize
8. Start the datalogger function which will record the power usage in Watts, and the power factor of the DVD player in Standby into a file on the computer. Data will be recorded once every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
9. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all DVD players.
10. Repeat steps 7-9 for additional Standby Modes such as Standby with or without the clock display.

On Mode Power Measurement

11. Insert the test DVD into the DVD player and start playing the DVD. Wait 15 minutes for the system to stabilize. The parameters of the test DVD are described in the equipment section.
12. Start the datalogger function which will record the power usage in Watts, and the power factor of the DVD player in on mode into a file on the computer. Data will be recorded every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
13. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all DVD players/recorders.

Recording Mode (Only for DVD Recorders)

14. If the unit has a DVD Recording feature continue with the following procedure. If not stop here, testing is done for the unit.
15. Set up the input DVD player according to the user's manual. Plug the unit directly into the wall and connect the component output of the input unit to the component input of the recording unit that will be measured. Put a blank 1-16x DVD-R into the DVD drive of the recording unit and place the test DVD into input DVD player.
16. Play the Test DVD on the input unit so that is outputting the signal to the recording unit. Follow the user's manual instructions on how to record from component input and start recording the signal. Wait 15 minutes for the system to stabilize.
17. Start the datalogger function which will record the power usage in Watts, and the power factor of the DVD recorder in record mode into a file on the computer. Data will be recorded every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
18. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all DVD players/recorders.

Waiting Mode (Only for DVD Recorders)

19. First Determine if the DVD recorder can be set to record at a set time. If it can then set it to record from the Component input at least one hour from the current time. Read the users manual to determine the mode the system needs to be in order to record the desired content. Set the system to that state whether it is standby mode or the on mode while sitting idle. Wait 15 minutes for the system to stabilize.
20. Start the datalogger function which will record the power usage in Watts, and the power factor of the DVD recorder in record mode into a file on the computer. Data will be recorded every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
21. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all DVD players/recorders.

Home Theater in a Box

Equipment:

- Electronic Product Design Inc. Single Phase Power Multimeter PLM1-LP
- Computer with Electronic Product Design Inc. Serial Software, Microsoft Excel and Microsoft Word
- Toshiba MD20Q41 Television / DVD Combination Serial Number: 98Z55818B
- Test DVD – Commercial DVD.
- Input DVD player - Insignia IS-DVD040924 SN: 510117308
- Test CD with 15 minute tracks of a 1 kHz sine tone set apart at 1 dB increments (10 tracks total on two CDs) only the first track is used.
- Fluke 179 True-rms Multimeter with Backlight and Temperature

Procedure:

Setup

1. Ensure test room ambient temperature is (23 ± 5) °C, in accordance with IEC 62301, section 4.2 and compliant with IEC 62087, section 5.1.2.
2. First plug the single phase power multimeter into a standard US 115V wall outlet. And set up the datalogger function to record every two seconds.
3. Then set up the HTIB System according to manufacturer instructions included in the box. Connect the system to the test TV as if it were to be used in a home using the composite connections, and plug the TV into a standard wall socket and turn the TV on and leave it in the on state for the rest of the experiment. Test the setup with a DVD to make sure it is hooked up properly.
4. Next record the Brand, Model, Serial Number, date of Manufacture and features the HTIB system has.
5. Record the Supply Voltage and frequency.
6. Plug the system into the Single Phase Multimeter output socket (which supplies power to the system through the wall outlet) and record the Default state into which the system went. Determine if the system has more than one standby state and record which features are enabled in the each of the standby modes. If there is a clock function set the time to some value so that it is keeping track of the time.
7. If the system does not have a built in DVD player hook up an external DVD player to provide the input signal for the HTIB unit. Connect the DVD player using composite connections. The DVD player should be connected directly to the wall and not be measured as part of the power consumption.

Standby Mode Power Measurement

8. Next turn the system into the on state and then back into the Default Standby Mode. Allow the system remain in Standby for 5 minutes in order to let the power consumption stabilize
9. Start the datalogger function which will record the power usage in Watts, and the power factor of the system in Standby into a file on the computer. Data will be recorded once every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
10. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all HTIB Systems.
11. Repeat steps 7-9 for additional Standby Modes such as Standby with or without the clock display.

On Mode Power Measurement

12. Find and record the impedance of the front left or right speaker which is listed on the speaker. Use the formula $V_{RMS} = (P*\Omega)^{1/2}$ where P = .05 Watts and Ω is the impedance of the speaker to calculate the V_{RMS} to be achieved.
13. Insert the test CD into either the unit itself or into the input DVD player unit so that the system is producing an audio output. Play the fist track on the CD which is the full scale 1 kHz sine tone. Attach the multimeter to the front left or right speaker wires so the red probe is on the signal wire and the black probe is on the ground wire. Turn on the multimeter and set it to measure the V_{RMS} of the alternating current. Adjust the volume or change tracks until the V_{RMS} measured is within 5 mV of the V_{RMS} calculated in step 11 or as close as you can get if the system has discrete volume levels. Record the actual V_{RMS} achieved in the results. After the volume is set to the correct level remove the CD and do not change the volume of the system for the rest of the experiment.
14. Record whether the HTIB system has a built in DVD player in it and record this in the results.
15. If the system does not have a built in DVD player use an external DVD for input to the system (the details of the input player are described in the equipment section). The input DVD player should be hooked up directly to a wall outlet and the power consumption of the DVD player is not counted towards the power consumption of the HTIB system. Start playing the DVD. Wait 15 minutes for the system to stabilize. The parameters of the test DVD are described in the equipment section.

16. If the system does have a built in DVD player insert the test DVD into the player In the HTIB system and start playing the DVD. Wait 15 minutes for the system to stabilize. The parameters of the test DVD are described in the equipment section.
17. Start the datalogger function which will record the power usage in Watts, and the power factor of the DVD player in on mode into a file on the computer. Data will be recorded every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
18. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all HTIB Systems

<u>Personal Video Recorder</u>

Equipment:

- Electronic Product Design Inc. Single Phase Power Multimeter PLM1-LP
- Computer with Electronic Product Design Inc. Serial Software, Microsoft Excel and Microsoft Word
- Toshiba MD20Q41 Television / DVD Combination

Procedure:

Setup

1. Ensure test room ambient temperature is (23 ± 5) °C, in accordance with IEC 62301, section 4.2 and compliant with IEC 62087, section 5.1.2.
2. First plug the Single Phase Power Multimeter into a standard US 115V wall outlet. And set up the datalogger function to record every two seconds.
3. Then set up the DVR according to manufacturer instructions included in the box. Connect the DVR to the test TV as if it were to be used in a home using the composite connections, and plug the TV into a standard wall socket and turn the TV on and leave it in the on state for the rest of the experiment. Plug the DVR into the Single Phase Multimeter output socket (which supplies power to the DVR through the wall outlet) and record the Default state into which the system went. Determine if the system has more than one standby state and record which features are enabled in the each of the standby modes. If there is a clock function set the time to some value so that it is keeping track of the time.
   Test the setup to ensure everything is working properly. Allow to sit in standby for up to 24 hours to load TVGOS data.

4. Next record the Brand, Model, Serial Number, date of Manufacture and features the DVR has.
5. Record the Supply Voltage and frequency.

Watch and Record Mode (Systems with two tuners only)

6. Set the system to start recording one channel then switch channels so another channel is being viewed on the television. Allow the system to set in this state for five minutes to stabilize
7. Start the datalogger function which will record the power usage in Watts, and the power factor of the DVR into a file on the computer. Data will be recorded once every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
8. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all DVRs.

Delayed Watching Mode

9. Set the system to start recording one channel. Allow the system to record for five minutes. Next pause the channel one minute (It will still continue recording) and then continue watching the channel. This should be playing back off of the hard drive as it recording the show one minute after it is recorded.
10. Start the datalogger function which will record the power usage in Watts, and the power factor of the DVR into a file on the computer. Data will be recorded once every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
11. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all DVRs.

Standby Mode Measurement

12. Next turn the DVR into the on state and then back into the Default Standby Mode. Allow the system remain in Standby for 5 minutes in order to let the power draw stabilize
13. Start the datalogger function which will record the power usage in Watts, and the power factor of the DVR in Standby into a file on the computer. Data will be recorded once every two seconds. Stop datalogging after 5 minutes. A total of

150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.

14. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all DVRs.
15. Repeat steps 12-14 for additional Standby Modes such as Standby with or without the clock display.

<u>Set-top Boxes</u>

Equipment:

- Electronic Product Design Inc. Single Phase Power Multimeter PLM1-LP

Procedure:

Setup

1. Ensure test room ambient temperature is (23 ± 5) °C, in accordance with IEC 62301, section 4.2 and compliant with IEC 62087, section 5.1.2.
2. First plug the single phase power multimeter into a standard US 115V wall outlet.
3. Make sure the STB is set up according to manufacturer or service providers instruction and is connected to the proper signal input
4. Next record the Brand, Model, Serial Number, date of Manufacture and features the Set Top Box has.
5. Record the Supply Voltage and frequency using the single phase power multimeter.
6. Next hit the mode button on the multimeter until the unit displays Hours and TA-Watts. This corresponds to the hours the test has been running and average power draw over that time in watts. Plug the Set Top Box into the outlet on the front of the multimeter, this should supply power to the Set Top Box.

Active Mode Power Measurement

7. Turn the connected TV on and switch the set Top box on so that it is displaying a live channel. If the STB has an integrated DVR with “time slip mode” which allows you to record TV and watch it as it is being recorded, enable recording and allow at least 30 seconds of delay between when the cable box receives the signal and when it is displayed. This can be done by

pausing the TV, letting it sit for 30 seconds and then resume playing the TV. If the STB does not enable pausing live TV, then simply set it to display a live channel. Allow the system to remain in this state for ten minutes.

8. After the ten minutes press and hold the option button on the multimeter until it displays all zeros. Release the button and the multimeter should start reading in data. Let the system run for another five minutes.
9. After the five minutes read the value of Time Average Watts and record that in the data table

Standby Mode Power Measurement

1. Switch the STB into its standby mode by pressing the power button. Allow the system to set for five minutes.
2. Start the datalogger function which will record the power usage in Watts, and the power factor of the STB in on mode into a file on the computer. Data will be recorded every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
3. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all STB.

Video Game Systems

Equipment:

- Electronic Product Design Inc. Single Phase Power Multimeter PLM1-LP
- Computer with Electronic Product Design Inc. Serial Software, Microsoft Excel and Microsoft Word
- Planar P42HSAT Television

Procedure:

Setup

1. Ensure test room ambient temperature is (23 ± 5) °C, in accordance with IEC 62301, section 4.2 and compliant with IEC 62087, section 5.1.2.
2. First plug the Single Phase Power Multimeter into a standard US 115V wall outlet. And set up the datalogger function to record every two seconds.
3. Then set up the Game System according to manufacturer instructions included in the box. Connect the system to the test TV as if it were to be used in a home using the composite connections, and plug the TV into a standard wall

socket and turn the TV on and leave it in the on state for the rest of the experiment. Test the setup with a game to make sure it is hooked up properly.

4. Next record the Brand, Model, Serial Number, date of Manufacture and features the game system has.
5. Record the Supply Voltage and frequency.
6. Plug the system into the Single Phase Multimeter output socket (which supplies power to the system through the wall outlet) and record the Default state into which the system went. If there is a clock function set the time to some value so that it is keeping track of the time.

Active Mode Power Measurement

7. Turn the system on and insert the compatible game into the system. Play the game as a single player as a consumer would for ten minutes.
8. After ten minutes start the datalogger function which will record the power usage in Watts, and the power factor of the system into a file on the computer. Data will be recorded once every two seconds. Continue to play the game after the recording has been started. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
9. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all game systems.

Pause Mode Power Measurement

10. Next pause the game using either a menu or a pause feature. Set down the controller so that there is no change in the player input and let the system set for five minutes
11. After five minutes start the datalogger function which will record the power usage in Watts, and the power factor of the system into a file on the computer. Data will be recorded once every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
12. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all game systems.

Standby Mode Power Measurement

13. Hit the power button on the system turning it into its standby state. Allow the game to remain in this state for five minutes.

14. After five minutes start the datalogger function which will record the power usage in Watts, and the power factor of the system into a file on the computer. Data will be recorded once every two seconds. Stop datalogging after 5 minutes. A total of 150 data points for each variable will be measured. Put this data into a spreadsheet using commas as the division between columns.
15. Calculate the average power consumption and power factor over the five minute period. Round the value to the nearest two decimal places for the power and two decimal places for the power factor; record the value in the cumulative spreadsheet of all game systems.

Appendix D – Power Draw Measurements by CEA

Several CEA member companies provided power draw data for their best-selling products circa 2006. As part of the data provision agreement, they collectively requested, however, that the report not show power draw measurements for specific units. Instead, we provide the unidentified power draw measurements along with their generic characteristics in the Tables that follow.

Compact Audio

Unit	Year of Manufacture	Off Power [W]	Active Power [W]
1	1991	2.4	NA
2	1991	2.4	NA
3	1992	5.3	NA
4	1995	9.5	NA
5	1995	2.0	NA
6	1998	15	NA
7	1999	0.1	NA
8	2002	2.5	12
9	2002	1.9	11
10	2003	11	NA
11	2003	2.1	NA
12	2004	3.3	13
13	2004	0.3	NA
14	2005	1.9	NA
15	2005	5.3	15
16	2005	2.7	11
17	2005	4.3	15
18	2005	0.6	33
19	2005	0.3	28
20	2005	0.3	34
21	2005	0.3	38
22	2005	2.1	8.5
23	2005	3.2	12
24	2005	15	39
25	2005	0.2	16
26	2005	2.1	7.1
27	2006	3.3	13
28	2006	4.4	15
29	2006	2.0	11
30	2006	2.4	11
31	2006	0.7	31
32	2006	3.4	24
33	2006	0.7	27

Unit	Year of Manufacture	Off Power [W]	Active Power [W]
34	2006	0.4	23
35	2006	3.1	NA
36	2006	0.5	21
37	2006	0.7	28
38	2006	16	NA
39	2006	21	48
40	2006	4.4	12
41	2006	12	33
42	2006	13	30
43	2006	0.2	27
44	2006	0.2	27
45	2006	0.2	28
46	2006	0.2	53
47	2006	0.2	32
48	2006	0.2	NA
49	2006	0.2	NA
50	2006	0.3	16
51		18	29

Cordless Telephones

Unit	Frequency	Digital or Analog?	Integrated TAD?	Maintenance Power (W)	Handset Removed Power (W)	Handsets
1	5.8 GHz	D	N	3.7	2.4	1
2	5.8 GHz	D	N	1.6		1
3	5.8 Ghz	A	N	3.3	2.1	1
4	5.8 GHz	A	N	3	1.9	1
5	900 MHz	A	N	2.60	1.60	1
6	900 MHz	A	N	2.70	1.60	1
7	900 MHz / 2.4 GHz	A	N	3.00	1.80	1
8	5.8GHz	A	N	3.5	2.7	2
9	5.8GHz	A	N	3.3	2.1	2
10	5.8GHz	D	Y	3.1	2.1	2
11	5.8GHz	D	Y	3.1	2	4
12	2.4 GHz		Y	3.6	2.7	1
13	2.4 GHz	D	Y	2.1		1
14	5.8 GHz	D	Y	1.6		2
15	900 MHz / 2.4 GHz	A	Y	3.60	2.20	1
16	5.8GHz	A	Y	3.3	2.1	4
17	5.8 Ghz	A	Y	4.3	3.3	1

DVD Players and Recorders

Unit	Manufacture Date	Off Power [W]	Active Power [W]	Record Power [W]
1	2005	0.8	11	n/a
2	2006	0.8	11	n/a
3	2006	0.7	5.9	n/a
4	2006	0.3	5.2	n/a
5	2006	5.2	10	n/a
6	2006	0.7	6.4	n/a
7	2006	0.4	8.8	n/a
8	2006	0.4	6.3	n/a
9	2006	1.5	8.2	n/a
10	2006	0.4	10	n/a
11		1.1	8.7	n/a
12		0.9	10	n/a
13	2006	0.5	7.8	n/a
14	2006	0.7	10	n/a
15	2006	2.8	13	n/a
16	2006	4.3	16	n/a
17		0.1	9.0	n/a
18		0.1	10	n/a
19	2006	0.1	23	n/a
20		0.1	8.1	n/a
21	2006	0.7	6.2	n/a
22	2006	1.2	8.9	n/a
23	2006	1.4	8.2	n/a
24	2006	1.6	18	20
25	2006	0.7	22	23
26	2006	1.9	14	17
27		2.5	20	23
28		2.6	20	23
29	2006	2.0	28	28
30		4.6	21	23
31		1.2	17	18
32	2006	0.9	16	17
33	2006	2.8	22	22
34		1.6	18	17
35		1.9	24	24

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Home Theater in a Box

Unit	Date of Manufacture	Integral DVD Player (Y/N)	Number of Speakers	Off Power [W]	Active Power [W]
1		N	6	0.1	38
2		N	6	0.2	36
3		Y	6	0.3	48
4		Y	6	0.3	53
5	2005	Y	2	3.3	17
6		N	6	0.1	41
7		Y	6	0.1	41
8	2006	Y	6	0.1	57
9		N	6	0.5	44
10		Y	6	0.9	29
11	2006	Y	6	0.7	31
12	2006	Y	6	0.5	29
13	2006	Y	6	0.7	34

Set-top Boxes

Unit	Service	Digital or Analog?	DVR?	HD?	Off Power (W)	Active Power (W)
1	DBS	D	Y	Y	37	37
2	DBS	D	N	Y	21	26
3	DBS	D	N	N	13	14
4	DBS	D	N	Y	15	23
5	DBS	D	N	N	15	18
6	DBS	D	N		12	13
7	Cable	D	N	N	10	10
8	Cable	D	Y	Y	30	32
9	Cable	D	N		14	14
10	Cable	D	Y	N	21	26
11	Cable	D	Y	Y	21	27
12	Cable	D	N	N	12	13
13	Cable	D/A	N	N	14	14
14	Stand-alone	D	Y	N	25	27

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Video Game Consoles

Unit	Model	Manufacture Date	Off Power (W)	Pause Power (W)	Active Power (W)
1	Xbox		2.0	68	68
2	Xbox 360	2006	2.2	168	173
3	Game Cube		0.9	20	21
4	PS2	2006	0.2	17	18