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Energy Use of Televisions and Videocassette Recorders in the U.S.

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Energy Use of Televisions and Videocassette Recorders in the U.S.

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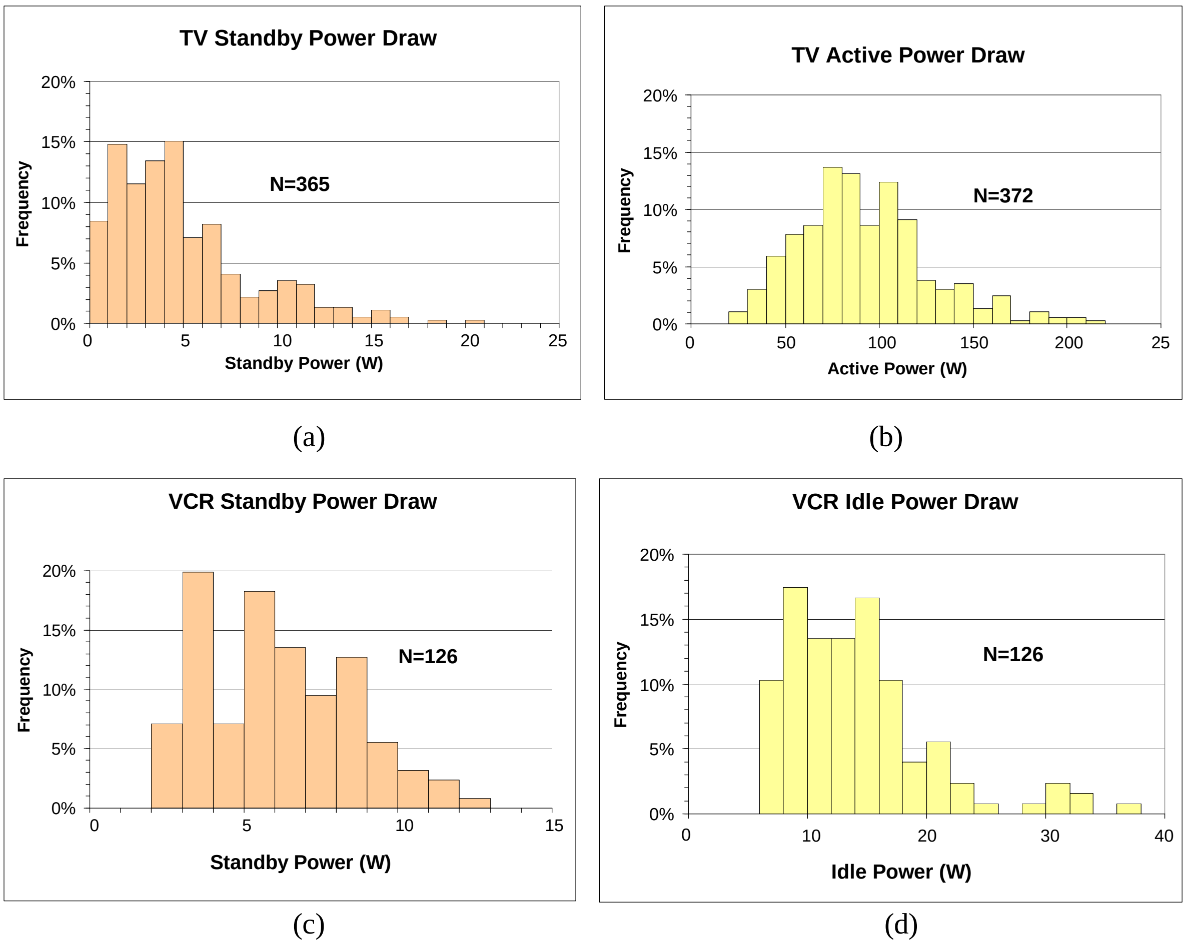
EXECUTIVE SUMMARY

This study was undertaken to estimate current energy use of residential televisions (TVs) and videocassette recorders (VCRs) in the United States. Ownership and usage statistics were taken from media research, while average power values were derived from power measurements of nearly 500 units, shown in Figure ES-1.

Figure ES-1. Power levels of TVs and VCRs measured for this study



(a) (b)

(c) (d)

When grouped by product characteristics, these power measurements indicate that TV active power draw is closely related to screen size (see Table ES-1) and manufacturer, while TV standby power draw is related only to manufacturer. VCR idle and standby power draw levels are related to manufacturer and year of manufacture: VCR power draw values have been steadily decreasing since 1985. Because of these relationships, average power values were weighted by industry-based estimates of the age, manufacturer, and size distributions of U.S. TVs and VCRs to ensure average power draw estimates that are representative of current U.S. stock.

Table ES-1. Average TV power draw by screen size

Screen Size (inches)	Average Power Active (watts)	Standby (watts)
<=18	47	3.1
19-20	68	5.1
25-27	90	4.9
30-36	114	5.3
39+	142	3.5
Weighted average	**75**	**4.5**

To estimate national TV and VCR energy consumption values, ranges of power and mode usage were created to represent usage patterns in homes with more than one unit. Average energy use for homes with one unit, two units, etc. were calculated and summed to provide estimates of total national TV and VCR energy consumption.

Results indicate that TVs and VCRs comprise 3.6% of U.S. residential electricity consumption. In homes with at least one TV, the average annual household TV energy consumption is 310 kWh, 23% of which is consumed while the sets are off. In homes with at least one VCR, the average annual household VCR energy consumption is 100 kWh, over 50% of which is consumed while the units are off. A summary of U.S. TV and VCR energy use is shown in Table ES-2. Calculated values are rounded to two significant digits.

Table ES-2. Summary of residential TV and VCR energy use in the U.S.

	TVs		VCRs	
Average active power (watts)	**75**		**17.0**	
Average idle power (watts)	**--**		**13.5**	
Average standby power (watts)	**4.5**		**5.9**	
Average household energy use	(kWh/home)	(%)[a]	(kWh/home)	(%)[a]
1 unit home	260	32%	71	63%
2 unit home	310	38%	140	28%
3 unit home	340	19%	210	8.2%
4 unit home	370	7.8%		
5 unit home	400	2.8%		
Weighted Average (kWh/home)	**310**		**100**	
Total U.S. energy (TWh/yr)	**31**		**9.1**	
Percentage of U.S. residential electricity use	**2.8%**		**0.82%**	

[a] Share of U.S. homes

This report estimates the energy use of TVs and VCRs in the residential sector only. Total U.S. TV and VCR energy consumption is expected to be roughly 10 to 15% higher, depending on the number of TVs and VCRs in the U.S. commercial and industrial sectors and the usage of those units.

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1. INTRODUCTION

In an effort to more accurately determine nationwide energy consumption, the U.S. Department of Energy has recently commissioned studies with the goal of improving its understanding of the energy use of appliances in the "miscellaneous" end-use category. This study presents an estimate of the residential energy consumption of two of the most common domestic appliances in the miscellaneous end-use category: color televisions (TVs) and videocassette recorders (VCRs).

We used a bottom-up approach in estimating national TV and VCR energy consumption. First, we obtained estimates of stock and usage from national surveys, while TV and VCR power measurements and other data were recorded at repair and retail shops. Industry-supplied shipment and sales distributions were then used to minimize bias in the power measurement samples. To estimate national TV and VCR energy consumption values, ranges of power draw and mode usage were created to represent situations in homes with more than one unit. Average energy use values for homes with one unit, two units, etc. were calculated and summed to provide estimates of total national TV and VCR energy consumption.

Previous studies have estimated residential TV and VCR energy use [1][2]. This report differs in two ways: (1) the power measurement database is more extensive, and (2) the method of estimating national energy consumption is more detailed.

First, earlier studies used relatively few [1] or no [2] actual power measurements, and average power values were not adjusted to ensure representativeness of U.S. stock. In contrast, average power values used in this study were calculated from an extensive database containing power measurements for nearly 500 units. These measurements were compared to industry-published distributions of product manufacturer, year of manufacture, and screen size. Based on these comparisons, average power values were adjusted to ensure average power values representative of current U.S. stock.

Second, previous reports assume that power and usage are the same across all units in a home, implying that household TV energy consumption increases in direct proportion to the number of units. The analysis presented in this report allows for different power and usage patterns among units within a home—i.e., one unit may be used more often than the others are, or may use more or less power than the others do. We believe that the method used in this study results in a more realistic relationship between number of units and household energy consumption.

2. DATA SOURCES AND METHODS OF ANALYSIS

The key factors we use to calculate national energy consumption for TVs and VCRs are:

- number of units in the U.S.
- hours of operation in each operating mode (typical usage)
- power levels in different modes

This section describes the data sources used in this study and the efforts taken to minimize bias in the power measurements.

2.1. Stock and Usage Statistics

Estimates of the number of TVs and VCRs in the U.S. were taken from the U.S. Energy Information Administration's *1997 Residential Energy Consumption Survey* (RECS) [3], a national survey collected from a sample of 5,900 households statistically selected to represent the 101 million households in the U.S in 1997 [4]. For the 1997 RECS, all TV/VCR combination units were counted as both TVs and VCRs [5].

TV and VCR usage statistics were taken from two media research efforts. Nielsen Media Research's *1998 Report on Television* bases usage estimates on data gathered from an electronic metering system placed on TV sets in 5,000 randomly selected U.S. households [6]. Media Dynamics' *TV Dimensions 1998* derives its usage estimates from various media and industry sources, including Nielsen survey data that are not reported in Nielsen's *Report on Television* [7].

2.2. Power Measurements

We contracted with two repair shops—one in Berkeley, California and one in Castro Valley, California—to measure and record power draw values for TVs and VCRs after repair.[1] Shops were given data log sheets, true RMS power meters capable of measuring to the nearest one-tenth of a watt (see Appendix A), and instructions to:

1. Record brand name, presence of remote control, and screen size (for TVs only).
2. Record model number, year of manufacture, and rated watts from the back/bottom panel.
3. Plug the unit into the meter and record the standby power draw when the digits on the power meter remain steady (do not fluctuate).

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[1] For practical reasons, the repair shops did not measure VCR power in play and record modes. Instead, average play/record power values are derived from measurements recorded at LBNL. (See Section 4.1.)

4. Switch the unit on. Set TVs to a station without reception, or "snow" and record the active power use. For VCRs, do not request play or any other motor driven function and record the idle power draw when the digits on the power meter remain steady (do not fluctuate).

5. Initial and date.

The repair shops earned $2 for each appliance measured and recorded. From July through November 1998, handwritten data log sheets were collected monthly by LBNL and manually entered into an electronic database.

Some advantages of this approach include the quick and economical collection of many measurements, confidence of accuracy due to the technicians' familiarity with the appliances, and confidence that the units passing through the repair shops would be used regularly, since consumers were willing to pay for their repair.

The major disadvantage is that the sample population was unlikely to be representative of U.S. stock. For example, compared to existing stock, units requiring repair are likely to be older because newer units are less likely to need repair. This problem was partially corrected by adding measurements of newer units measured at retail shops as discussed in a later section. The methods and data sources we used to determine representative distributions of product age, and other product characteristics with the potential to effect power use, are discussed below.

2.3. Minimizing Bias in the Sample of Power Measurements

To determine whether the TV and VCR power measurements taken at the repair shops were representative of U.S. stock, we first estimated existing distributions for associated characteristics of U.S. TVs and VCRs. The three main characteristics that have the potential to affect power draw of TVs and VCRs are age, manufacturer, and screen size.[2]

To approximate characteristic distributions of existing stock, we collected industry estimates of number of units shipped, manufacturer market share, and TV sales by screen size. These distributions were adjusted for vintaging effects using a unit lifetime of 11 years [8] and the "4/3 Retirement Function" [9], which assumes that stock retires according to the function:

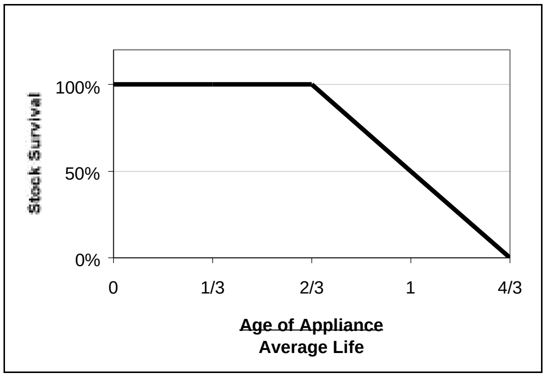
$$Stock\ Survival = \begin{cases} 1, & 0 < AGE \le \frac{2}{3} LIFE \\ 2 - \frac{1.5(AGE)}{LIFE}, & \frac{2}{3} LIFE < AGE \le \frac{4}{3} LIFE \end{cases} \tag{1}$$

where *AGE* is the age of the appliance and *LIFE* is the expected lifetime of the appliance.

[2] In some cases, different models within the same size, manufacturer, and year category also showed significant differences in power draw values.

A graph of the 4/3 Retirement Function is shown in Figure 2-1.[3]

Figure 2-1. The 4/3 Retirement Function [9]



These weighted averages were then used to create "expected" distributions, i.e., the distributions of product age, manufacturer, or screen size that we would expect to find in an unbiased sample. The data used to create these expected distributions are discussed below.

Age

The age of current stock depends on the life expectancy of the appliance and the number of units sold in each year. The expected lifetime of both TVs and VCRs is 11 years [8], while the expected lifetime of a TV/VCR unit is 6 years [10]. The numbers of TVs, VCRs and TV/VCRs sold in each year between 1985 and 1997 were taken from Appliance Magazine's *Statistical Review* [11][12] as shown in Figure 2-2. Values for 1998 were not yet available and so were estimated to be the same as 1997.

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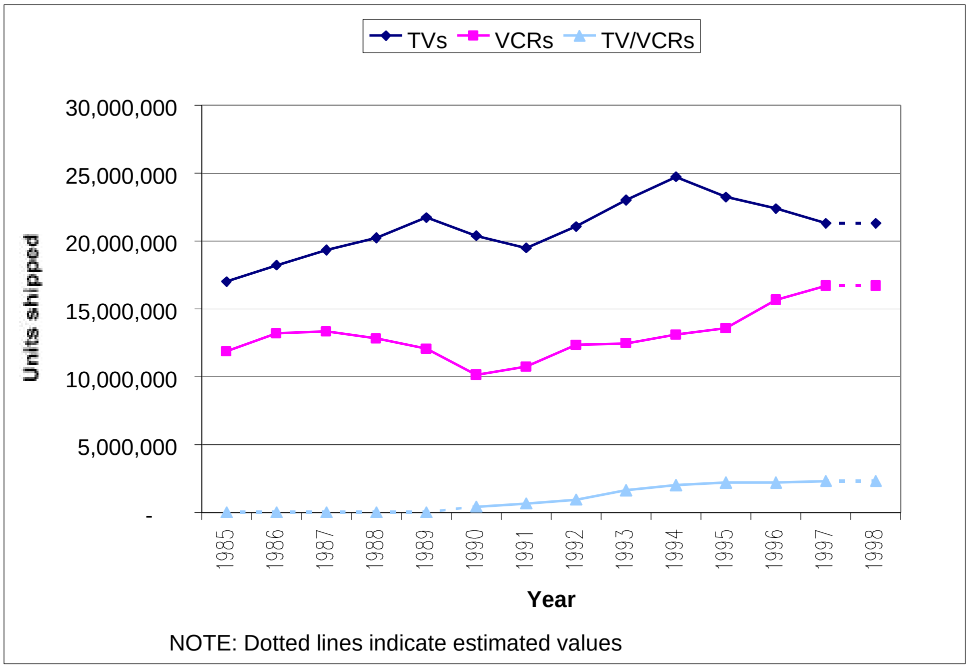
[3] Although the 4/3 Retirement Function has not been thoroughly tested in the field, it did provide reasonable estimates of the age distributions for the TVs and VCRs that were measured at the repair shops. (See Sections 3.2 and 4.2.)

Figure 2-2. Number of TVs, VCRs, and TV/VCRs shipped in the U.S. between 1985 and 1998 [11][12]



Manufacturer

Nine years (1989-97) of manufacturer market shares were taken from Appliance Magazine's *Portrait of the U.S. Appliance Industry* [13], which lists the U.S. market share for the top 10 to 12 appliance manufacturers. Figures for these reports are gathered from "surveys of appliance OEMs, industry suppliers, market analysts, confidential sources, and APPLIANCE magazine estimates" [8]. We estimated manufacturer market shares for the years 1985-1988 and for 1998. We also estimated 1989 market shares for VCRs due to questionable data in the first *Portrait of the U.S. Appliance Industry* printed in 1990. TV and VCR manufacturer market shares used in this study are shown in Tables 2-1 and 2-2.

Table 2-1. Manufacturer market shares of TVs shipped in the U.S., 1985-1998 [13]

TV Manufacturer	Year													
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Thomson [a]	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.22	0.19	0.21	0.23	0.23	0.23	0.23
N.A.P. [b]	0.11	0.11	0.11	0.11	0.11	0.13	0.12	0.12	0.15	0.15	0.15	0.15	0.14	0.14
Zenith	0.11	0.11	0.11	0.11	0.11	0.12	0.11	0.12	0.12	0.12	0.13	0.13	0.13	0.13
Sony	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.07	0.08	0.09	0.10	0.10
Sharp	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07
Sanyo	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.06	0.06	0.06	0.06
Matsushita [c]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.04	0.04	0.04	0.05	0.05
Toshiba	0.03	0.03	0.03	0.03	0.03	0.05	0.06	0.05	0.05	0.05	0.04	0.04	0.05	0.05
Mitsubishi	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01
Samsung	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.04	0.03	0.03	0.02	0.03	0.03	0.03
Goldstar [d]	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02
Hitachi	0.02	0.02	0.02	0.02	0.02	0.02	na	na	na	na	na	na	na	na
Others	0.17	0.17	0.17	0.17	0.17	0.13	0.15	0.19	0.20	0.16	0.15	0.14	0.12	0.12
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[a] RCA, GE

[b] Philips-Magnavox

[c] Panasonic, Quasar

[d] Goldstar, LG Electronics

NOTE: Values in shaded columns are estimated.

Table 2-2. Manufacturer market shares of VCRs shipped in the U.S., 1985-1998 [13]

VCR Manufacturer	Year													
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Thomson [a]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.16	0.18	0.18	0.21	0.19	0.19
Matsushita [b]	0.21	0.21	0.21	0.21	0.21	0.21	0.18	0.15	0.11	0.12	0.10	0.9	0.13	0.13
N.A.P. [c]	0.09	0.09	0.09	0.09	0.09	0.09	0.11	0.11	0.11	0.11	0.12	0.11	0.11	0.11
Sony	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.07	0.07	0.07
JVC	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.06	0.06	0.06	0.06
Sharp	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.05
Zenith	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Sanyo/Fisher	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.05	0.04	0.04	0.04
Toshiba	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.02	0.02	0.03	0.04	0.04	0.04
Hitachi	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03
Mitsubishi	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Goldstar [d]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.05	0.04	0.04	0.02	0.02
Samsung	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.05	0.03	na	na	na
Others	0.05	0.05	0.05	0.05	0.05	0.05	0.13	0.19	0.24	0.11	0.18	0.18	0.18	0.18
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[a] RCA, GE

[b] Panasonic, Quasar

[c] Philips-Magnavox

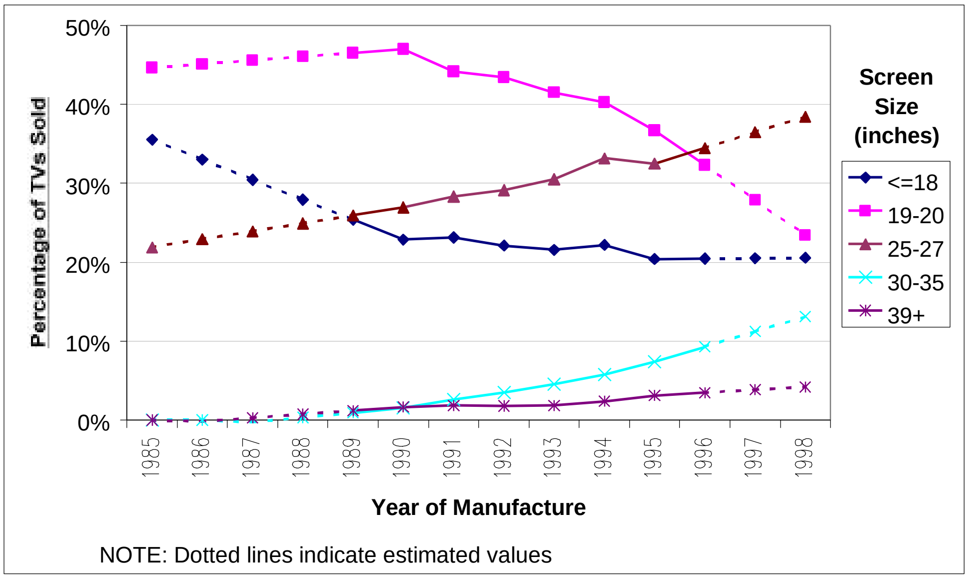
[d] Goldstar, LG Electronics

NOTE: Values in shaded columns are estimated.

Screen Size

Screen size sales were taken from industry sales to dealers data reported in Television Digest [14][15][16][17][18][19]. We estimated values for 1985-88 and 1997-98 based on trends seen in years for which statistics were available. Percentages of TVs sold in each of five screen size categories—less than or equal to 18 inches, 19-20 inches, 25-27 inches, 30-35 inches, and greater than or equal to 39 inches—are shown in Figure 2-3.

Figure 2-3. Percentage of TV screen sizes sold in the U.S. between 1985 and 1998 [13-18]



Television Digest did not report sales figures for TV/VCR units by screen size, as was done for direct view and projection TVs. Since the vast majority of TV/VCR units have 13 or 20 inch screens, we split the TV/VCR sales figures evenly between the "<=18" inch and "19-20" inch categories for this study. Although TVs and TV/VCR units have different expected lifetimes, the effect of this difference is negligible since TV/VCR units represented less than five percent of TVs in the U.S.

2.4. Calculation of Unit Energy Consumption

Nearly all consumer appliances have at least two power modes and many have more than two. Annual unit energy consumption (*UEC*) of any appliance can be estimated as:

$$UEC = \sum_{i=1}^{M} P_i \cdot T_i \qquad (2)$$

where M is the number of available appliance modes, P_i is the average power draw of the appliance in mode i, and T_i is the number of hours per year that the appliance is in mode i. For each appliance, S T_i = 8760 hours per year.

Televisions sold in the U.S. generally have only standby (off) and active (on) modes, while VCRs have standby (off), idle (on), and several active modes involving the playing, recording, rewinding, pausing, etc. of videocassettes. For this report, we will address the time spent in and power consumed during the active and standby modes of both appliances. Of the many VCR modes that could be considered "active" modes, this study includes only play and record modes. The VCR "idle" mode will be investigated as well. This mode occurs when the VCR is on but not active.

2.5. Calculation of Household and National Energy Consumption

Many households have more than one of any given appliance. For each unit in a household, UEC is calculated using Equation 2. Average annual household energy consumption values for households with N units (HEC_N) are calculated as the sum of the N UEC values:

$$HEC_N = \sum_{i=1}^{N} UEC_i \qquad (3)$$

National energy consumption (E) attributable to a specific appliance is then calculated as:

$$E = \sum_{N=1}^{U} H_N \cdot HEC_N \qquad (4)$$

where U is the maximum number of units in a home, H_N is the number of homes in the U.S. with N units, and HEC_N is the average aggregate energy consumption for homes with N units.

3. TELEVISIONS: ANALYSIS AND RESULTS

In this section, we first present a summary of all TV data used in this study, including number of color TVs in the U.S.,[4] typical operating hours, and power measurements. Effects of TV age, manufacturer, and screen size on power levels are calculated, and, where appropriate, industry shipment and sales distributions are used to weight average unit power draw values derived from the power measurements. Household and national energy consumption values are estimated using ranges of power and usage values. Results presented include average unit, average household, and total national energy consumption of color TVs in the U.S.

3.1. TV Data

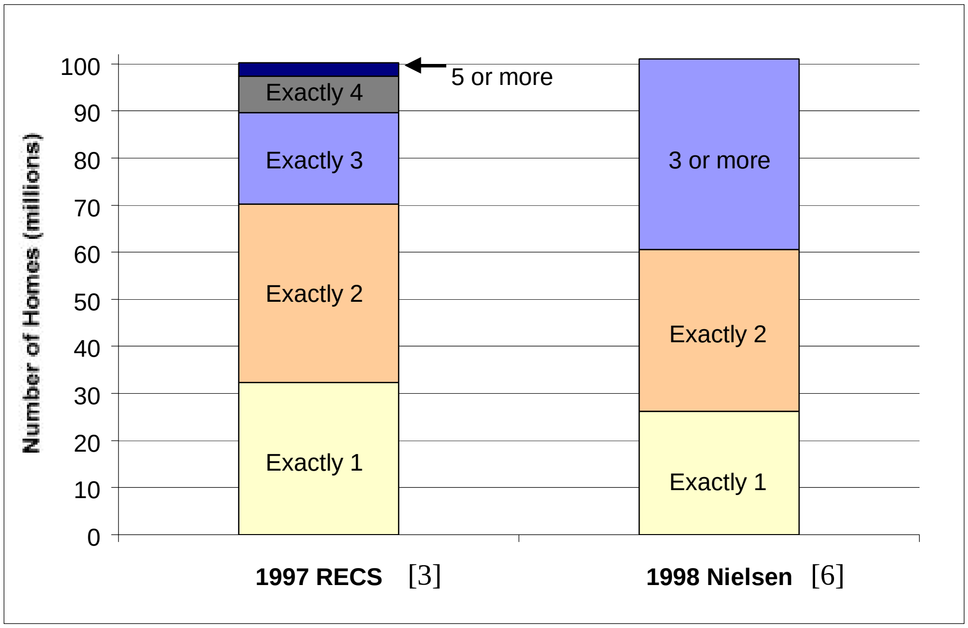
This section describes the number of TVs in U.S. homes, typical usage, and TV power measurements collected at repair shops.

Number of TVs

There are 211.5 million TVs in U.S. homes [3], an estimated 10.8 million of which are TV/VCR combination units [9][13]. The U.S. Energy Information Administration (EIA) provided information about the number of color TVs in each of the 101 million U.S. homes [3] as shown in Figure 3-1. Nielsen reported similar findings [6], also shown in Figure 3-1 for comparison.

[4] Black and white TVs are not included in this study.

Figure 3-1. Number of TVs in U.S. homes



Using an average TV lifetime of 11 years [8], an average TV/VCR lifetime of 6 years [10], shipment data [11][12] and the 4/3 Retirement Function [9], about 238 million of the 308 million TVs and TV/VCR combination units shipped since 1985 should still be operating. The difference between this number and the number obtained by the EIA survey is about 26 million units. This difference could be partially attributed to the commercial TVs that are counted in shipment data, but are not counted by the EIA survey. The uncertainty in the average lifetime of TVs and TV/VCRs is also likely to be a factor.

TV Usage

We calculated household TV usage as the sum of three different activities: watching broadcast television, watching videocassettes, and playing video games. Average time per household spent in each of these activities was derived from media research and used to calculate average household TV usage as follows.

The total number of broadcast television viewing hours was calculated from several different values. Nielsen [6] reports that the average U.S. home watches broadcast television for 7.2 hours per day. This number is not an accurate estimate of TV set usage because it includes all recording activity, whether or not the TV is on during the recording session. In addition, the Nielsen estimate does not include videocassette watching, video game playing, or the time multiple sets are watched simultaneously.

To transform the Nielsen estimate of “broadcast viewing hours” to a number that represents “TV set usage hours” we first subtracted the average amount of time that households record broadcast television with the TV off—about 0.15 hours per day per TV-home[5] [7]—from Nielsen's estimate. The resulting value is about 7.05 hours per day per TV-home.

Next, we added the amount of time two or more sets are tuned in simultaneously. This is necessary because Nielsen reports only the amount of time that *at least one TV* is tuned in. For example, if a husband and wife both watch TV from 7:00 to 10:00 every night, but the husband watches TV1 in the living room while the wife watches TV2 in the bedroom, Nielsen reports that the household television usage is 3 hours per day [20]. For our purposes, we would like to know the aggregate viewing hours for all TV sets, which would be TV1 usage plus TV2 usage, or 6 hours per day. According to media sources, two or more TVs are simultaneously tuned to different channels for 12% of the time that broadcast television is watched in homes with more than one TV [7]. Therefore, the average TV usage for a house with one TV remains 7.05 hours, while the average TV usage for households with more than one TV is 7.05 plus 12% of 7.05, or 7.9 hours.[6]

In the 88.9% of U.S. households that own a VCR, TVs are used to watch videocassettes for 4.0 hours per week [7], or 0.57 hours per day. In addition, in the 33% of homes that own video game equipment, video games are used 3 to 3.5 hours weekly [7]. For this report we use a video game usage of 3.25 hours per week, or 0.46 hours per day. These values were converted to hours per TV-home and added to the values calculated above to obtain average daily usage values of 7.7 hours for homes with one TV set, and 8.6 hours for homes with more than one TV set. A summary of average daily U.S. national and household TV usage is presented in Table 3-1.

Table 3-1. Average daily national and household TV usage

	Homes w/ Appliance (millions)	**Avg. Usage per Home w/ Appliance** (hrs/day/home)	**U.S. Total Usage** (MM hrs/day)	**Avg. Usage per TV-Home** (hrs/day/TV-home)
Broadcast (1TV)	32.3 [a]	7.1	228	7.1
Broadcast (2+TVs)	67.9 [a]	7.9	536	7.9
VCR	88.9 [a]	0.57	51	0.51
Video Game	33.3 [b]	0.46	15	0.15
Total 1 TV-home	*[Broadcast (1TV) + VCR + Video Game]*			7.7
Total 2+ TV-home	*[Broadcast (2+TVs) + VCR + Video Game]*			8.6
U.S. Total			**830**	**8.3**

[a] EIA [2]

[b] Media Dynamics [5]

[5] A "TV-home" is a home with at least one TV.

[6] These values do not include the number of hours that three or more TVs are tuned in simultaneously. For more information on the possible effects of this omission on our results, see Section 4.6.

TV Power Measurements

This section provides a summary of the 321 TVs measured at the repair shops. For a complete list of the TV power measurements used in this study, see Appendix B.

Figure 3-2 shows the distribution of power levels measured while the TVs were active. In an attempt to obtain comparable results, all TVs were set to a channel with no reception ("snow"); however, even this method does not guarantee reliable measurements, since "snow" on one channel may be brighter or dimmer than the "snow" on another channel. See Appendix C for more information on the reliability of power measurements.

Figure 3-2. TVs measured at repair shops: distribution of active power draw levels

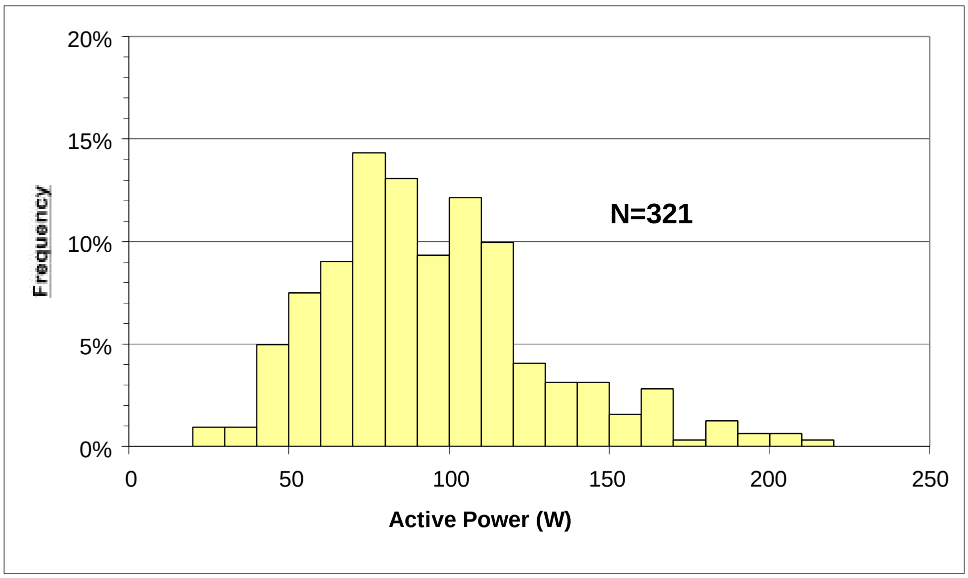
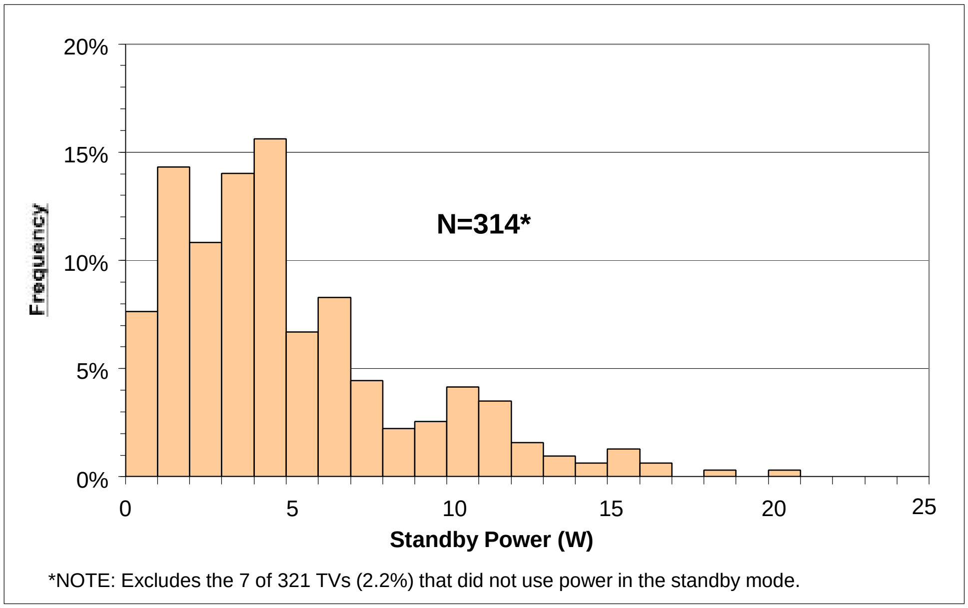


Figure 3-3 shows the distribution of power measurements taken while the TVs were in standby mode. This graph excludes 7 of the 321 TVs measured at the repair shop because they did not use power in standby mode.

Figure 3-3. TVs measured at repair shops: distribution of standby power draw levels



Because the measurements represented in Figures 3-2 and 3-3 were taken at repair shops, it is likely that they are not representative of U.S. TV stock. The following section will address this issue.

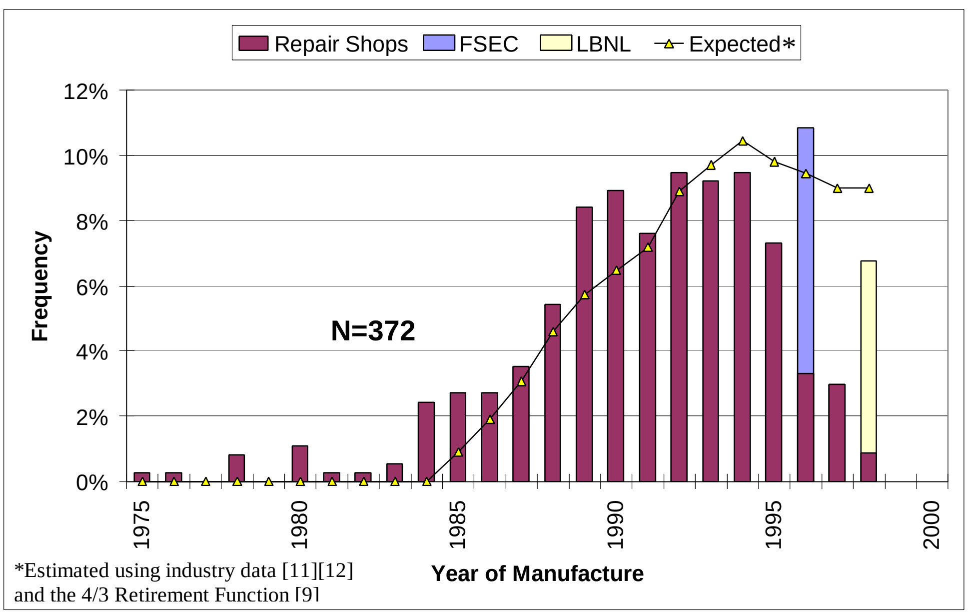
3.2. Representativeness of the Collected TV Data Sample

This section compares characteristics of the power measurement data set used in this study to characteristics we would expect to see in an unbiased data set. In particular, this section compares the collected distributions of TV age (year of manufacture), manufacturer, and screen size to “expected” distributions calculated from industry data as described in Section 2.3.

Age

As one might expect, relatively few new TVs were measured at the repair shops. To offset this lack of newer units, the data set was supplemented by retail shop measurements of twenty-eight 1996 units measured by the Florida Solar Energy Center (FSEC), and twenty-three 1998 units measured by Lawrence Berkeley National Laboratory (LBNL). Figure 3-4 shows a comparison between the complete data set of 372 TVs and the expected age distribution, which was obtained as described in Section 2.3. For a complete list of power measurements used in this study, see Appendix B.

Figure 3-4. Age distribution of TVs measured at repair and retail shops compared to the expected distribution of an unbiased sample



Market Share

Figure 3-5 shows the market share distribution of the TVs measured for this study compared to the expected distribution, which was obtained as described in Section 2.3. See Appendix D for a chart matching code letters A through M to the respective manufacturers' names.

Figure 3-5. Manufacturer market share distribution of TVs measured at repair and retail shops compared to the expected distribution of an unbiased sample

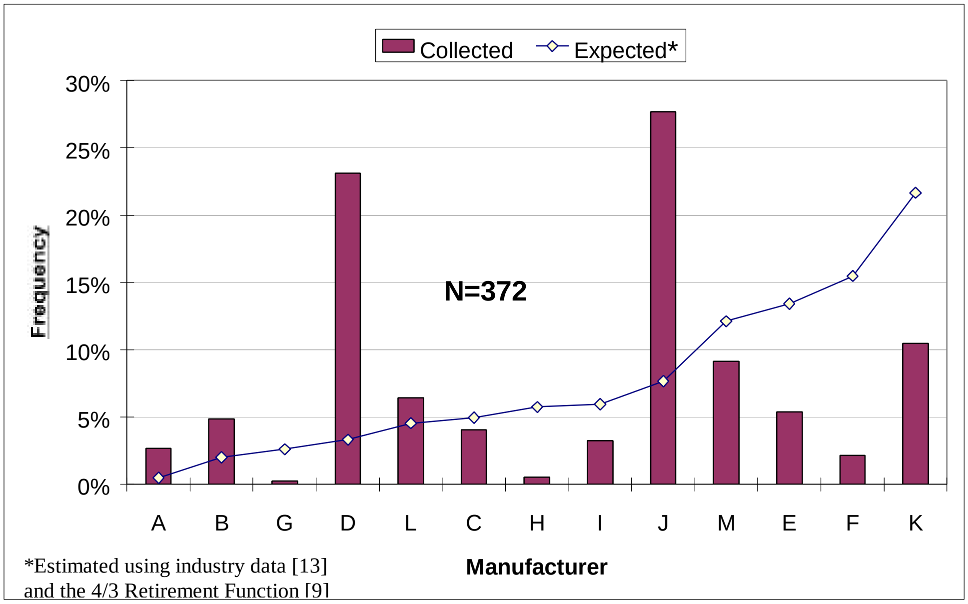
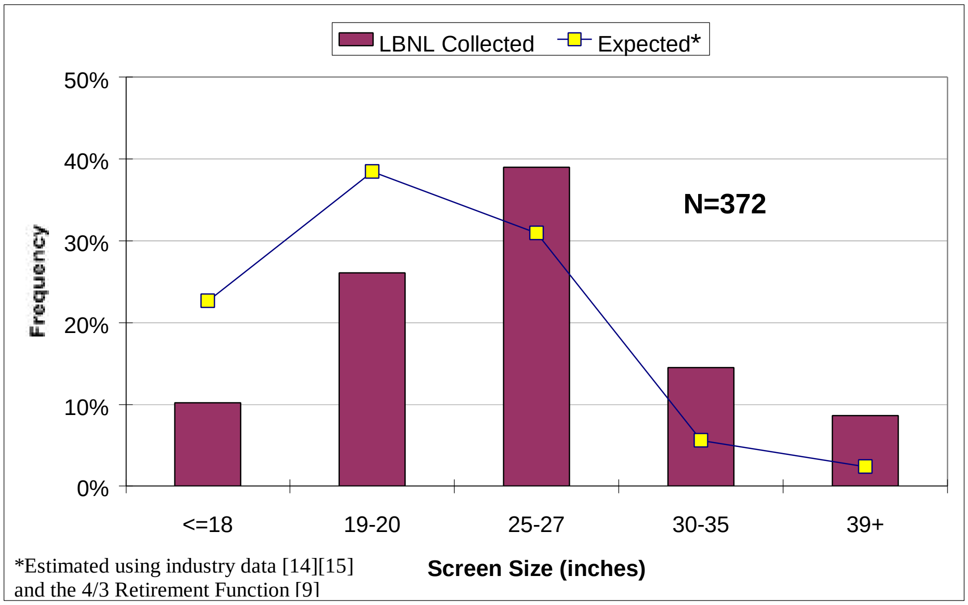


Figure 3-5 shows that the market-share distribution found in our sample deviates significantly from the expected distribution. One might think that the high frequency of manufacturers D and J in the repair shops indicate that these manufacturers produce TVs that are more likely to require repair; however, surveys show that this is not true [21][22][23]. One reason for this discrepancy may be that these brands are more valued and thus more likely to be repaired than replaced. Another possibility is that our sample population has been affected by local manufacturer bias; i.e. the distribution of TVs in California may not be representative of the national average.

Screen Size

Figure 3-6 shows the screen size distribution of the TVs measured for this study compared to the expected distribution, which was obtained as described in Section 2.3.

Figure 3-6. Screen size distribution of TVs measured at repair and retail shops compared to the expected distribution of an unbiased sample



It can be seen from Figure 3-6 that, overall, the screen sizes in our sample are larger than the expected distribution. This may imply that consumers are more likely to discard smaller units than to repair them, or that smaller units are less likely to malfunction.

3.3. Effects of Manufacturer, Screen Size, and Year on TV Power Draw

This section describes the results of an analysis of variance conducted on the TV data measured for this study. For plots showing the effects of manufacturer, year of manufacture, and screen size on the power levels of these TVs, see Appendix E.

Results of an analysis of variance[7] indicate that 'screen size' and 'manufacturer' are significant in predicting active power draw, while 'year of manufacture' is not. For standby power draw, only 'manufacturer' has a significant effect, while 'screen size' and 'year of manufacture' do not. A summary of the results of the analysis of variance is given in Table 3-2.

[7] Main effect: 'manufacturer.' Covariates: 'screen size,' 'year of manufacture.'

Table 3-2. Results of an analysis of variance conducted on TV data measured at repair and retail shops, with main effect 'manufacturer' and covariates 'screen size' and' year of manufacture'

Variable	**Active**			**Standby**		
	F	df	p	F	df	p
Manufacturer	3.0	12	<0.0005	11.8	12	<0.0005
Screen Size	367.3	1	<0.0005	3.0	1	0.084
Year of Manufacture	0.6	1	0.421	0.2	1	0.639

Further analysis showed that that there is a positive correlation between active power draw and screen size (Pearson r = 0.740). These results imply that (1) some manufacturers consistently make more efficient TVs than other manufacturers, (2) larger TVs use more power when they are on than smaller TVs do, and (3) neither active nor standby TV power use has changed significantly since 1985. (See Appendix F)

While the effect of screen size on standby power draw is not statistically significant at the 0.05 alpha level, the probability of only 8.4% shown in Table 3-2 suggests that further investigation may be warranted. For more information about the relationship between TV screen size and power draw, see Appendix G.

3.4. Average TV Power Draw Levels

Because power draw is related to both size and manufacturer, and because the distributions of size and manufacturer in our database were not representative of U.S. stock, average power draw values were weighted according to expected distributions based on industry data. The average TV power draw ($\overline{P_{TV}}$) is calculated as:

$$\overline{P_{TV}} = \sum_{m=1}^{M} \sum_{s=1}^{S} f_s f_m \overline{P_{sm}} \tag{5}$$

where M is the number of manufacturers, S is the number of screen size categories, f_s is the expected market share for screen size s, f_m is the expected market share for TV manufacturer m, and $\overline{P_{sm}}$ is the mean power draw (based on the power measurement database containing 372 TVs) for all of the size s units shipped by manufacturer m.

Table 3-3 shows that the average active and standby TV power levels calculated using Equation 5 are 75 watts and 4.5 watts, respectively. Average values derived using only screen size, only market share or no weighting strategies are also presented for comparison.

Table 3-3. Average unit TV power draw values: comparison of results obtained using different weighting methods

Weighting method	**Active** (watts/unit)	**Standby** (watts/unit)
None	92	4.9
Expected manufacturer market share	81	4.9
Expected screen size	77	4.5
Expected market share & screen size	**75**	**4.5**

NOTE: Values used in this study are in bold

3.5. Household and National TV Energy Consumption

In Section 3.3 we showed that there is a positive correlation between the screen size and the active power draw of TVs. This implies that watching a larger TV is more energy-intensive than watching a smaller TV. Since more than two-thirds of U.S. homes have more than one TV set and nearly one-third have more than two [3], TV size distributions within homes and the relationship between screen size and viewing hours must be considered.

Based on the data shown in Figure 3-1, five categories of homes were created: homes with one, two, three, four, and five TVs. For each category, a distribution of TVs was created according to "usage rank," which is based on how much the TV is used. TV1 is always the most watched TV, TV2 is the next most watched, etc. Homes with only one TV have only a TV1. TVs in a home with five TVs are named TV1, TV2, TV3, TV4, and TV5, where TV5 is the least watched TV. The numbers of TV1s, TV2s, TV3s, TV4s, and TV5s in the U.S. are shown in Table 3-4.

Table 3-4. Distribution of U.S. TVs by usage rank [3]

Usage Rank	**No. of TVs** (millions)	**Percentage of U.S. TVs**
TV1	100.2	47.4%
TV2	67.9	32.1%
TV3	30.0	14.2%
TV4	10.6	5.0%
TV5	2.8	1.3%
Total	**211.5**	**100%**

NOTE: TV1 is the most used TV in any home, TV2 the second most used TV, etc. Since there are 100.2 million homes in the U.S. with at least one TV set, there are 100.2 million TV1s in the U.S.

The expected TV screen size distribution and average power draw values derived from the power measurement database are given in Table 3-5.

Table 3-5. TV screen sizes: expected screen size distribution and average TV power draw values

Screen Size (inches)	**Expected Distribution** [9][14][15]	**Active Power** (watts)	**Standby Power** (watts)
<=18	25%	47	3.1
19-20	36%	68	5.1
25-27	31%	90	4.9
30-36	5.6%	114	5.3
39+	2.4%	142	3.5
Weighted average		**75**	**4.5**

NOTE: The expected TV screen size distribution can also be seen in Figure 3-6.

Using the data in Tables 3-4 and 3-5, *minimum (min)*, *maximum (max)* and *recommended (rec)* energy use scenarios were created. The minimum scenario is based on the assumption that the *smallest* 47% of U.S. TVs are the most used (TV1). The maximum scenario is based on the assumption that the *largest* 47% of U.S. TVs are the most used. The recommended case assumes that, where there is a choice, there is a tendency to watch the largest TV, while the second largest TV, third largest TV, etc., are watched progressively less. Evidence of this trend can be found in the following paragraphs from Consumer Reports:

> TV sets with a 19 or 20 inch screen are often second or third TVs in the household, bought for someplace other than the living room—and where fancy features are likely to be less of a priority. [21]
>
> Indeed, sets of this size (25 inch) are now often promoted not as the primary TV set for the living room, but as a second or even third set for a larger bedroom or family room. [22]

Recommended values are therefore calculated as the midpoint between the average TV active and standby power draw values of 75 and 4.5 watts, respectively, and the maximum power use values. The resulting active and standby power use values used in this study are shown in Table 3-6.

Table 3-6. Average power use of TVs by usage rank (watts/unit)

Usage Rank	**Active Power** *min*	*rec*	*max*	**Standby Power** *min*	*rec*	*max*
TV1	57	83	92	4.0	4.7	4.9
TV2	81	70	65	5.0	4.7	4.8
TV3	93	61	47	4.9	3.8	3.1
TV4	120	61	47	4.9	3.8	3.1
TV5	142	61	47	3.5	3.8	3.1

NOTE: min, rec and max indicate a range of estimates as described in the text, where min=minimum, rec=recommended, and max=maximum estimates.

To facilitate understanding of Table 3-6, we provide here the details of the calculations for the *min*, *max*, and *rec* "Active" power values in the first row (TV1). In the minimum case, we assume that the smallest 47% (Table 3-4) of TVs in the U.S. are the primary TVs. Using Table 3-5, the smallest 47% of TVs include all of the TVs in the <=18 inch category (25% of the total) and 22 of the total 36% of U.S. TVs represented in the 19-20 inch category (22% of the total). Also from Table 3-5, the average active power draw of <=18 inch and 19-20 inch TVs are 47 watts and 68 watts, respectively. Therefore, the minimum average "Active" power estimate is calculated as (25%•47W + 22%•68W)/47%, or 57 watts. Similarly, the maximum estimate is calculated as (2.4%•142W+5.6%•114W+31%•90W+8%•68W)/47%, or 92 watts. The recommended value is calculated as the midpoint between the average active power of 75 watts and the maximum value of 92 watts, which is 83 watts.

Since, TV1s in the minimum scenario are smaller than average, they use less power "on" than do TV1s in the maximum scenario, which are larger than average. The opposite trend is seen in the TV5 category, because the minimum energy use scenario includes all the largest TVs, and the maximum energy use scenario includes all the smallest TVs.

Assumptions must also be made about the usage of different size TVs within a home. In the minimum energy use scenario, every household uses the smallest television in the house for 7.7 hours per day, and homes with more than one television use the second smallest TV simultaneously for 12% [7] of 7.7, or 0.8 hours per day. In the maximum energy use scenario, every household uses the largest television in the house for 7.7 hours per day, and homes with more than one unit use the second largest TV for 0.8 hours per day.

The recommended usage estimates assume a tendency toward watching the largest TV in the home. While studies show that people prefer to watch larger TVs [24], no information could be found regarding the percentage of time spent watching the different size TVs in the home. Therefore, values for the recommended usage values were estimated. First we assumed that homes with five TV sets used them, from largest to smallest: 50, 25, 12.5, 7.5 and 5 percent of the time. Homes with four TVs then split the usage of the fifth TV (5%) equally between the four sets (+1.25% each), for a 51.25/ 26.25/13.75/8.75 percent split. Similarly, the smallest TV usage for the 4-TV-home (8.75%) was split equally between the 3 remaining sets to estimate usage in a 3-TV-home, etc. The resulting viewing hour assumptions are presented in Table 3-7.

Table 3-7. Average household and unit TV usage in homes with 1, 2, 3, 4, and 5 TV sets (hrs/day)

	Active Usage			**Standby Usage**		
	min	*rec*	*max*	*min*	*rec*	*max*
1 TV-home total	**7.7**	**7.7**	**7.7**	**16.3**	**16.3**	**16.3**
TV1	7.7	7.7	7.7	16.3	16.3	16.3
2 TV-home total	**8.6**	**8.6**	**8.6**	**39.4**	**39.4**	**39.4**
TV1	7.7	5.4	7.7	16.3	18.6	16.3
TV2	0.8	3.2	0.8	23.2	20.8	23.2
3 TV-home total	**8.6**	**8.6**	**8.6**	**63.4**	**63.4**	**63.4**
TV1	7.7	4.6	7.7	16.3	19.4	16.3
TV2	0.8	2.5	0.8	23.2	21.5	23.2
TV3	0.0	1.4	0.0	24.0	22.6	24.0
4 TV-home total	**8.6**	**8.6**	**8.6**	**87.4**	**87.4**	**87.4**
TV1	7.7	4.4	7.7	16.3	19.6	16.3
TV2	0.8	2.2	0.8	23.2	21.8	23.2
TV3	0.0	1.2	0.0	24.0	22.8	24.0
TV4	0.0	0.7	0.0	24.0	23.3	24.0
5 TV-home total	**8.6**	**8.6**	**8.6**	**111.4**	**111.4**	**111.4**
TV1	7.7	4.3	7.7	16.3	19.7	16.3
TV2	0.8	2.1	0.8	23.2	21.9	23.2
TV3	0.0	1.1	0.0	24.0	22.9	24.0
TV4	0.0	0.6	0.0	24.0	23.4	24.0
TV5	0.0	0.4	0.0	24.0	23.6	24.0

NOTE: min, rec and max indicate a range of estimates as described in the text, where min=minimum, rec=recommended, max=maximum estimates.

Note that the usage values for the minimum and maximum scenarios are exactly the same: TV1 is used 7.7 hrs/day and TV2 is used 0.8 hrs/day. This is because, by definition, TV1 is the *most used* TV in the home. Minimum energy values will be calculated by assuming that TV1 is a small (low-power) set, while the maximum energy values will be calculated by assuming that TV1 is a large (high-power) set (see Table 3-6). In both cases, it is necessary to use the maximum possible usage for TV1.

Total "Standby Usage" values for homes with more than one set are greater than 24 hours per day because multiple sets are in standby mode at the same time. The total standby usage value for each home is equal to the number of sets times 24 hours per day minus the number of hours per day the TVs are used.

For each TV, unit energy consumption was calculated using Equation 2. Average household TV energy consumption values for households with 1, 2, 3, 4, and 5 television sets were calculated using Equation 3 and are presented in Table 3-8. National TV energy consumption values calculated using Equation 4 are presented in Table 3-9. To facilitate computation for the reader, values in Tables 3-8 and 3-9 are shown to three significant digits in some places; however, please keep in mind that they are only accurate to two significant digits.

Table 3-8. Average annual household and unit TV energy use by number of TVs in home (kWh/yr)

	Active Energy			**Standby Energy**			**Total Energy**		
	min	*rec*	*max*	*min*	*rec*	*max*	*min*	*rec*	*max*
1 TV-home total (kWh/yr/home)	**160**	**233**	**258**	**24**	**28**	**29**	**184**	**261**	**287**
TV1 (kWh/yr/unit)	160	233	258	24	28	29	184	261	287
2 TV-home total (kWh/yr/home)	**185**	**243**	**278**	**66**	**67**	**70**	**251**	**311**	**348**
TV1 (kWh/yr/unit)	160	162	258	24	32	29	184	194	287
TV2 (kWh/yr/unit)	25	81	20	42	35	41	67	117	61
3 TV-home total (kWh/yr/home)	**185**	**235**	**278**	**109**	**101**	**97**	**294**	**336**	**375**
TV1 (kWh/yr/unit)	160	140	258	24	33	29	184	173	287
TV2 (kWh/yr/unit)	25	63	20	42	37	41	67	100	61
TV3 (kWh/yr/unit)	0.0	32	0.0	43	31	27	43	63	27
4 TV-home total (kWh/yr/home)	**185**	**232**	**278**	**152**	**135**	**124**	**338**	**367**	**403**
TV1 (kWh/yr/unit)	160	133	258	24	34	29	184	166	287
TV2 (kWh/yr/unit)	25	57	20	42	37	41	67	94	61
TV3 (kWh/yr/unit)	0.0	26	0.0	43	32	27	43	58	27
TV4 (kWh/yr/unit)	0.0	17	0.0	43	32	27	43	49	27
5 TV-home total (kWh/yr/home)	**185**	**231**	**278**	**183**	**168**	**151**	**368**	**399**	**430**
TV1 (kWh/yr/unit)	160	129	258	24	34	29	184	163	287
TV2 (kWh/yr/unit)	25	54	20	42	37	41	67	92	61
TV3 (kWh/yr/unit)	0.0	24	0.0	43	32	27	43	55	27
TV4 (kWh/yr/unit)	0.0	14	0.0	43	32	27	43	47	27
TV5 (kWh/yr/unit)	0.0	9.5	0.0	31	33	27	31	42	27
Weighted Average	**177**	**237**	**272**	**71**	**69**	**69**	**248**	**307**	**340**

NOTE: min, rec and max indicate a range of estimates as described in the text, where min=minimum, rec=recommended, max=maximum estimates. Values are accurate to two significant digits.

Table 3-9. National TV energy consumption (TWh/yr)

	Active Energy			Standby Energy			Total Energy		
	min	*rec*	*max*	*min*	*rec*	*max*	*min*	*rec*	*max*
1-TV Homes	5.3	7.6	8.3	0.8	0.9	0.9	6.1	8.5	9.3
2-TV Homes	7.1	9.3	10.6	2.5	2.6	2.7	9.7	11.9	13.3
3-TV Homes	3.7	4.6	5.4	2.1	2.0	1.9	5.8	6.6	7.3
4-TV Homes	1.5	1.8	2.2	1.2	1.1	1.0	2.7	2.9	3.2
5+ TV Homes	0.5	0.7	0.8	0.5	0.5	0.4	1.0	1.1	1.2
Total U.S.	**18**	**24**	**27**	**7.2**	**7.0**	**7.0**	**25**	**31**	**34**

NOTE: min, rec and max indicate a range of estimates as described in the text, where min=minimum, rec=recommended, max=maximum estimates. Values are accurate to two significant digits.

3.6. Sources of Uncertainty in the Calculation of National TV Energy Consumption

We used industry shipment data to derive the “expected” distribution of screen sizes as discussed in Section 2.3. According to the data collected at the repair shops, larger TVs are more likely to be repaired than smaller TVs. This may imply that smaller TVs are more likely to be retired at an earlier age, rather than being repaired. Thus, actual U.S. TV stock may contain a lower fraction of smaller TVs than the “expected” distribution used in this study. This effect would be particularly prominent in sets manufactured before 1992, which are likely to have a higher frequency of malfunction than newer sets. Based on the screen-size distribution collected at the repair shops, correction of this discrepancy could add as much as 6.5%, or 2 TWh/yr, to our recommended national annual TV energy use estimate. If, instead, the lack of smaller TVs at the repair shop implies that smaller TVs are used less often and are therefore less likely to malfunction, there may be a higher percentage of smaller TVs than was calculated for the expected distribution. However, since the implication of this scenario is that these smaller TVs are not being used, this would not significantly effect our results.

We did not include the percentage of time that three or more TV sets are in use simultaneously nor the time two or more televisions are tuned to the *same* channel. Inclusion of these factors adds a maximum of 1.8% to the national energy estimates.

Although we used 11 years for the lifetime of a television as printed in Appliance Magazine in September of 1997, the September 1998 issue reports that the average life expectancy is 9 years. We used the value published in 1997 because the expected age distribution created using an expected lifetime of 11 years provided a better fit to the data collected at the repair shops.

The use of both the expected manufacturer market share and screen size distributions to weight average power draw values assumes that these two characteristics are independent. However, it is almost certainly true that some manufacturers sell more large TVs and some sell more small TVs. To test the effect of this assumption on the final results, we weighted average power draw values using only the expected manufacturer market share, and separately, only the expected screen size distribution (Table 3-3). Using either of these weighting methods alone assumes no independence between manufacturer and screen size, and changes the final national energy use results by less than 3%.

This study does not include the energy use of black and white televisions because the number of black and white TVs in the U.S. is insignificant compared to the number of color TVs. According to shipment data [11][12] and a life expectancy of 8 years [8], there are about 5 million black and white TVs in the U.S., accounting for about 2.3% of the national TV population. Since this estimate includes green and amber monitors [12], which are not considered “TVs” for the purposes of this report, the actual number of black and white TVs in the U.S. is even less. In addition, we expect the black and white TV sets that are still in circulation to be smaller, more efficient and watched less than the average color TV. We are therefore confident that the inclusion of black and white TVs would not add significantly to the results of this study.

This study does not include television sets used in the commercial sector, for example those in hospitals and hotel rooms, due to the difficulty estimating usage of such sets. Based on the difference between shipment data and EIA survey data (see Section 3.1), we estimate that there are between 20 and 30 million commercial TVs in the U.S. Assuming that usage of commercial TVs is similar to usage of residential TVs, inclusion of commercial TV sets would increase our estimate of total national energy consumption by roughly 10 to 15 percent.

Although we assume that TVs are plugged in at all times, it is possible that some households unplug their TVs when not in use.

Appliances with low power factor, such as TVs, require more current and increase distribution losses. Accounting for these losses in our calculations would increase the supply-side energy required for U.S. TVs.

4. VIDEOCASSETTE RECORDERS: ANALYSIS AND RESULTS

Our approach to estimating VCR energy consumption parallels that for TVs. First, we present a summary of all VCR data used in this study, including the number of VCRs in the U.S., typical usage, and power draw measurements. Effects of VCR age and manufacturer on unit power draw levels are calculated, and, where appropriate, industry shipment and sales distributions are used to weight average unit power draw values derived from power measurements. Results presented include average unit, average household, and total national energy consumption of U.S. VCRs.

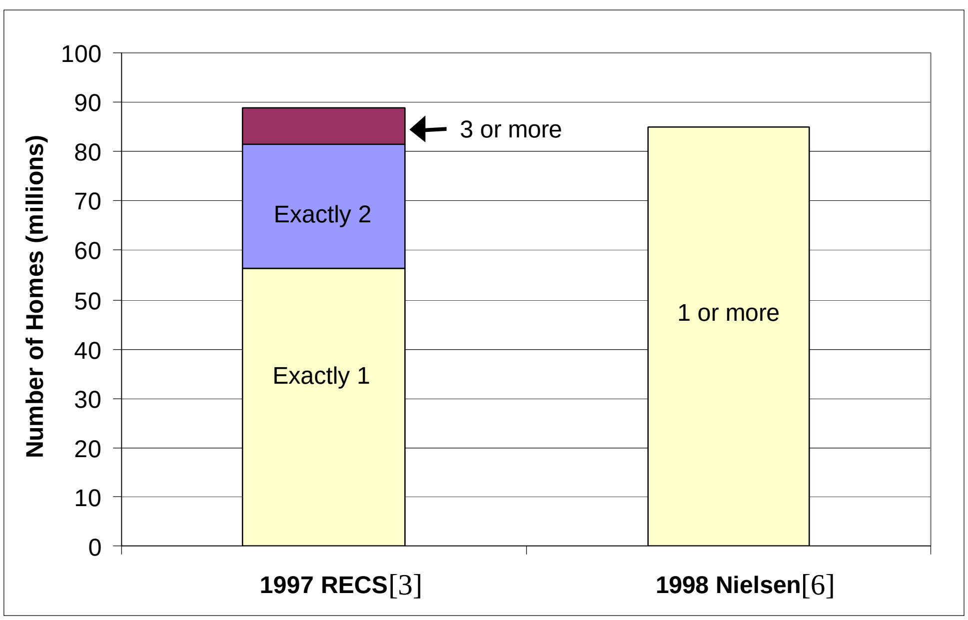
4.1. VCR Data

This section describes the number of VCRs in U.S. homes, typical usage, and VCR power measurements collected at repair shops.

Number of VCRs

The EIA reports that there are 128.7 million VCRs in U.S. homes [3], an estimated 10.8 million of which are TV/VCR units [9][13]. The numbers of homes with one, two, and three or more units as reported by the EIA [3] are shown in Figure 4-1. Nielsen [6] reports similar findings, which are shown in Figure 4-1 for comparison.

Figure 4-1. Number of VCRs in U.S. homes



According to an average VCR lifetime of 11 years [8], an average TV/VCR lifetime of 6 years [10], shipment data [11][12] and the 4/3 Retirement Function [9], about 152 million of the 184 million VCRs and TV/VCR combination units shipped since 1985 should still be operating. The difference between this number and the number obtained by the EIA survey is about 23 million units. This difference can be partially attributed to the commercial VCRs that are counted in shipment data, but are not counted by the EIA survey. The uncertainty in the average lifetime of VCRs and TV/VCRs is also likely to be a factor.

VCR Usage

Hours of operation were taken from Media Dynamics [7]. Similar results were published in a survey of households in the Midwestern U.S. [25] and are included in Table 4-1 for comparison.

Table 4-1. Average household VCR usage (hrs/week/VCR-home)

Source	Play	Record	Total
Media Dynamics [7]	**4.0**	**1.9**	**5.9**
Wachter [25]	3.3	1.9	5.3

NOTE: Values used in this study are in bold

VCR Power Measurements

This section describes the VCR power measurements collected at the repair shops. For a complete list of the VCR power measurements used to determine average idle and standby power draw, see Appendix H. For a complete list of the VCR power measurements used to determine average VCR play/record power draw, see Appendix I.

Figure 4-2 shows the distribution of idle mode power levels of the 106 VCRs measured at the repair shops. These values represent power draw of the VCRs while they were on and no motor driven functions were being performed. Figure 4-3 shows the distribution of power levels measured while the VCRs were in standby mode.

Figure 4-2. VCRs measured at repair shops: distribution of idle power draw levels

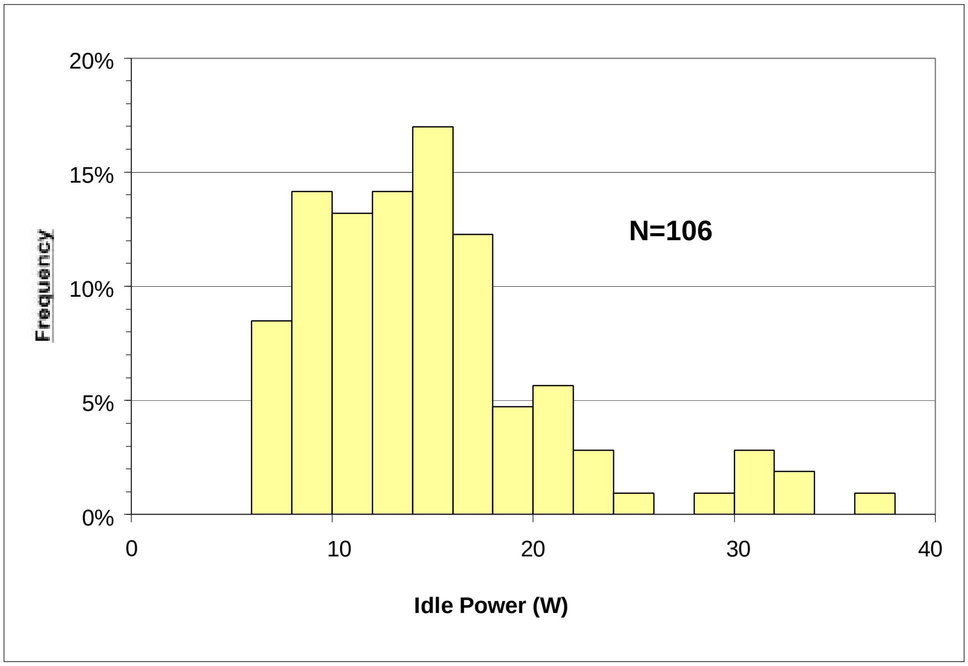
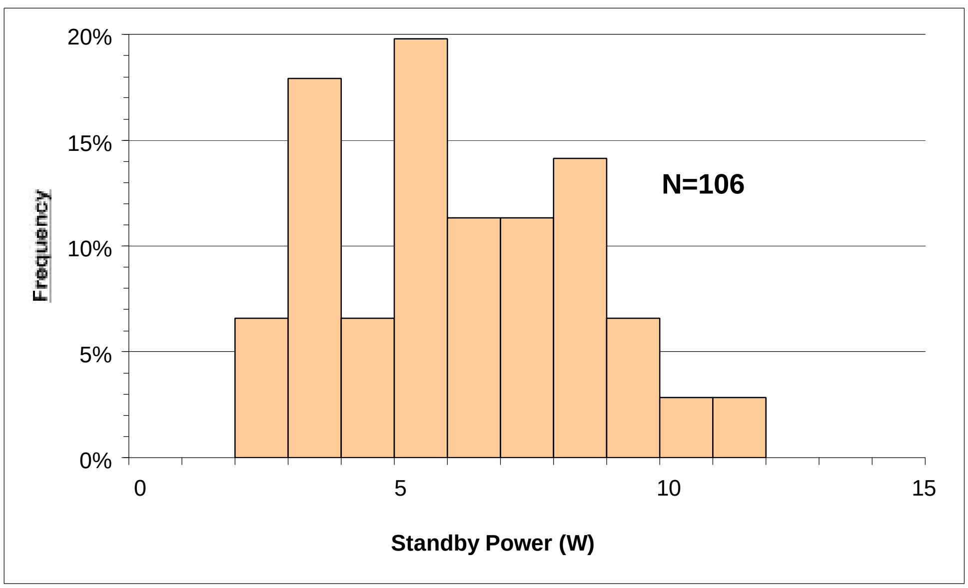


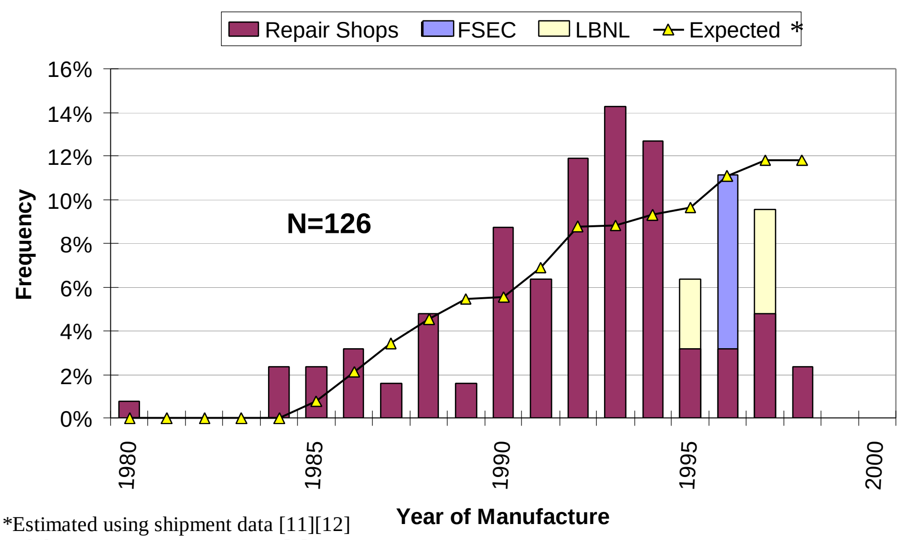
Figure 4-3. VCRs measured at repair shops: distribution of standby power draw levels



4.2. Representativeness of the Collected VCR Data Sample

Power measurements and other information were taken at repair shops as discussed in the study overview. To offset a lack of newer units, the 106 repair shop measurements were supplemented with four 1995 and six 1997 units measured at LBNL, and ten 1997 units measured at FSEC. Distributions of age and manufacturer of the final sample of 126 VCRs are compared to the expected distributions in Figures 4-4 and 4-5.

Figure 4-4. Age distribution of VCRs measured at repair and retail shops compared to the expected distribution of an unbiased sample



*Estimated using shipment data [11][12]
and the 4/3 Retirement Function [9]

Figure 4-5. Manufacturer market share distribution of VCRs measured at repair and retail shops compared to the expected distribution of an unbiased sample

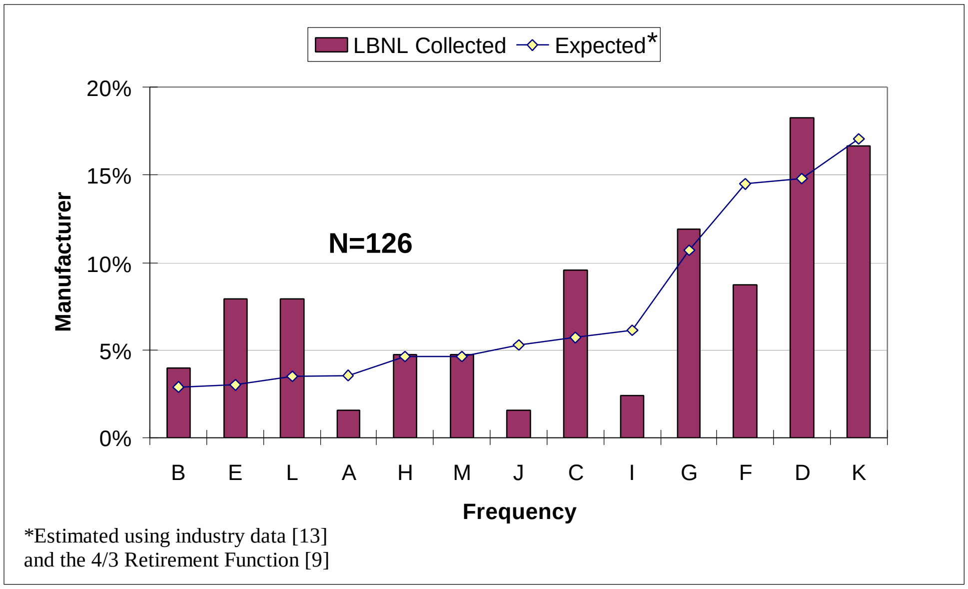


Figure 4-5 shows that our sample was fairly representative of manufacturer market share. See Appendix D for a chart matching code letters A-M to the respective manufacturers' names.

4.3. Effects of Manufacturer and Year on VCR Power Draw

The results of an analysis of covariance[8] indicate that the manufacturer and year of manufacture were significant in predicting both idle and standby power draw levels, as shown in Table 4-2.

Table 4-2. Results of an analysis of variance conducted on VCR data measured at repair and retail shops, with main effect 'manufacturer' and covariate 'year of manufacture'

Variable	**Idle**			**Standby**		
	F	Df	p	F	df	p
Manufacturer	3.5	12	<0.0005	3.3	12	<0.0005
Year	30.3	1	<0.0005	5.0	1	<0.0005

Further analysis showed negative correlations between year of manufacture and power draw in both the idle (Pearson r = -0.424) and standby (Pearson r = -0.282) modes. These results imply that (1) some manufacturers consistently make more efficient VCRs, and (2) VCR energy efficiency has been improving since 1985. (See Appendix F.)

[8] Main effect: manufacturer. Covariate: year.

4.4. Average VCR Power Draw Levels

Because power draw of VCRs is related to the age of the unit, and because the distribution of 'year of manufacture' in our database was not representative of U.S. stock, average VCR power draw values were weighted by the expected 'year of manufacture' distribution. The average unit power draw of VCRs ($\overline{P_{VCR}}$) is calculated as:

$$\overline{P_{VCR}} = \sum_{y=1988}^{1998} f_y \overline{P_y} \qquad (6)$$

where is f_y is the expected frequency of stock VCRs manufactured in year y, and $\overline{P_y}$ is the mean power draw for all VCRs in our database manufactured in year y. Average power draw values obtained using Equation 6 are presented in Table 4-3.

Table 4-3. Average unit VCR power draw values: comparison of results obtained using different weighting methods (watts/unit)

Weighting Method	**Play/ Record[a]**	**Idle**	**Standby**
None	17.0	14.3	6.2
Manufacturer	17.0	13.6	6.3
Year of manufacture	**17.0**	**13.5**	**5.9**

NOTE: Values used in this study are in bold.
[a]The average play/record power draw of 17.0 watts was derived from a sample of 21 VCRs previously measured at LBNL. See Appendix I.

4.5. Household and National VCR Energy Consumption

In Section 4.3 we showed that age is a significant factor in predicting power draw of VCRs, such that newer VCRs are more efficient. This implies that watching an older VCR is more energy-intensive than watching a newer one. Since more than one-third of U.S. households have more than one VCR [3], VCR age distributions within homes and the relationship between age and usage must be considered.

Based on the data shown in Figure 4-1, three categories of homes were created: homes with one, two, and three VCRs. Homes with more than three units were counted as three-unit homes. For each home, a distribution of VCRs was created according to usage rank, which is based on how much the VCR is used. VCR1 is always the "primary" or most used VCR, VCR2 is the next most used, and VCR3 is the least used. The numbers of VCR1s, VCR2s, and VCR3s in the U.S. are shown in Table 4-4.

Table 4-4. Distribution of U.S. VCRs by usage rank [3]

Usage Rank	VCRs in U.S. (millions)	Percentage of U.S. VCRs
VCR1	88.9	69.1%
VCR2	32.5	25.3%
VCR3	7.3	5.7%

NOTE: VCR1 is the most used VCR in any home, VCR2 the second most used, etc. Since there are 88.9 million homes in the U.S. with at least one VCR, there are 88.9 million VCR1s.

The expected 'year of manufacture' distribution and average power draw values derived from the VCR power measurement database are given in Table 4-5.

Table 4-5. VCR year of manufacture: expected distribution and average VCR power draw values

Year	% of U.S. VCRs [9][11][12]	Average Power	
		Idle (watts)	Standby (watts)
1985	0.76%	19.8	7.5
1986	2.1%	20.5	8.4
1987	3.4%	19.9	9.8
1988	4.5%	15.6	6.9
1989	5.4%	21.4	8.6
1990	5.5%	18.0	6.2
1991	6.9%	13.8	6.3
1992	8.7%	15.4	6.8
1993	8.8%	15.1	5.7
1994	9.3%	13.2	5.9
1995	9.6%	10.9	5.1
1996	11%	9.8	5.3
1997	12%	11.5	6.1
1998	12%	8.3	3.2
Weighted average		**13.5**	**5.9**

Using the data in Table 4-4 and the expected age distribution and average power values shown in Table 4-5, *minimum (min)*, *maximum (max)* and *recommended (rec)* energy use scenarios were created. The minimum scenario is based on the assumption that the *newest* 69.1% of U.S. VCRs are the most used (VCR1). The maximum scenario is based on the assumption that the *oldest* 69.1% of VCRs are the most used. For the recommended case, we assume no relationship between age and usage. The resulting idle and standby power draw values used in this study are shown in Table 4-6.

Table 4-6. Average power use of VCRs by usage rank (watts/unit)

Usage Rank	**Idle Power**			**Standby Power**		
	min	*rec*	*max*	*min*	*rec*	*max*
VCR1	11.7	13.5	15.1	5.3	5.9	6.5
VCR2	17.0	13.5	10.2	7.0	5.9	5.2
VCR3	19.8	13.5	8.3	8.8	5.9	3.2

NOTE: min, rec and max indicate a range of estimates as described in the text, where min=minimum, rec=recommended, max=maximum estimates.

So, for example, the "Idle" value of 11.7 watts for VCR1 in the minimum scenario is: (12%•8.3+12%•11.5+11%•9.8+9.6%•10.9+9.3%•13.2+8.8%•15.1+6.6%•15.4)/69.1%. Likewise, the "Standby" value of 15.1 watts for VCR1 in the maximum scenario is: (12%•19.8+12%•20.5+11%•19.9+9.6%•15.6+9.3%•21.4+8.8%•18.0+6.6%•13.8)/69.1%.

The critical factor in our estimates of national VCR energy consumption is the amount of time VCRs are left in the idle mode when they are not being used for playing or recording. Some VCRs may be left in this mode out of habit or to record at a preset time, while others are used for cable reception and/or changing TV channels. The minimum scenario assumes that no VCRs are ever left in idle mode. The maximum scenario assumes that all VCRs are left in idle mode at all times. The recommended scenario assumes that 25% of the time that U.S. VCRs are not being used to play or record, they are in the idle mode.[9]

Assumptions must also be made about the distribution of usage in homes that have more than one unit. In all scenarios, play/record usage values were therefore estimated as follows. Homes with three VCRs use the primary VCR (VCR1) 80% of the time, VCR2 14% of the time, and VCR3 6% of the time. Homes with two VCRs use VCR1 83% of the time and VCR2 17% of the time. The resulting usage assumptions are presented in Table 4-7.

[9] Since no information was available on this subject, we were forced to provide a rough estimate based on our experience.

Table 4-7. Average household and unit VCR usage in homes with 1, 2, and 3 VCRs (hrs/day)

	Play/Record Usage	Idle Usage			Standby Usage		
	rec	*min*	*rec*	*max*	*min*	*rec*	*max*
1 VCR-home total	**0.84**	**0.0**	**5.8**	**23.2**	**23.2**	**17.4**	**0.0**
VCR1	0.84	0.0	5.8	23.2	23.2	17.4	0.0
2 VCR-home total	**0.84**	**0.0**	**11.8**	**47.2**	**47.2**	**35.4**	**0.0**
VCR1	0.70	0.0	5.8	23.3	23.3	17.5	0.0
VCR2	0.14	0.0	6.0	23.9	23.9	17.9	0.0
3 VCR-home total	**0.84**	**0.0**	**17.8**	**71.2**	**71.2**	**53.4**	**0.0**
VCR1	0.67	0.0	5.8	23.3	23.3	17.5	0.0
VCR2	0.12	0.0	6.0	23.9	23.9	17.9	0.0
VCR3	0.05	0.0	6.0	23.9	23.9	18.0	0.0

NOTE: min, rec and max indicate a range of estimates as described in the text,
where min=minimum, rec=recommended, max=maximum estimates.

Note that the sums of the play/record, idle, and standby usage values increase linearly with the number of VCRs in the home to account for added power draw of multiple units. Thus, the total daily usage in homes with 2 VCRs is 48 hours, while the total daily usage in homes with 3 units is 72 hours.

For each VCR, unit energy consumption is calculated using Equation 2. Average household VCR energy consumption values for households with 1, 2, and 3 VCRs are calculated using Equation 3. Results, presented in Table 4-8, are accurate to two significant digits.

Table 4-8. Average annual household and unit VCR energy use by number of VCRs in the home (kWh/yr)

	Play/Record	Idle			Standby			Total		
	rec	*min*	*rec*	*max*	*min*	*rec*	*max*	*min*	*rec*	*max*
1 VCR-home total (kWh/yr/home)	**5.2**	**0.0**	**28**	**128**	**45**	**38**	**0.0**	**50**	**71**	**133**
VCR1 (kWh/yr/unit)	5.2	0.0	28	128	45	38	0.0	50	71	133
2 VCR-home total (kWh/yr/home)	**5.2**	**0.0**	**58**	**218**	**106**	**77**	**0.0**	**111**	**140**	**223**
VCR1 (kWh/yr/unit)	4.3	0.0	29	128	45	38	0.0	50	71	133
VCR2 (kWh/yr/unit)	0.9	0.0	29	89	61	39	0.0	62	69	90
3 VCR-home total (kWh/yr/home)	**5.2**	**0.0**	**88**	**290**	**183**	**116**	**0.0**	**188**	**209**	**295**
VCR1 (kWh/yr/unit)	4.2	0.0	29	128	45	38	0.0	49	71	133
VCR2 (kWh/yr/unit)	0.7	0.0	29	89	61	39	0.0	62	69	90
VCR3 (kWh/yr/unit)	0.3	0.0	29	72	77	39	0.0	77	69	73
Weighted Average	**5.2**	**0.0**	**42**	**166**	**74**	**55**	**0.0**	**79**	**102**	**171**

NOTE: min, rec and max indicate a range of estimates as described in the text, where min=minimum, rec=recommended, max=maximum estimates. Values are accurate to two significant digits.

National energy consumption values calculated using the values in Table 4-8 and the number of 1-, 2- and 3-VCR homes in the U.S. [3] are presented in Table 4-9.

Table 4-9. National VCR energy consumption (TWh/yr)

	Play/Record	Idle			Standby			Total		
	rec	*min*	*rec*	*max*	*min*	*rec*	*max*	*min*	*rec*	*max*
1-VCR Homes	0.3	0.0	1.6	7.2	2.5	2.1	0.0	2.8	4.0	7.5
2-VCR Homes	0.1	0.0	1.5	5.5	2.7	1.9	0.0	2.8	3.5	5.6
3+ VCR Homes	0.0	0.0	0.6	2.1	1.3	0.8	0.0	1.4	1.5	2.2
Total	**0.5**	**0.0**	**3.7**	**14.8**	**6.5**	**4.9**	**0.0**	**7.0**	**9.1**	**15.2**

NOTE: min, rec and max indicate a range of estimates as described in the text, where min=minimum, rec=recommended, max=maximum estimates. Values are accurate to two significant digits.

4.6. Sources of Uncertainty in the Calculation of National VCR Energy Consumption

We used 11 years for the lifetime of a VCR as printed in Appliance Magazine in September of 1997; however, the September 1998 issue reports that the average life expectancy is 6 years. We used the value published in 1997 because the expected age distribution created using an expected lifetime of 11 years provided a better fit to the data collected at the repair shops.

The idle vs. standby usage is the critical assumption in the VCR analysis. To our knowledge, there is no information available about the percentage of time VCRs are left in idle mode instead of the standby mode. Although we assume that this value is about 25%, there is no way to confirm this assumption at this time.

For practical reasons, the play/record power use was not recorded at the repair shops; therefore, we used an average value obtained from VCRs measured previously by LBNL. A small error in this value would have insignificant effects on our final results because VCRs are so infrequently in the play or record modes. (See Table 4-7.)

Although we assume that VCRs are plugged in at all times, it is possible that some households unplug their VCRs when not in use. We expect that the number of such households is small, since pulling the plug would mean that real-time clock information would be lost.

This study does not include VCRs used in the commercial sector. Based on the difference between shipment data and EIA survey data (see Section 4.1), we estimate that there are between 20 and 30 million commercial VCRs in the U.S. Assuming that usage of commercial VCRs is similar to usage of residential VCRs, inclusion of these units would increase our estimate of total national VCR energy consumption by roughly 10% to 15%.

VCRs have a low power factor, requiring more current and increasing distribution losses. Accounting for these losses in our calculations would increase the total supply-side energy required for U.S. VCRs.

5. DISCUSSION

5.1. Summary of Recommended Values and Comparison to Other Studies

This section presents power and energy consumption values recommended for use by the DOE and other policy makers.

Results for TVs are based on the assumption that homes with only one TV are likely to have a larger than average unit, and that homes with more than one TV are likely to use the larger units more than the smaller units. Results for VCRs are based on the assumption that homes with only one VCR are as likely to have a new unit as an old unit, and that homes with more than one VCR are as likely to use the newer units as the older units. VCR estimates further assume that, on average, U.S. VCRs are left in idle mode 25% of the time that they are not being used to play or record.

Recommended average household TV and VCR energy consumption values, rounded to two significant digits, are listed in Table 5-1.

Table 5-1. Recommended average household TV and VCR energy consumption values

Number of units in home	**TVs** (kWh/yr/home)	**VCRs** (kWh/yr/home)
1	260	71
2	310	140
3	340	210
4	370	
5	400	
Weighted average	**310**	**100**

Note: Recommended values have been rounded to two significant digits

Recommended power and energy consumption values for TVs and VCRs are presented in Tables 5-2 and 5-3, respectively. Percentages of total U.S. energy consumption are based on the 1998 national residential electricity consumption of 3.772 quadrillion BTUs, or 1105 TWh [26]. Values presented in other recent reports are listed for comparison.

Table 5-2. Recommended power and energy consumption values for TVs in the U.S. residential sector compared to results of other studies

Televisions	**This Study**	**Sanchez et al.** [1]	**Zogg et al.** [2]	**EIA** [27]
Total number of units (millions)	211.5	191	229	
Avg. units/home[a]	2.1	1.9	2.3	
Avg. active usage (hrs/day/home)	8.3	7.8 [b]	9.2 [b]	
Avg. active power (watts)	75	77	60	
Avg. standby power (watts)	4.5	4	4	
Avg. UEC (kWh/yr/unit)	150 [c]	141	117	
Total U.S. energy (TWh/yr)	31	26	27	67
Percentage of U.S. residential electricity consumption	2.8%	2.4%	2.5%	6.0%

[a] Based on 101 million U.S. homes.

[b] For consistency, usage is described in terms of *household* usage (hrs/day/home), calculated as the product of the unit usage and the number of units per home.

[c] To be consistent with the standard UEC definition, the UEC value presented here is calculated as the total U.S. TV energy use divided by the number of TVs in the U.S.

Note that our estimate of the TV energy consumption of a 1-TV household (Table 5-1) is 260 kWh/year. This value is much higher than the average TV UEC of 150 kWh/year (Table 5-2) because it is based on the assumption that, on average, homes with one TV set use it for 7.7 hours per day. The UEC, on the other hand, is based on the assumption that all TVs, no matter how many units are in the household, are used for 3.9 hours per day.[10] This assumption is unrealistic because it implies that the TV in an average 1-TV home is used for 3.9 hours per day, while the TVs in an average 5-TV home are used for 19.5 hours per day.

Table 5-3. Recommended power and energy consumption values for VCRs in the U.S. residential sector compared to the results of other studies

Videocassette Recorders	**This Study**	**Sanchez et al.** [1]	**Zogg et al.** [2]
Total number of units (millions)	128.7	135	123
Avg. play/record usage (hrs/day/home)	0.84	0.96 [a]	0.88 [a]
Avg. idle usage (hrs/day/home)	8.5	4.6	4.2
Avg. play/record power (watts)	17.0	15.7	15.7 [b]
Avg. idle power (watts)	13.5	10.7	10.7 [b]
Avg. standby power (watts)	5.9	5.4	5.6
Avg. UEC (kWh/yr)	71	57	57
Total U.S. energy (TWh/yr)	9.1	7.6	6.9
Percentage of U.S. residential electricity consumption	0.82%	0.7%	0.6%

[a] Value calculated as the product of the unit usage and the number of units per home.

[b] Value taken from Sanchez et al. [1].

[10] Quotient of the average household use of 8.2 hrs/day and the average 2.1 TVs/home.

For VCRs, the results of this study are higher than the results of both Sanchez et al. [1] and Zogg et al. [2]. This can be attributed in part to our higher estimate for time left in the idle mode. We chose to assume that VCRs are left on about 25% of the time that they are not being used to play or record, while the other studies shown in Table 5-3 appear to have used a figure closer to 15%. To our knowledge, there is no information about the amount of time that VCRs are left in this mode.

Another factor causing our VCR energy use estimate to be higher is the database of power measurements used to derive average power values. The database of power measurements used in Sanchez et al. [1] and cited by Zogg et al. [2] consisted mainly of new units. As we found in this study, VCRs have become significantly more efficient over time. Since our database consisted of both new and old units, and average values were weighted using a realistic distribution of newer and older units, it is expected that our values are higher.

TV/VCR combination units are included both in the TV results and in the VCR results. Because the sum of separate TV and VCR standby power use values is 10.4 watts, while that of a TV/VCR combination unit is only about 7.6 watts, these results are not additive. Because of this 3.9-watt difference, the 10.8 million TV/VCR combination units in the U.S. use about 0.27 TWh less energy every year than would separate units. Due to rounding, this difference does not effect the final combined U.S. TV and VCR energy consumption estimate of 40 TWh/yr.

5.2. Forces and Trends That May Change These Results in the Future

The TV and VCR markets are extremely competitive and dynamic. As a result, new technologies appear frequently and have the potential to rapidly penetrate the market. This situation is further complicated by government mandated changes in technology. Some foreseen trends and their energy impacts are discussed below.

Increasing number of usage options

A number of services are becoming available that may affect TV and VCR usage, including "pay-per-view" and "video-on-demand." Both of these services give consumers more viewing options, which may encourage them to watch more TV. At the same time, an increase in the use of these services may be offset by the reduced time spent watching videocassettes.

Thanks to new set-top boxes, people can now browse the Internet using a TV instead of a computer. TV energy use may increase if consumers use the TV to access the web; however, increased web use may simply displace broadcast TV time, leading to small net changes in TV operating hours.

TV Screen Size

Ten years ago, only 2% of TVs sold in the U.S. were larger than 27 inches. Since then, this percentage has been increasing steadily. In 1999, the number of 30+ inch TVs is expected to reach 20% and the consumer preference for larger TVs is expected to continue. One popular trend that compliments large TV ownership is home theater, which consists of a large TV and a sophisticated surround sound system. Such systems are said to exist in 14% of U.S. homes [28]. Because of the continuing trend to buy larger TVs and the strong correlation between screen size and energy use, TV energy use is expected to increase in the near future.

New Technologies

New technologies and appliances will effect power levels and possibly usage as well. Digital television (DTV) receivers in particular are expected to increase TV power use significantly. By 2006, when the television industry hopes to complete conversion to DTV, most TVs will either be fitted with digital receiver boxes, or will be replaced by DTV sets that have these receivers built in. Since DTV receivers use about 16 watts and must be left on at all times [29], TV standby energy use after 2006 is expected to be more than three and a half times the current TV standby energy use.

New display technologies may also have a significant effect on TV energy use. Currently, plasma display panels (PDPs) and liquid crystal displays are vying for position as the favored flat-panel display technology. In the TV market, it seems that PDPs may have the advantage over LCDs mainly because they can be made larger. Since plasma screens have a higher active power draw than the currently popular cathode ray tubes (CRTs), they have the potential to contribute to significantly higher annual TV energy use. At present, however, prices of PDPs remain too high to pose a real threat to the CRT industry. It is impossible to predict the effect of new display technologies on long-term TV energy use because competition to produce the fastest, brightest, most efficient and cheapest display creates new technologies on a regular basis. For example, one recently announced flat panel display technology is organic electroluminescence (EL), which boasts thinner, brighter, faster and much more energy efficient displays than existing LCDs. Although the prototype is just over 5 inches diagonally, larger models are expected to begin appearing in products in 2000 [30].

Although TV/VCR combination units are not a “new” technology, sales continue to climb. Sales in the first three quarters of 1998 rose by 32 percent over sales for the same time period last year [31]. Since TV and VCR power supplies tend to waste between 1 and 5 watts each in all power modes, TV/VCR units may reduce power use by using one power supply instead of two. Integration of other appliances, such as TVs and Internet appliances, should have the same effect.

Sales of digital versatile disc (DVD) players have exploded recently, while VCR sales have been flat [31]. Because the industry is still in its infancy, the replacement of VCRs with DVD players would have an uncertain effect on energy use. Based on 20 DVD players measured at LBNL, the average standby mode power draw of DVD players is lower than that of VCRs (4.2 vs. 5.9 W), while the average idle power draw was higher (15.6 vs. 13.5 W).

Energy efficiency regulations and voluntary programs

The United States does not have minimum efficiency regulations for TVs or VCRs, but Japan does and Europe is considering them. These standards, especially those in Japan, will influence the efficiency of units sold in the United States. For example, Japanese manufacturers have been informally asked by the Ministry of International Trade and Industry (MITI) to reduce TV standby losses to one watt. Other voluntary programs, such as the United States' ENERGY STAR® program and Europe's Group for Efficient Appliances (GEA) program, are also expected to result in reduced standby power use for both TVs and VCRs.

6. CONCLUSIONS

This study investigated power draw levels and national residential energy use of TVs and VCRs in the U.S. We found that the active power draw levels of TVs are closely related to screen size, while standby power draw levels seem to depend only on manufacturer. In addition, it appears that some TV and VCR manufacturers consistently make more efficient units than do others. Although average power draw levels of TVs have remained relatively stable over the past 15 years, VCRs have become significantly more efficient.

The average active and standby power draw levels of U.S. TVs are 75 and 4.5 watts, respectively. Annual household energy consumption levels of TVs range from 260 kWh for a home with one set to 400 kWh for a home with five. Average household TV energy consumption is 310 kWh per year. Nationally, residential TVs use 31 TWh of electricity per year, or about 2.8% of U.S. residential electricity consumption.

The average play/record, idle, and standby power levels of U.S. VCRs are 17.0, 13.5 and 5.9 watts, respectively. Annual household energy consumption levels of VCRs range from 71 kWh for a home with one unit to 210 kWh for a home with three. Average household VCR energy consumption is 100 kWh per year. Nationally, residential VCRs consume 9.1 TWh of electricity per year, or 0.8% of U.S. residential electricity consumption.

Combined, TVs and VCRs, including TV/VCR combination units, use 40 TWh/yr, or 3.6% of U.S. residential electricity consumption.

Current trends demonstrate that the TV and VCR end-uses are likely to undergo many changes in the next decade. For this reason, the results presented in this report will be valid for only a brief time, perhaps less than three years, before a reassessment is needed.

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APPENDIX A: SINGLE PHASE POWER MULTIMETER, MODEL PLM-1-LP

Electronic Product Design, Inc., 2145 Debra Drive, Springfield, Oregon 97477

The Single Phase Power Multimeter (model PLM-1-LP) is an electronic instrument used to measure parameters associated with power consumption by an electrical load that is normally operated from a 50 or 60 hertz power line. Power is supplied to the load via a permanent power cord exiting the rear panel and a 15 amp, 120-volt outlet on the front panel. An internal 0.1-ohm shunt, wired in series with the neutral wire, senses the current. The voltage is measured between the hot and neutral wires. Power is provided to the measuring electronics via the same power cord. Current is limited to three amps RMS with an inline, 3 amp, slow-blow fuse accessible at the rear panel.

The Single Phase Power Multimeter measures; true RMS voltage and current; true power; and peak voltage, current, and power. This meter also calculates Power-Factor, Volt-Amps, and VARS. In addition the PLM-1-LP accumulates Time and Watt-Hours.

Display information, time, and accumulations of power are stored away in a non-volatile memory. If measuring power is lost, when it returns, the meter will power up and still retain the latest recorded information. Reset of Watt-hours and Time is accomplished via the front panel momentary switches.

A dual line, 16 character per line, LCD provides a visual output to the operator. Two front-panel pushbuttons allow sequencing through the different displays of values. All measurements and calculations are updated at 1 second intervals, and if your meter includes the RS232 option, all the measurements and calculations are output at 9600 baud, once each second. RS232 isolation is a minimum of 1500 volts.

Operating temperature: 25 ± 10 degrees C. Bandpass: 100th harmonic of 60 Hz (6Khz).
Crest factor: Peak current (10 amps) divided by measured RMS current.

MEASUREMENT	RANGE	ACCURACY
RMS Voltage	0.1 to 140.0 volts	0.5% +1 LSD
RMS Current	0. 001 to 3.000 amps	0.5% +1 LSD
Watts	0.1 to 420.1 watts	0.5% +1 LSD
Peak Voltage	0.1 to 200.0 volts	1% +1 LSD
Peak Current	0.01 to 10.00 amps	1% +1 LSD
Peak Power	1 to 2,000 watts	1% +1 LSD
Volt-Amps	0.1 to 420.0 VA	1% + 1 LSD
Power Factor	0.00 to 1.00	1.5%
VARS	1 to 420 VARS	1.5% (PF = 0.1 to 0.9)
Accumulate Power (Wh)	0.01 to 999999.99	05% + 1LSD
Hours	0.01 to 655.36	0.01% + 1LSD

APPENDIX B: TV DATA

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Hitachi	32	32CX12B	1996	3.1	132	143	x	FSEC
Hitachi	46	46UX20B	1996	2.3	145	165	x	FSEC
Hitachi	50	50XS18B	1996	1.6	142	163	x	FSEC
JVC	13	C13710	1996	1.9	35	60	x	FSEC
Matsushita	20	CT20G11	1996	1.1	81	204	x	FSEC
Matsushita	27	CT27G11	1996	1.2	102	240	x	FSEC
Philips-Mag	9	PRO91OX	1996	2.8	38	55	x	FSEC
Philips-Mag	9	PR0910X	1996	2.9	37	55	x	FSEC
Philips-Mag	13	PR1356 B121	1996	6.3	52	120	x	FSEC
Philips-Mag	19	PS1963C	1996	5.7	64	144	x	FSEC
Philips-Mag	25	TR2516C	1996	6.5	114	180	x	FSEC
Philips-Mag	27	TS2753C 103	1996	6.8	85	216	x	FSEC
Sony	20	KV20M20	1996	5.0	49	N/A	x	FSEC
Sony	32	KV32XBR45	1996	4.1	109	195	x	FSEC
Thomson	13	E13334WH	1996	2.2	30	70	x	FSEC
Thomson	13	E13334WH	1996	2.2	30	70	x	FSEC
Thomson	27	PS27113	1996	4.2	149	170	x	FSEC
Thomson	27	27GT616	1996	5.7	80	135	x	FSEC
Thomson	27	F27675BC	1996	7.1	109	120	x	FSEC
Thomson	32	F32632SB	1996	9.6	93	140	x	FSEC
Thomson	35	F35670MB	1996	9.8	114	140	x	FSEC
Toshiba	27	CF27F30	1996	0.6	61	N/A	x	FSEC
Toshiba	32	CF32F40	1996	0.5	84	100	x	FSEC
Toshiba	35	CF35F50	1996	0.5	75	108	x	FSEC
Zenith	13	SR1324S	1996	2.7	55	75	x	FSEC
Zenith	19	SY1951Y	1996	5.5	46	90	x	FSEC
Zenith	25	SY2549S	1996	5.5	59	110	x	FSEC
Zenith	27	SM2789BT8	1996	3.8	104	174	x	FSEC
Hitachi	36	36UX58B	1998	13.8	106	145	x	LBNL
JVC	20	AV20921	1998	0.4	39	87	x	LBNL
JVC	20	AV20921	1998	0.4	56	87	x	LBNL
JVC	32	AV32950	1998	3.2	77	130	x	LBNL
Matsushita	20	CT20G23	1998	1.1	62		x	LBNL

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Matsushita	20	CT20G23	1998	1.2	60		x	LBNL
Mitsubishi	27	CS27609	1998	13.4	87	165	x	LBNL
Philips-Mag	13	PR1317C	1998	5.0	43		x	LBNL
Philips-Mag	13	PR1302C	1998	5.2	50		x	LBNL
Philips-Mag	25	TS2574C	1998	8.1	95		x	LBNL
Philips-Mag	27	MX2791B	1998	4.8	72		x	LBNL
Sharp	13	13KM100	1998	1.7	43	69	x	LBNL
Sharp	25	25KM100	1998	3.1	104		x	LBNL
Sharp	32	32KX1000	1998	1.6	77	145	x	LBNL
Sharp	36	36KS400	1998	1.5	104		x	LBNL
Sony	9	KV9PT50	1998	4.0	25	53	x	LBNL
Sony	20	KV20V80	1998	7.0	47	100	x	LBNL
Sony	27	KV27V65	1998	0.3	73	170	x	LBNL
Sony	32	KB32XBR200	1998	0.9	126		x	LBNL
Thomson	13	E1334WH	1996	2.1	31	70	x	LBNL
Thomson	20	F20632SE	1998	11.8	81	110	x	LBNL
Toshiba	13	CF13H22	1998	2.2	35	55	x	LBNL
Zenith	25	A25A02D	1998	4.9	88	103	x	LBNL
Hitachi	13	CT13C7	1985	5.3	41	67	x	Repair
Hitachi	26	CT2667	1987	0.8	117	169	x	Repair
Hitachi	27	27AX4B	1993	1.7	124	155	x	Repair
Hitachi	27	27MX1B	1991	1.2	73	135	x	Repair
Hitachi	27	CT7970B	1990	3.1	109	150	x	Repair
Hitachi	31	31UX5B	1994	4.3	136	180	x	Repair
JVC	13	C1321	1991	4.1	45	85	x	Repair
JVC	13	C1329	1989	3.9	44	85	x	Repair
JVC	14	C14MIU	1993	7.6	62	85	x	Repair
JVC	20	AV20CM6	1995	1.0	88	115	x	Repair
JVC	20	AV20CM4	1993	1.1	83	120	x	Repair
JVC	20	AV20TP5	1995	1.2	88	120	x	Repair
JVC	20	AV20CM3	1993	1.1	50	110	x	Repair
JVC	20	AV20CM5	1995	1.1	86	120	x	Repair
JVC	25	C2570	1985	2.0	92	130	x	Repair
JVC	26	AV2672	1992	1.0	70	130	x	Repair

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
JVC	26	AV2672S	1992	1.1	59	130	x	Repair
JVC	27	AV27CM3	1992	1.1	108	147	x	Repair
JVC	27	AV27CM3	1993	1.2	91	147	x	Repair
JVC	35	AV35BP3	1992	0.9	160	195	x	Repair
Matsushita	9	UP1775E	1986	0.0	47	43	NO	Repair
Matsushita	20	CTL2053R	1989	1.1	48		x	Repair
Matsushita	20	PVM2028	1989	8.5	48	120	x	Repair
Matsushita	25	TU9828AC	1986	3.6	75	130	x	Repair
Matsushita	25	TU9840	1985	1.7	82	110	x	Repair
Matsushita	27	CT27S1R	1993	1.4	120		x	Repair
Matsushita	27	CTM2771S	1990	1.1	82		x	Repair
Matsushita	27	CT27SF12T	1995	1.4	82		x	Repair
Matsushita	27	CTN2761S	1992	1.3	75	180	x	Repair
Matsushita	31	CTL3191S	1990	0.9	149		x	Repair
Matsushita	61	PT61G45	1996	1.4	117		x	Repair
Mitsubishi	13	CS1347R	1991	1.0	40	75	x	Repair
Mitsubishi	13	CS13103	1995	2.7	55	64	x	Repair
Mitsubishi	19	CS1984R	1984	3.3	73	120	x	Repair
Mitsubishi	19	CS2013R	1987	10.6	65	119	x	Repair
Mitsubishi	20	CS2011	1986	1.8	74	140	x	Repair
Mitsubishi	20	CS20SXI	1992	2.0	53	115	x	Repair
Mitsubishi	20	CS20RXI	1993	2.3	54	115	x	Repair
Mitsubishi	20	CS20103	1997	2.7	70	84	x	Repair
Mitsubishi	20	CS20102	1993	3.3	57	115	x	Repair
Mitsubishi	20	CS20EX1	1992	5.0	73	130	x	Repair
Mitsubishi	20	CS2005	1991	7.0	62	120	x	Repair
Mitsubishi	20	CS2060R	1989	10.0	81	120	x	Repair
Mitsubishi	20	CS2060	1988	11.9	86	120	x	Repair
Mitsubishi	20	CS2052R	1985	13.8	79	147	x	Repair
Mitsubishi	25	CS2566R	1990	3.7	87	165	x	Repair
Mitsubishi	25	CJ2588R	1984	3.2	86	165	x	Repair
Mitsubishi	25	CS2572R	1983	4.4	79	138	x	Repair
Mitsubishi	26	CS2653R		10.7	79	150	x	Repair
Mitsubishi	26	CS2643R	1986	2.0	80	155	x	Repair

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Mitsubishi	26	CS2671R	1989	4.4	99	155	x	Repair
Mitsubishi	26	CK2694R	1987	5.3	92	185	x	Repair
Mitsubishi	26	CK2690	1986	8.4	95	175	x	Repair
Mitsubishi	26	CS2620I	1994	8.9	136	145	x	Repair
Mitsubishi	26	CS2656R	1989	10.5	90	149	x	Repair
Mitsubishi	26	CS2610	1990	10.5	102	145	x	Repair
Mitsubishi	26	CK2600R	1988	10.6	71	150	x	Repair
Mitsubishi	26	CS2630I	1994	10.9	104	145	x	Repair
Mitsubishi	26	CS26ER1	1993	11.2	90	145	x	Repair
Mitsubishi	26	CS26EXI	1992	11.5	108	145	x	Repair
Mitsubishi	26	CS2667	1985	18.2	109	193	x	Repair
Mitsubishi	26	CS2653	1987	10.6	69	150	x	Repair
Mitsubishi	27	CK2730R	1990	1.8	129	160	x	Repair
Mitsubishi	27	CS2771R	1990	2.1	108	187	x	Repair
Mitsubishi	27	CS2724R	1991	2.1	120	187	x	Repair
Mitsubishi	27	CS2715	1991	2.4	113	165	x	Repair
Mitsubishi	27	CS27EX1	1992	11.6	90	150	x	Repair
Mitsubishi	27	CS27EX1	1993	11.8	103	150	x	Repair
Mitsubishi	27	CS2710R	1992	12.2	91	130	x	Repair
Mitsubishi	27	CK27306	1997	12.0	98	165	x	Repair
Mitsubishi	31	CS3114R	1990	2.2	135	205	x	Repair
Mitsubishi	31	CS3121	1996	4.8	144	265	x	Repair
Mitsubishi	31	CS3120R	1989	5.3	118	250	x	Repair
Mitsubishi	31	CK3101	1987	5.6	108	210	x	Repair
Mitsubishi	31	CK3136R	1991	6.8	126	265	x	Repair
Mitsubishi	31	CS31MX1	1992	12.3	103	175	x	Repair
Mitsubishi	31	CS3131	1990	4.8	161	210	x	Repair
Mitsubishi	31	CK3112	1988	5.6	115	200	x	Repair
Mitsubishi	31	CS31301	1993	11.9	114	175	x	Repair
Mitsubishi	31	CS31MX1	1993	12.8	165	210	x	Repair
Mitsubishi	32	CS32207	1997	3.2	81	175	x	Repair
Mitsubishi	35	CS35405	1996	4.5	86	195	x	Repair
Mitsubishi	35	CK3531R	1991	4.9	149	220	x	Repair
Mitsubishi	35	CS3505R	1989	5.2	121	210	x	Repair

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Mitsubishi	35	CS3520	1989	5.3	118	275	x	Repair
Mitsubishi	35	CK3502R	1986	8.3	118	230	x	Repair
Mitsubishi	35	CK35MX2	1992	11.0	110	205	x	Repair
Mitsubishi	35	CS36509	1997	15.0	106	200	x	Repair
Mitsubishi	35	CS3520R	1990	6.5	112	275	x	Repair
Mitsubishi	35	CS3515	1991	2.3	110	210	x	Repair
Mitsubishi	35	CK3536	1991	6.8	130	290	x	Repair
Mitsubishi	35	CK3527	1992	7.3	157	240	x	Repair
Mitsubishi	35	CK3526	1992	7.3	120	240	x	Repair
Mitsubishi	40	VS405R	1985	13.7	114	200	x	Repair
Mitsubishi	40	VS4001	1989	4.1	147	230	x	Repair
Mitsubishi	40	VS410	1988	4.5	119	210	x	Repair
Mitsubishi	40	CS40FX1	1992	6.9	115	290	x	Repair
Mitsubishi	40	VS406	1987	13.7	115	200	x	Repair
Mitsubishi	45	VS4502R	1990	3.9	166	230	x	Repair
Mitsubishi	45	VS4562R	1993	16.4	155	200	x	Repair
Mitsubishi	45	VS4502	1989	2.9	139	230	x	Repair
Mitsubishi	45	VS4503	1992	3.9	177	270	x	Repair
Mitsubishi	46	VS463	1987	6.3	150	210	x	Repair
Mitsubishi	46	VS468	1988	15.4	190	210	x	Repair
Mitsubishi	50	VS5003	1991	3.6	140	270	x	Repair
Mitsubishi	50	VS5062	1993	14.2	145	260	x	Repair
Mitsubishi	50	VS5001	1989	4.0	163	230	x	Repair
Mitsubishi	50	VS5071	1994	10.0	170	280	x	Repair
Mitsubishi	50	VS5073	1994	15.6	186	290	x	Repair
Mitsubishi	50	VS5075	1995	16.3	135	250	x	Repair
Mitsubishi	60	VS6017	1992	3.3	190	300	x	Repair
Mitsubishi	60	VS6004R	1991	3.8	162	270	x	Repair
Mitsubishi	60	VS6061R	1993	15.6	142	260	x	Repair
Mitsubishi	60	VS6041	1995	1.8	120	250	x	Repair
Mitsubishi	60	VS6021R	1990	3.6	200	270	x	Repair
Mitsubishi	70	VS7004	1994	4.6	168	270	x	Repair
Other	13	13BO81	1982	0.0	56		NO	Repair
Other	19	TC1965	1990	5.1	84	102	x	Repair

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Other	19	6852127	1985	6.3	81	130	x	Repair
Other	19	CTSG9369TCT	1996	11.4	114	100	x	Repair
Other	20	CT2030S	1987	3.0	80	120	x	Repair
Other	25	685-2498	1992	0.8	64	125	x	Repair
Other	25	MWL2573S	1994	12.0	97	106	x	Repair
Other	27	CT2700S	1988	1.8	101	160	x	Repair
Philips-Mag	20	PR1901C127	1997	6.4	58		x	Repair
Philips-Mag	25	RX4470AK01	1990	0.8	88	115	x	Repair
Philips-Mag	25	RG4956PE02	1986	9.8	76	120	x	Repair
Philips-Mag	25	RJ4910	1989	3.5	62		x	Repair
Philips-Mag	25	CR4524	1994	5.1	67	150	x	Repair
Philips-Mag	27	RJ6050AK02	1988	2.8	70		x	Repair
Philips-Mag	27	RK6070	1989	2.8	66		x	Repair
Philips-Mag	27	RS5266	1987	5.8	110	115	x	Repair
Philips-Mag	27	TS2775	1997	6.9	60	180	x	Repair
Philips-Mag	46	RK8558	1990	3.3	121	200	x	Repair
Samsung	25	TC2540S	1989	4.9	60	130	x	Repair
Sanyo	20	AVM2001	1993	6.5	70	70	x	Repair
Sanyo	27	AVM2504	1994	5.9	74	94	x	Repair
Sharp	13	13H-M60	1996	2.6	48	62	x	Repair
Sharp	19	19FM50	1994	3.8	58	80	x	Repair
Sharp	25	25SB720	1991	3.5	81	120	x	Repair
Sharp	25	25AS120	1991	3.9	89	110	x	Repair
Sharp	27	27GS60	1995	3.1	82	125	x	Repair
Sharp	27	27EES50	1993	5.1	200	140	x	Repair
Sharp	27	27ES100	1993	5.0	102	140	x	Repair
Sharp	27	27E550	1994	4.9	80	140	x	Repair
Sony	8	KV8AD11	1993	2.5	30	32	x	Repair
Sony	8	KV8AD10	1990	4.5	28	33	x	Repair
Sony	9	KV9PT50	1996	4.4	39	53	x	Repair
Sony	12	KV1206		0.0	68	95	NO	Repair
Sony	13	KV13TR24	1991	2.2	51	97	x	Repair
Sony	13	KV13M10	1994	4.1	48	75	x	Repair
Sony	13	KV1393R	1988	4.6	56	97	x	Repair

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Sony	13	KV13VM20	1995	5.6	57	85	x	Repair
Sony	13	KV1380R	1989	6.0	78	100	x	Repair
Sony	13	KV1370R		6.0	59	97	x	Repair
Sony	13	KV131R24	1991	2.9	47	97	x	Repair
Sony	13	KV13TR25	1991	3.3	49	97	x	Repair
Sony	17	KV1723D	1975	0.0	97	125	NO	Repair
Sony	17	KV1746	1981	3.0	61	73	x	Repair
Sony	19	KV1998R	1986	4.3	101	140	x	Repair
Sony	19	DV1998R	1987	4.4	103	140	x	Repair
Sony	19	KV19TR20	1990	4.4	76	120	x	Repair
Sony	19	KV19TS20	1991	4.4	72	120	x	Repair
Sony	19	KV19TS20	1992	4.4	78	120	x	Repair
Sony	19	KV19TS20	1990	4.6	69	120	x	Repair
Sony	19	KV19TR20	1992	4.8	60	120	x	Repair
Sony	20	KV20EXR10	1991	0.9	85	130	x	Repair
Sony	20	KV20EXR20	1992	1.0	85	130	x	Repair
Sony	20	KV20EXR20	1991	1.1	86	130	x	Repair
Sony	20	KV20XBR	1984	1.2	75	145	x	Repair
Sony	20	KV20EXR20	1992	1.2	81	130	x	Repair
Sony	20	KV20S10	1994	3.3	75	100	x	Repair
Sony	20	KV20S10	1995	3.3	73	100	x	Repair
Sony	20	KV20S10	1990	3.4	41	100	x	Repair
Sony	20	KV20S10	1995	3.4	65	100	x	Repair
Sony	20	KV20S10	1994	3.8	55	100	x	Repair
Sony	20	KV20V50	1994	4.0	72	120	x	Repair
Sony	20	KV20TS32	1995	4.3	76	120	x	Repair
Sony	20	KV20TS27	1991	4.4	70	125	x	Repair
Sony	20	KV20TS20	1989	4.5	102	130	x	Repair
Sony	20	KV20TS20	1989	4.5	99	130	x	Repair
Sony	20	KV2095R	1987	4.6	77	125	x	Repair
Sony	20	KV20TR21	1989	4.6	98	125	x	Repair
Sony	20	KV20TS30	1990	4.6	97	130	x	Repair
Sony	20	KV20TS22	1989	5.0	102	130	x	Repair
Sony	20	KV2080R	1987	6.2	103	130	x	Repair

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Sony	20	KV20VM30	1998	6.6	75	108	x	Repair
Sony	20	KV20V60	1997	6.7	75	90	x	Repair
Sony	20	KV2093R	1988	4.0	105	130	x	Repair
Sony	25	KV25XBR	1984	1.2	124	185	x	Repair
Sony	25	KV25XBR	1985	1.3	103	185	x	Repair
Sony	26	KV2643R	1980	5.0	118	160	x	Repair
Sony	27	KV27SXR10	1988	0.6	125	170	x	Repair
Sony	27	KV27EXR20	1993	0.9	128	160	x	Repair
Sony	27	KV27XBR10	1989	1.0	101	225	x	Repair
Sony	27	KV27EXR15	1990	1.0	101	165	x	Repair
Sony	27	KV27EXR25	1991	1.0	106	165	x	Repair
Sony	27	KV27EXR25	1992	1.0	115	165	x	Repair
Sony	27	KV27XBR10	1991	1.1	99	225	x	Repair
Sony	27	KV27V15	1995	3.1	88	170	x	Repair
Sony	27	KV27TS27	1991	3.2	133	110	x	Repair
Sony	27	KV27TS27	1992	3.3	109	160	x	Repair
Sony	27	KV27TW75	1992	3.5	92	170	x	Repair
Sony	27	KV27TS35	1992	3.6	93	170	x	Repair
Sony	27	KV27TX40	1989	3.9	106	160	x	Repair
Sony	27	KV27TS22	1988	4.1	89	160	x	Repair
Sony	27	KV27TS21	1991	4.2	125	160	x	Repair
Sony	27	KV27XBR45	1995	4.2	103	185	x	Repair
Sony	27	KV27XBR96	1994	4.7	145	270	x	Repair
Sony	27	KV27XBR96S	1994	4.8	117	270	x	Repair
Sony	27	KV27XBR45	1996	4.8	106	185	x	Repair
Sony	27	KV27TS29	1993	5.6	82	165	x	Repair
Sony	27	KV2729R	1987	6.3	122	155	x	Repair
Sony	27	KV2781R	1985	6.4	117	165	x	Repair
Sony	27	KV27V20	1996	7.7	78	180	x	Repair
Sony	27	KV27V20	1996	8.0	79	180	x	Repair
Sony	27	KV27EXR20	1992	1.0	97	160	x	Repair
Sony	27	KV27HSR10	1989	1.1	105	225	x	Repair
Sony	27	KV27XBR15	1990	1.1	116	225	x	Repair
Sony	27	KV2791	1986	6.6	90	165	x	Repair

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Sony	27	KV27V20	1997	6.6	71	180	x	Repair
Sony	27	KV27DS24	1988	6.8	98	160	x	Repair
Sony	27	KV27V22	1997	7.5	70	180	x	Repair
Sony	29	KV29XBR85	1992	1.2	134	286	x	Repair
Sony	29	KV29XBR05	1991	1.3	138	286	x	Repair
Sony	32	KV32HSR10	1989	1.1	142	240	x	Repair
Sony	32	KV32XBR15	1990	1.1	164	240	x	Repair
Sony	32	KV32XBR55	1992	1.2	152	240	x	Repair
Sony	32	KV32XBR75	1991	1.3	133	240	x	Repair
Sony	32	KV32TW75	1992	3.4	110	195	x	Repair
Sony	32	KV32XBR35	1992	5.8	141	225	x	Repair
Sony	32	KV32S26	1998	7.2	88	185	x	Repair
Sony	32	KV32S26	1998	7.8	77	185	x	Repair
Sony	32	KV32XBR10	1990	1.1	120	240	x	Repair
Sony	32	KV32XBR37	1994	4.6	106	190	x	Repair
Sony	32	KV32SXR10	1988	0.7	99	185	x	Repair
Sony	32	KV32TS20	1992	3.6	90	185	x	Repair
Sony	46	KPR46EXR15	1993	5.0	205	255	x	Repair
Sony	46	KPR46CX25	1990	1.2	151	290	x	Repair
Sony	53	KV53XBR35	1995	4.1	211	350	x	Repair
Sony	53	KP53XBR45	1996	2.2	181	300	x	Repair
Sony	61	KP61XBR28	1994	3.9	204	220	x	Repair
Thomson	13	E13231GM	1990	2.9	47	70	x	Repair
Thomson	19	F19201BK	1994	2.1	75	85	x	Repair
Thomson	19	F19220BK	1994	2.1	65	95	x	Repair
Thomson	19	F19201BK	1994	2.0	40	85	x	Repair
Thomson	19	F19220BK	1995	2.2	28	95	x	Repair
Thomson	19	F19204WJ	1995	3.0	46	85	x	Repair
Thomson	20	F20301SF	1994	2.2	76	85	x	Repair
Thomson	20	20GT324	1994	2.2	65	85	x	Repair
Thomson	20	20GT324	1994	2.2	73	120	x	Repair
Thomson	20	X20102SG	1994	2.5	74	85	x	Repair
Thomson	20	F20345	1991	3.2	58	100	x	Repair
Thomson	20	F20251WN	1994	6.3	91	100	x	Repair

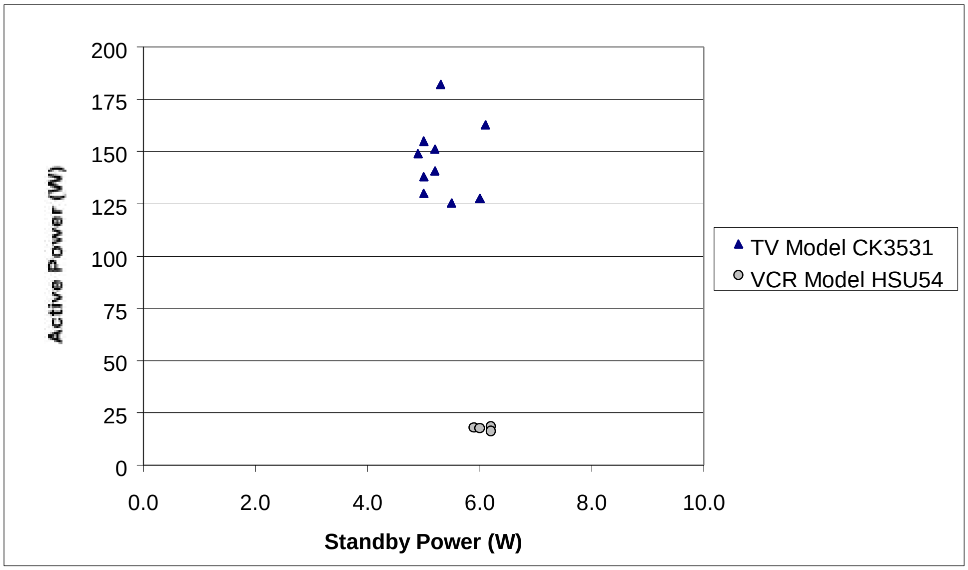
Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Thomson	20	F20632SE	1997	9.7	98	110	x	Repair
Thomson	20	J20330BL	1995	6.9	93	120	x	Repair
Thomson	20	PS20105	1994	8.1	92	110	x	Repair
Thomson	20	F20631SE	1993	7.0	89	100	x	Repair
Thomson	25	F25190SB	1992	5.6	115	125	x	Repair
Thomson	25	T25251NN	1993	6.0	106	125	x	Repair
Thomson	25	T25651BL	1993	6.1	108	125	x	Repair
Thomson	25	25GT506	1994	6.3	111	125	x	Repair
Thomson	25	F25250BC	1995	6.5	81	120	x	Repair
Thomson	25	25GT520	1993	6.6	85	125	x	Repair
Thomson	25	GSR673T	1984	0.0	56	88	NO	Repair
Thomson	25	GJR699PR	1984	4.8	71	94	x	Repair
Thomson	25	25NC168	1988	5.9	69	125	x	Repair
Thomson	26	G26275CK	1988	2.9	82	120	x	Repair
Thomson	27	F27240NT	1995	6.5	109	125	x	Repair
Thomson	27	27GT65U	1989	3.2	54	120	x	Repair
Thomson	27	PS27108	1995	8.8	99	125	x	Repair
Thomson	31	F31672ET	1994	7.6	126	140	x	Repair
Toshiba	19	CE19G10	1997	0.9	59	54	x	Repair
Toshiba	19	CF1922J	1990	2.6	75		x	Repair
Toshiba	20	CE909	1989	1.3	52	80	x	Repair
Toshiba	20	CF2010J	1990	1.7	60	68	x	Repair
Toshiba	20	CF2028A	1989	2.1	77	69	x	Repair
Toshiba	20	CF2010J	1990	2.1	74	68	x	Repair
Toshiba	20	CF2034J	1989	2.4	65		x	Repair
Toshiba	20	CF915	1986	2.8	64	70	x	Repair
Toshiba	20	C2034M	1985	1.8	55		x	Repair
Toshiba	20	CF2038A	1988	3.8	72	75	x	Repair
Toshiba	26	CF2655	1989	1.0	110	98	x	Repair
Toshiba	26	CX2668	1988	3.7	103	99	x	Repair
Toshiba	27	CF27C30	1994	0.8	102	87	x	Repair
Toshiba	27	CX2778	1989	4.6	82	104	x	Repair
Toshiba	30	CF30C50	1994	0.9	112	111	x	Repair
Toshiba	30	CF3060K	1990	1.1	108	116	x	Repair

Brand	Size	Model	Year	Off	On	Rated	Remote	Source
Toshiba	30	CF30C50	1994	0.9	88	111	x	Repair
Toshiba	30	CF3048	1992	2.5	111		x	Repair
Toshiba	32	CX32D60	1995	1.0	94	112	x	Repair
Toshiba	32	CF3274J	1990	1.3	169	163	x	Repair
Zenith	13	SRV1300S	1995	12.6	38	70	x	Repair
Zenith	19	SR1941Y	1995	7.3	46	82	x	Repair
Zenith	19	SL7935S	1993	9.5	62	86	x	Repair
Zenith	19	SS1937S9	1993	10.5	60	93.5	x	Repair
Zenith	19	SLS1937S	1993	15.1	111	99	x	Repair
Zenith	20	SMS20535	1994	7.1	51	79	x	Repair
Zenith	20	H2071H2	1989	10.7	93	93	x	Repair
Zenith	23	SS2345P	1983	4.4	76	89	x	Repair
Zenith	23	G4549	1978	0.0	113	180	NO	Repair
Zenith	25	SMS2550S	1994	7.2	76	109	x	Repair
Zenith	25	SM2568S	1995	9.3	88	114	x	Repair
Zenith	25	SR2573DT	1995	11.7	110	106	x	Repair
Zenith	25	SM2511W7	1978	4.4	75	119	x	Repair
Zenith	25	A2508	1984	0.0	85	93	NO	Repair
Zenith	25	SZ2519	1984	3.6	84	93	x	Repair
Zenith	25	SM2527	1984	4.7	92	180	x	Repair
Zenith	25	SE2505	1988	5.9	73	92	x	Repair
Zenith	27	SL2737RK	1993	10.6	112	130	x	Repair
Zenith	27	SY2772DT	1996	7.5	86	112	x	Repair
Zenith	27	SG2767H	1990	10.0	68	85	x	Repair
Zenith	27	SM2745	1995	4.0	91	170	x	Repair
Zenith	27	SJ2722	1993	8.0	65	105	x	Repair
Zenith	27	SCS2504	1993	8.1	75	100	x	Repair
Zenith	27	SS2504	1993	9.9	88	100	x	Repair
Zenith	27	CK2765	1993	10.4	61	100	x	Repair
Zenith	27	SG2721	1990	10.5	88	120	x	Repair
Zenith	27	SJ2722LX8	1992	11.2	67	86	x	Repair
Zenith	27	PL2789	1988	12.8	77	108	x	Repair
Zenith	27	SE2725R	1988	20.7	95	118	x	Repair

APPENDIX C: RELIABILITY OF POWER MEASUREMENTS

Power measurements are not 100% reliable. Figure C1 shows two examples. The first is TV model number CK3531, of which ten different units were measured. For the same model (different units), active power draw varies from 125 to about 180 watts, while standby power draw varies from 5 to 6 watts. The second example is VCR model number HSU54. The four units drew between 16 and 18 watts while active and between 5.9 and 6.2 watts in standby.

Figure C1. Measured power consumption values for different units with the same model number



APPENDIX D: TV AND VCR MANUFACTURER CODES AND RANKINGS

Table D1 shows the manufacturer codes used in this study.

Table D1. TV and VCR manufacturer codes used in this study

TVS	VCRs
A Hitachi	A Goldstar
B JVC	B Hitachi
C Matsushita (Panasonic, Quasar)	C JVC
D Mitsubishi	D Matsushita (Panasonic, Quasar)
E N.A.P. (Magnavox, Sylvania,	E Mitsubishi
F Other	F Other
G Samsung	G N.A.P. (Magnavox, Sylvania,
H Sanyo	H Sanyo
I Sharp	I Sharp
J Sony	J Sony
K Thomson (RCA, GE)	K Thomson (RCA, GE)
L Toshiba	L Toshiba
M Zenith	M Zenith

To determine whether manufacturers were consistently efficient or inefficient in the power modes measured, each manufacturer was assigned two different ranks: one for standby power draw and one for active or idle power draw, where 1 represents the most efficient manufacturer. These rankings are shown in Tables D2 and D3.

Table D2. TV manufacturer power consumption rankings

	A	B	C	D	E	F	G	H	I	J	K	L	M
Standby Rank	6	3	1	12	7	10	8	11	4	5	9	2	13
Active Rank	12	3	7	13	6	2	1	9	10	11	4	8	5

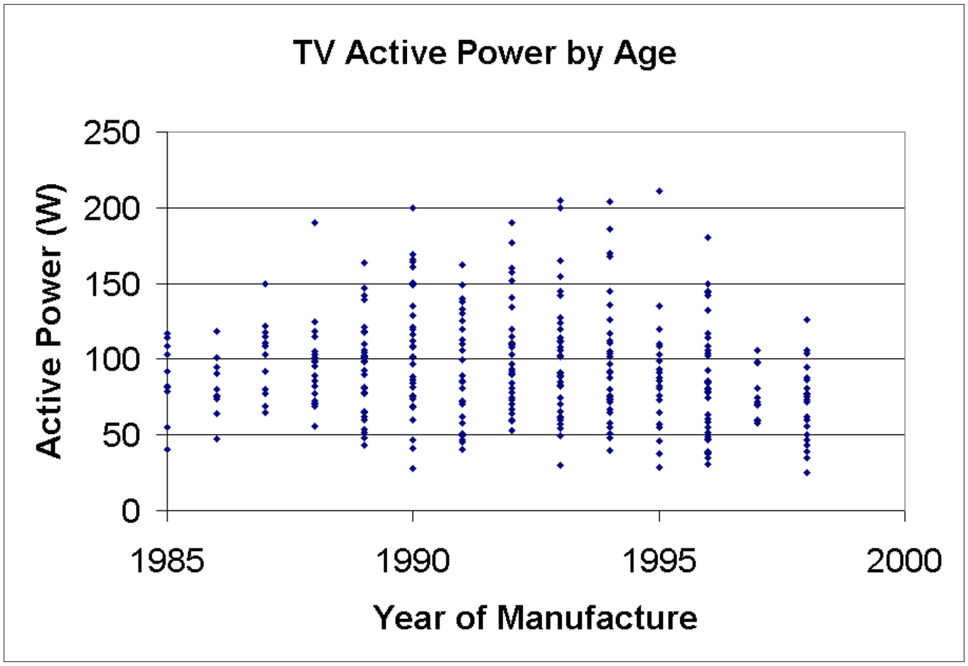
Table D3. VCR manufacturer power consumption rankings

	A	B	C	D	E	F	G	H	I	J	K	L	M
Standby Rank	5	13	1	6	8	12	2	11	10	7	4	3	9
Idle Rank	5	12	7	1	11	10	3	8	2	13	4	9	6

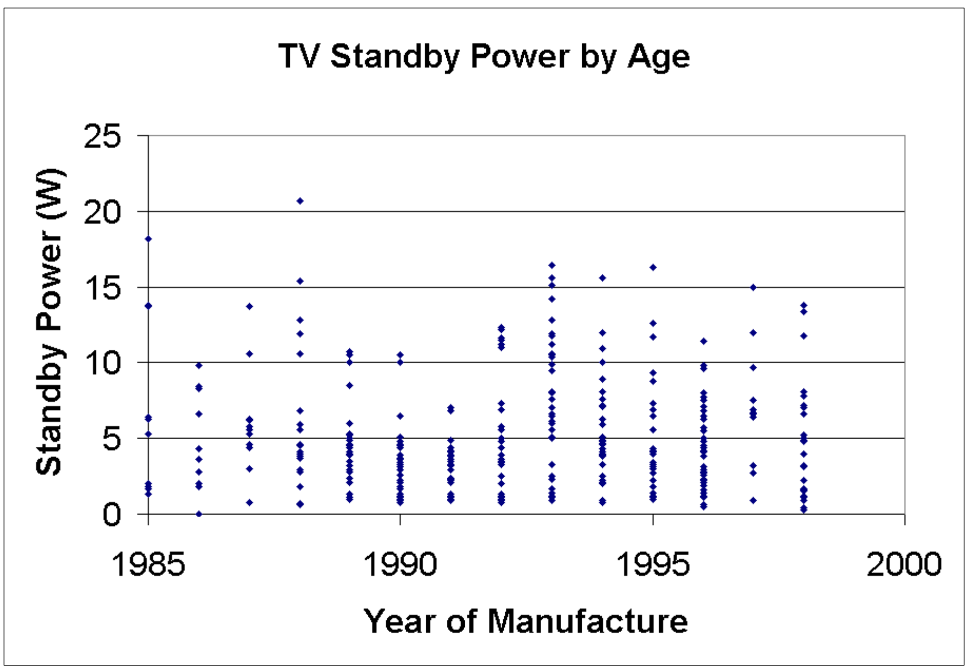
There seems to be no correlation between the active and standby rankings of the TV manufacturers (r = -0.066). A correlation analysis of the VCR rankings suggests that there is a tendency for manufacturers that make VCRs with high standby power consumption to also make VCRs with high idle power consumption (r=0.37).

APPENDIX E: SCATTER PLOTS OF POWER MEASUREMENT DATA

Figure E1. Effect of age on TV power use

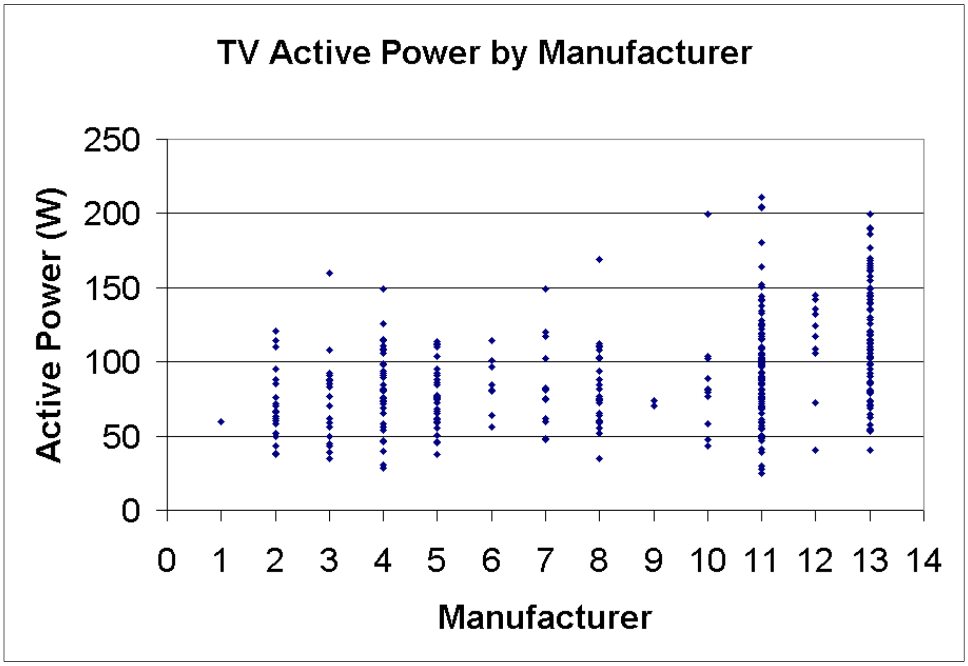


(a)

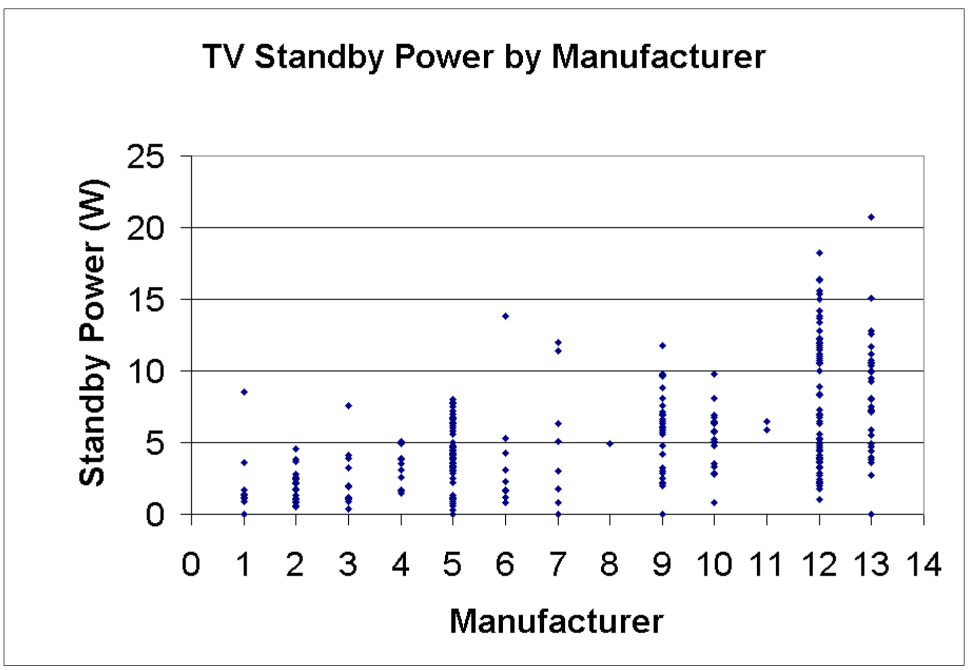


(b)

Figure E2. Effect of manufacturer on TV power use

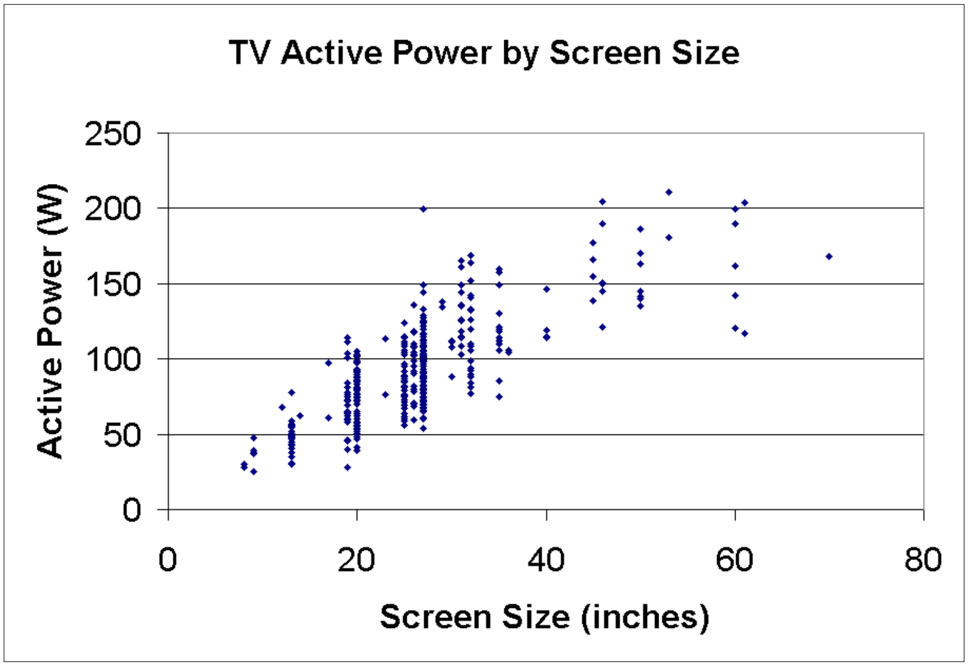


(a)

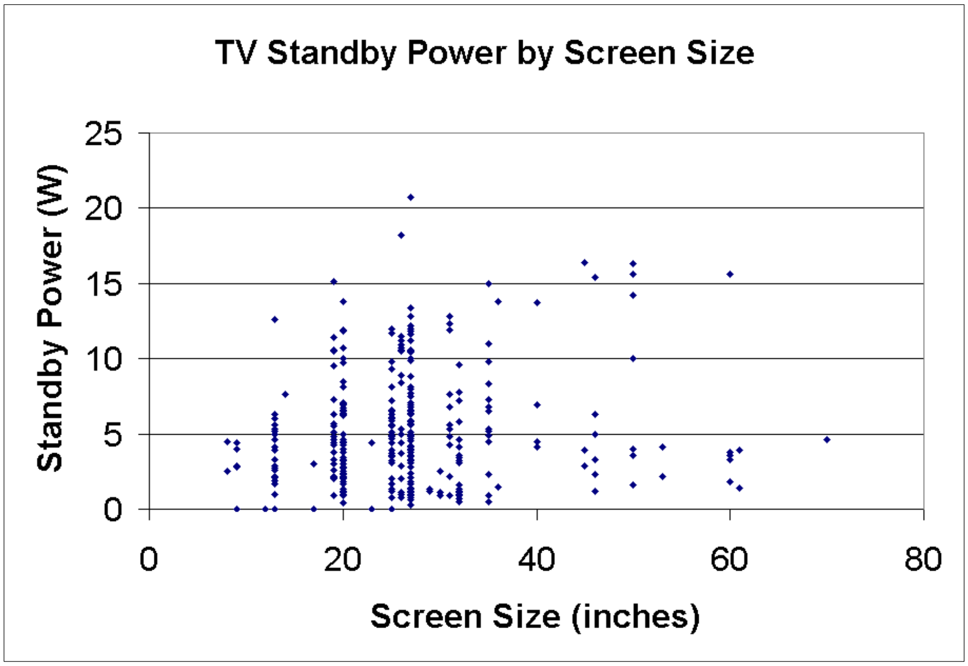


(b)

Figure E3. Effect of screen size on TV power use

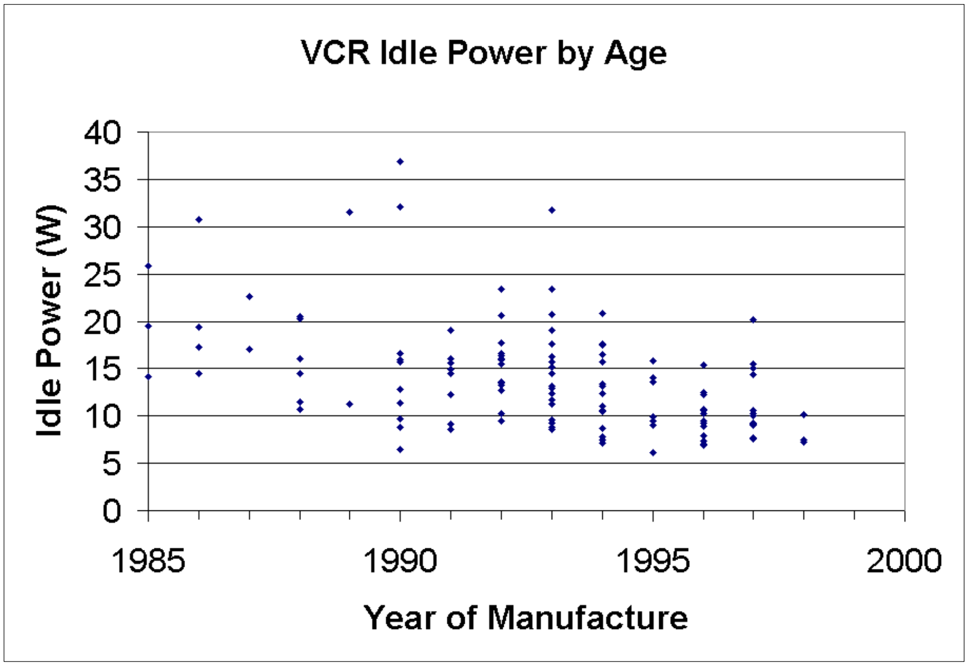


(a)

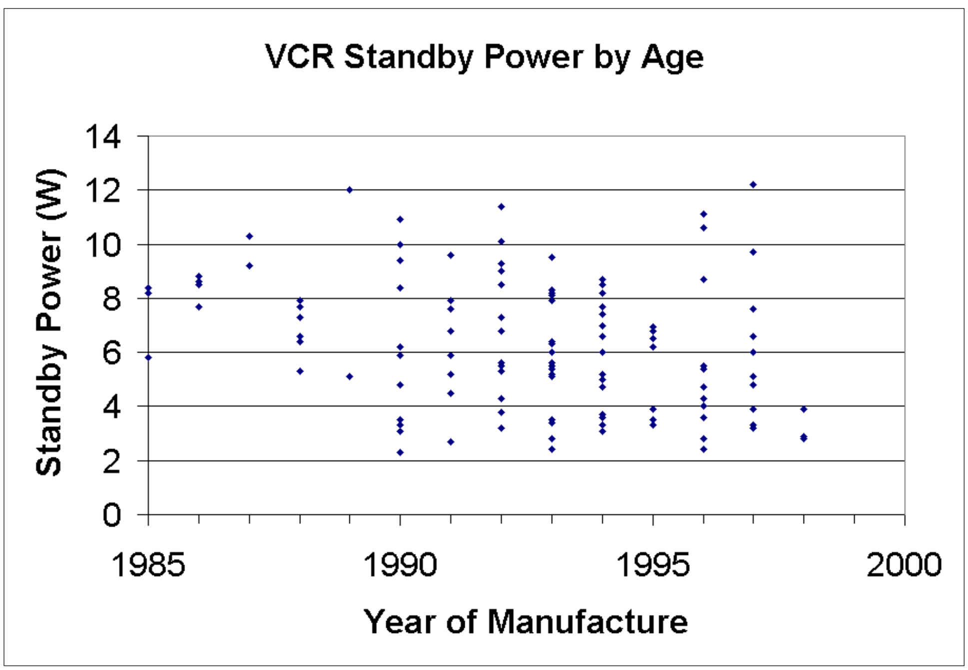


(b)

Figure E4. Effect of age on VCR power use

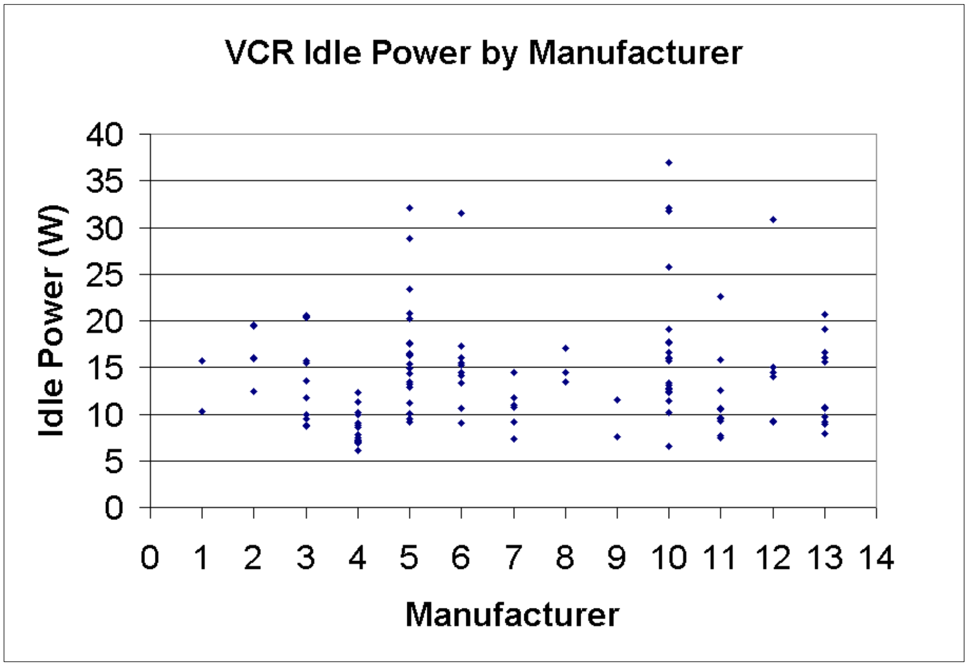


(a)

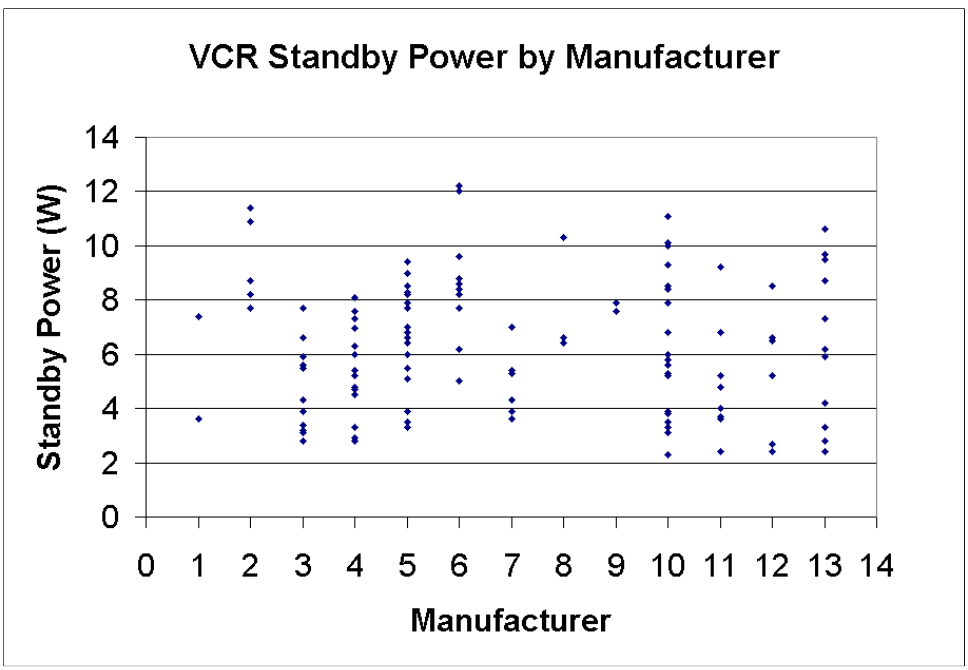


(b)

Figure E5. Effect of manufacturer on VCR power use



(a)



(b)

APPENDIX F: HISTORIC TRENDS IN TV AND VCR POWER DRAW

Figure F1. TV trends: active power draw

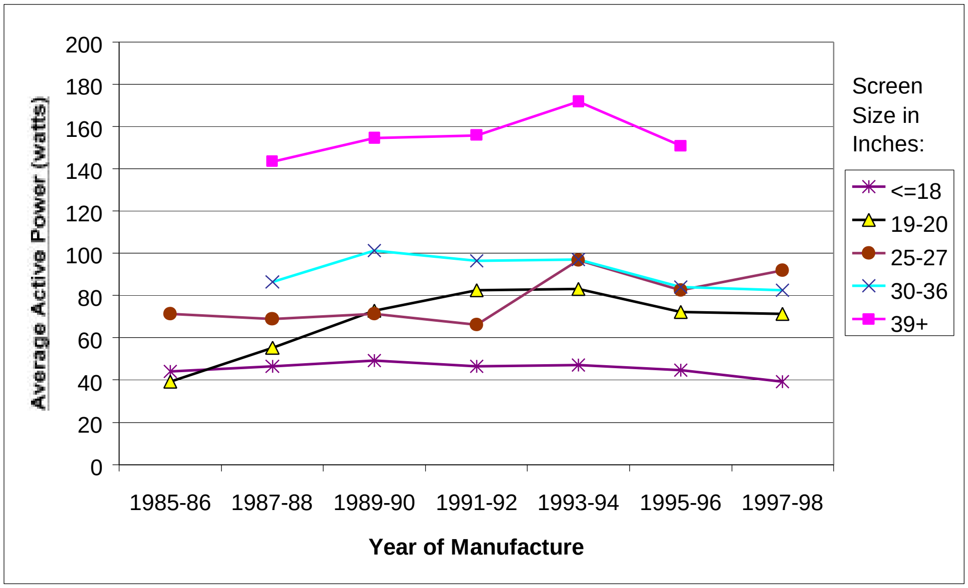


Figure F2. TV trends: standby-mode power draw

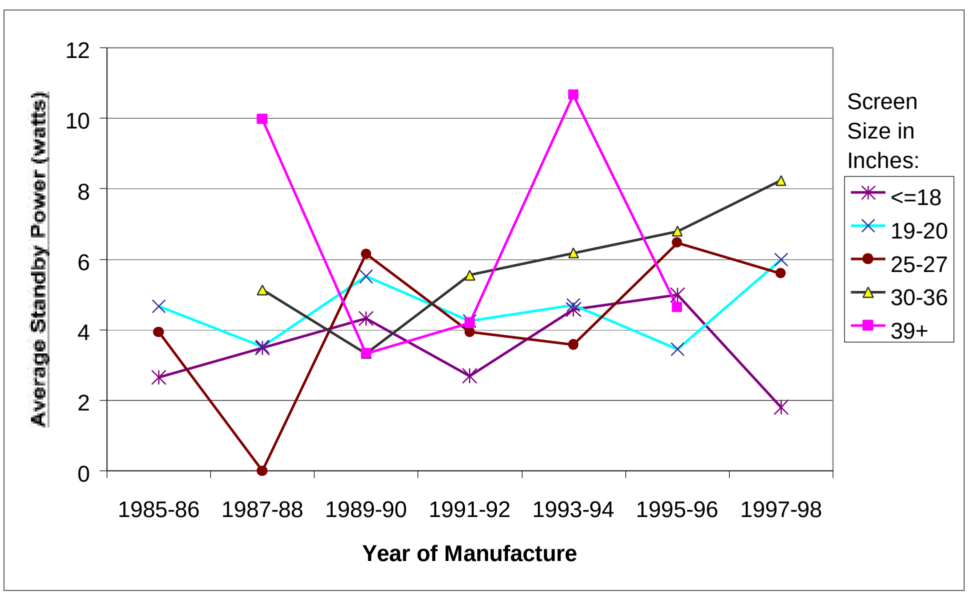


Figure F3. VCR trends: Idle-mode power draw

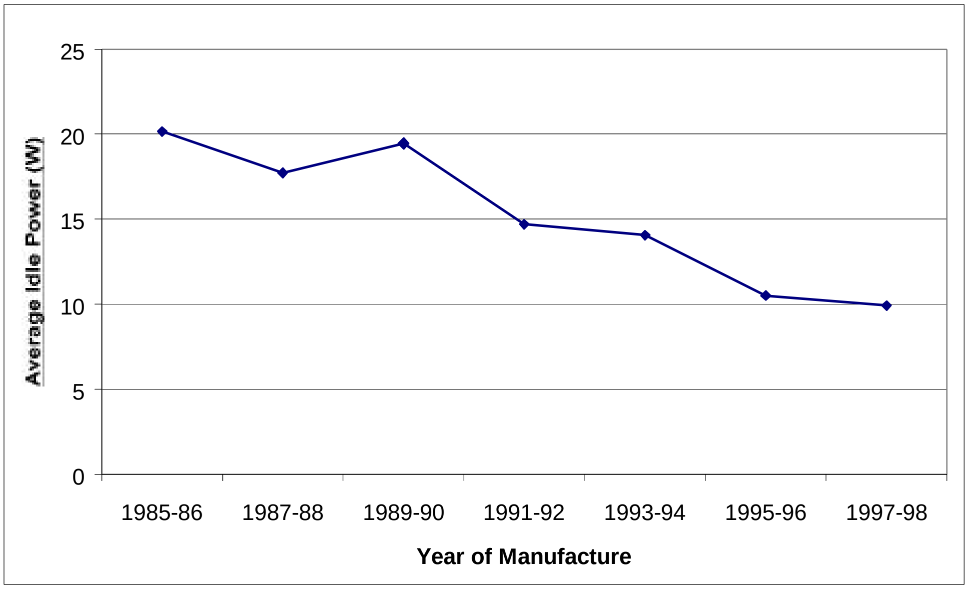
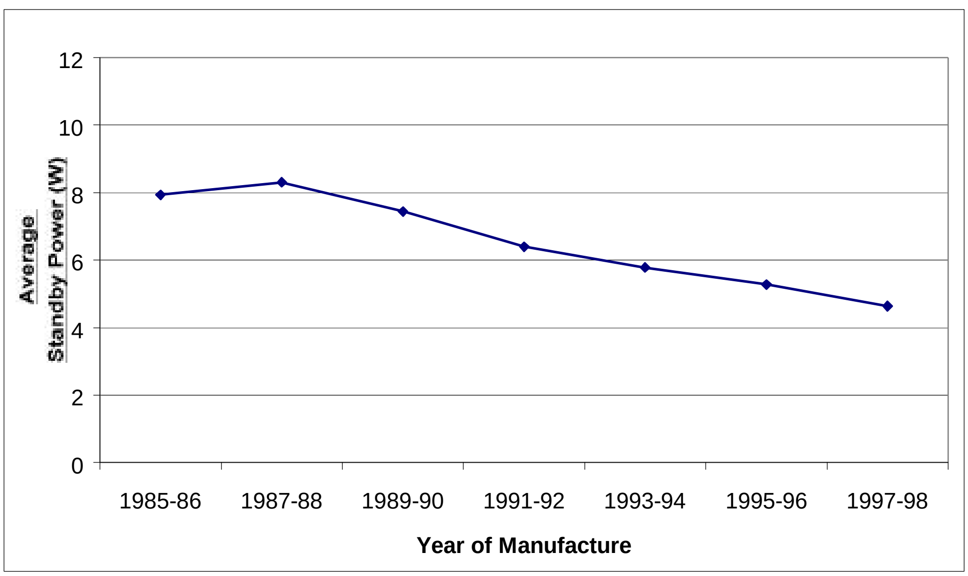


Figure F4. VCR trends: Standby-mode power draw



APPENDIX G: EFFECT OF TV SCREEN SIZE ON POWER DRAW

Active power consumption clearly increases as TV screen size increases, as shown in Figure G1. However, the relationship between standby power consumption and screen size is not clear, as shown in Figure G2.

Figure G1. Average active power consumption values by screen size

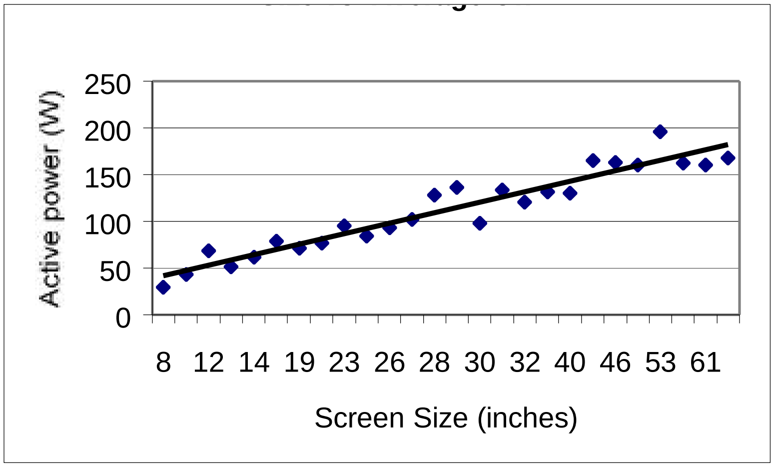
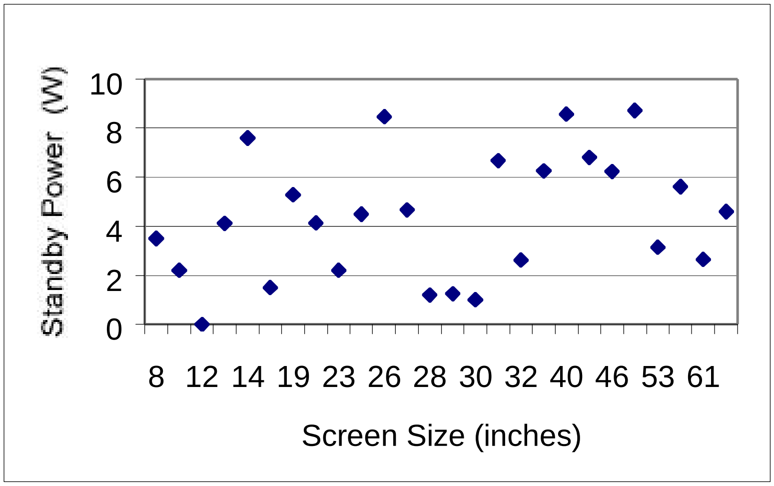
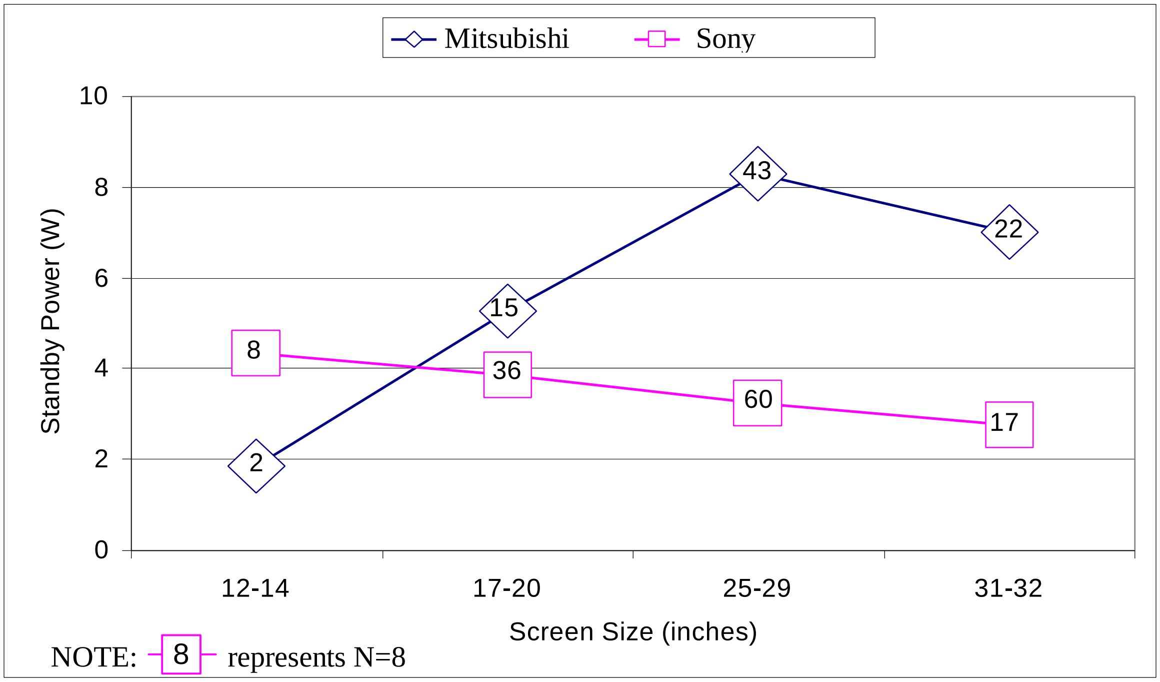


Figure G2. Average standby power consumption values by screen size



The analysis of covariance discussed in Section 3.3 suggests that there may be some connection between screen size and standby power draw. However, a comparison between the average standby power draw values of different sizes units of two TV manufacturers suggests that manufacturer is a much more important factor in the determination of standby power draw than is screen size.

Figure G3. Average standby power draw values of two TV manufacturers by screen size



APPENDIX H: VCR POWER MEASUREMENT DATA

Brand	Model	Year	Off (W)	On (W)	Rated (W)	Remote	Source
Goldstar	GVRF468	1996	3.6	10.3	19	x	FSEC
Philips-Mag	VRU222AT	1996	4.3	7.3	17	x	FSEC
Thomson	PSVR57	1996	4.0	12.5	22	x	FSEC
Thomson	VG2056	1996	4.0	9.5	17	x	FSEC
Thomson	VG4056	1996	4.0	9.3	17	x	FSEC
Thomson	VG4251	1996	3.6	10.6	19	x	FSEC
Zenith	VR2106	1996	2.8	7.9	16	x	FSEC
Zenith	VR4156	1996	8.7	8.9	19	x	FSEC
Zenith	VR4206HF	1996	2.4	9.2	18	x	FSEC
Zenith	VR4256HF	1996	10.6	10.7	19	x	FSEC
Matsushita	PV4401	1995	3.3	6.1	18	x	LBNL
Matsushita	VHQ580	1995	7.0	9.9	23	x	LBNL
Matsushita	PV7452	1997	6.0	9.0	23	x	LBNL
Mitsubishi	HSU770	1997	6.6	20.2	35	x	LBNL
Mitsubishi	HSU790	1997	5.1	14.4	22	x	LBNL
Other	SV211E	1995	6.2	9.0	17	x	LBNL
Other	GV 6060	1997	12.2	15.5	29	x	LBNL
Thomson	VR519	1997	4.8	7.7	18	x	LBNL
Toshiba	M750	1995	6.5	14.0	22	x	LBNL
Toshiba	M728	1997	6.6	15.0	23	x	LBNL
Goldstar	VRB438	1994	7.4	15.7	30	x	Repair
Hitachi	VT1320	1985	8.2	19.5	32	x	Repair
Hitachi	FVT11100	1986	7.7	19.4	32	x	Repair
Hitachi	VT350	1990	10.9	15.9	26	x	Repair
Hitachi	VTF361	1992	11.4	16.1	28	x	Repair
Hitachi	VTM181	1994	8.7	12.4	24	x	Repair
JVC	HRD750	1988	7.7	20.5	30	x	Repair
JVC	HRS4700	1988	6.6	20.3	34	x	Repair
JVC	HRD200	1990	5.9	15.7	26	x	Repair
JVC	HRD720	1992	3.2	9.5	24	x	Repair
JVC	HRD865U	1992	4.3	13.6	23	x	Repair
JVC	HRDX40	1992	5.6	15.5	24	x	Repair
JVC	HRS6700	1992	5.5	20.6	35	x	Repair
JVC	HRD910	1993	3.4	11.7	24	x	Repair

Brand	Model	Year	Off (W)	On (W)	Rated (W)	Remote	Source
JVC	HRDX44U	1993	2.8	8.8	19	x	Repair
JVC	HRDX420	1994	3.1	8.7	19	x	Repair
JVC	HRD870	1995	3.9	13.6	23	x	Repair
JVC	HRJ620	1997	3.2	10.0	21	x	Repair
Matsushita	VH6400	1990	4.8	8.8	18	x	Repair
Matsushita	PV2101	1991	4.5	8.6	18	x	Repair
Matsushita	VH6415	1991	7.6	12.3	23	x	Repair
Matsushita	PV4260	1992	7.3	10.2	23	x	Repair
Matsushita	PV2301	1993	6.3	8.6	19	x	Repair
Matsushita	PV4362	1993	8.1	11.3	23	x	Repair
Matsushita	PV2401	1994	5.2	7.8	18	x	Repair
Matsushita	VHQ42	1994	4.7	7.1	18	x	Repair
Matsushita	VHQ620	1996	4.7	7.0	18	x	Repair
Matsushita	VHQ620	1996	5.4	6.9	18	x	Repair
Matsushita	VHQ820	1998	2.9	7.5	18	x	Repair
Matsushita	VHQ820	1998	2.8	7.2	18	x	Repair
Mitsubishi	HS400UR	1984	8.5	28.8	42	x	Repair
Mitsubishi	HS339	1989	5.1	11.2	23	x	Repair
Mitsubishi	HSU82	1990	9.4	32.1	47	x	Repair
Mitsubishi	HSU32	1991	7.9	14.9	26	x	Repair
Mitsubishi	HSU250	1992	5.5	13.5	23	x	Repair
Mitsubishi	HSU56	1992	6.8	16.4	28	x	Repair
Mitsubishi	HSU65	1992	9.0	23.4	37	x	Repair
Mitsubishi	HS34	1993	5.5	12.9	22	x	Repair
Mitsubishi	HSU110	1993	5.1	13.2	23	x	Repair
Mitsubishi	HSU58	1993	6.4	16.3	29	x	Repair
Mitsubishi	HSU61	1993	8.3	23.4	35	x	Repair
Mitsubishi	HSU500	1994	7.0	16.5	29	x	Repair
Mitsubishi	HSU52	1994	7.7	17.6	30	x	Repair
Mitsubishi	HSU54	1994	6.0	17.5	28	x	Repair
Mitsubishi	HSU69	1994	8.5	20.8	34	x	Repair
Mitsubishi	HSU760	1994	8.2	20.8	34	x	Repair
Mitsubishi	HSU550	1995	3.5	9.5	20	x	Repair
Mitsubishi	HSU580	1995	3.5	9.5	20	x	Repair

Brand	Model	Year	Off (W)	On (W)	Rated (W)	Remote	Source
Mitsubishi	HSU410	1996	5.5	15.4	28	x	Repair
Mitsubishi	HSU430	1997	3.3	9.2	19	x	Repair
Mitsubishi	HSU570	1998	3.9	10.1	20	x	Repair
Other	HN915	1984	7.7	13.3	34	x	Repair
Other	VCR875	1985	8.4	14.1	26	x	Repair
Other	SVC7500	1986	8.6	17.3	32	x	Repair
Other	VRVCR885	1986	8.8	14.5	27	x	Repair
Other	DS8000U	1989	12.0	31.5	45	x	Repair
Other	N958U	1991	9.6	16.1	28	x	Repair
Other	VCR4000	1993	8.2	15.2	27	x	Repair
Other	HVM110	1994	5.0	10.6	25	x	Repair
Philips-Mag	VR9525	1984	7.0	11.7	21	x	Repair
Philips-Mag	VR1260AT01	1988	5.3	10.7	22	x	Repair
Philips-Mag	VR3460	1993	5.4	14.5	25	x	Repair
Philips-Mag	VR9362	1994	3.6	11.0	19	x	Repair
Philips-Mag	VRT422	1997	3.9	9.1	19	x	Repair
Sanyo	FVH905	1987	10.3	17.1	28	x	Repair
Sanyo	FVH6300	1988	6.4	14.5	24	x	Repair
Sanyo	VHR9385	1994	6.6	13.4	26	x	Repair
Sharp	XA200	1988	7.9	11.5	24	x	Repair
Sharp	VCA555	1997	7.6	7.6	20	x	Repair
Sony	SL2410	1985	5.8	25.8	45	x	Repair
Sony	EVC100	1990	2.3	6.5	12	x	Repair
Sony	SLHF1000	1990	10.0	36.9	55	x	Repair
Sony	SLV690	1990	3.5	12.8	26	x	Repair
Sony	SLV696	1990	3.1	11.4	25	x	Repair
Sony	SLVR5UC	1990	8.4	32.1	45	x	Repair
Sony	SLV555	1991	6.8	19.1	33	x	Repair
Sony	SL390	1992	3.8	15.9	26	x	Repair
Sony	SLV373	1992	8.5	16.0	28	x	Repair
Sony	SLV585	1992	5.3	17.7	30	x	Repair
Sony	SLV900	1992	9.3	12.7	24	x	Repair
Sony	SLV900HF	1992	10.1	13.3	25	x	Repair
Sony	SLVR1000	1992	6.8	16.6	30	x	Repair

Brand	Model	Year	Off (W)	On (W)	Rated (W)	Remote	Source
Sony	SLV373	1993	5.6	15.7	28	x	Repair
Sony	SLV585	1993	6.0	19.1	30	x	Repair
Sony	SLV595	1993	3.5	12.4	25	x	Repair
Sony	SLV686	1993	5.2	17.6	30	x	Repair
Sony	SLVU5R	1993	7.9	31.8	45	x	Repair
Sony	SLV696	1994	3.3	13.1	25	x	Repair
Sony	SLV760	1996	11.1	12.3	27	x	Repair
Sony	SLV495	1997	3.9	10.2	23	x	Repair
Thomson	VPT390	1987	9.2	22.6	38	x	Repair
Thomson	VG4025	1993	2.4	9.6	21	x	Repair
Thomson	VG4033	1994	5.2	7.5	18	x	Repair
Thomson	VH64	1994	3.7	10.5	22	x	Repair
Thomson	PSVR61	1995	6.8	15.8	23	x	Repair
Toshiba	SV970	1986	8.5	30.8	46	x	Repair
Toshiba	M221	1991	5.2	14.5	27	x	Repair
Toshiba	M449	1991	2.7	9.1	21	x	Repair
Toshiba	M228	1993	2.4	9.3	21	x	Repair
Zenith	VR9775	1979	4.2	19.1	30	x	Repair
Zenith	VR1800	1988	7.3	16.0	29	x	Repair
Zenith	HVRG170	1990	3.3	9.7	19	x	Repair
Zenith	VRL4170	1990	6.2	16.6	30	x	Repair
Zenith	VRF165	1991	5.9	15.6	24	x	Repair
Zenith	VR2420	1993	9.5	20.7	35	x	Repair
Zenith	VR4256	1997	9.7	10.6	19	x	Repair

APPENDIX I. VCR POWER MEASUREMENTS USED TO DETERMINE AVERAGE ACTIVE POWER DRAW

Brand Name	Model	Year	Off (W)	On (W)	Play (W)	Rated (W)	Source
Panasonic	PV-4451	1994	6.5	9.7	13.5	23.0	LBNL
Panasonic	PV-4651	1996	6.9	10.0	14.2		LBNL
Hitachi	VT-1310A	1984	9.7	19.9	26.0	32.0	LBNL
Symphonic	SV211E	1995	6.2	9.0	13.7	17.0	LBNL
Mitsubishi	HS-339UR	1986	6.1	12.9	18.3	26.0	LBNL
Quasar	VHQ580	1995	7.0	9.9	13.5	23.0	LBNL
Sony	SLV-595HF	1990	3.9	13.7	17.5	25.0	LBNL
Panasonic	PV-4114	1991	6.4	10.8	13.2	19.0	LBNL
Panasonic	PV-4151	1991	6.3	10.2	14.2	23.0	LBNL
Magnavox	VRU242AT01	1996	5.6	8.8	13.5	17.0	LBNL
Panasonic	PV-1330	1996	6.6	11.5	13.8	20.0	LBNL
Panasonic	PV-4401	1995	3.3	6.1	9.8	18.0	LBNL
Sanyo	VHR-5420	1990	4.6	9.3	14.0	18.0	LBNL
Fisher	FVH-4508	1992	4.6	11.2	14.3	18.0	LBNL
Sony	SLV-585HF	1993	6.3	18.3	22.8	30.0	LBNL
Sony	SLV-640HF	1996	5.9	14.7	18.4	27.0	LBNL
Toshiba	M750	1995	6.5	14.0	16.4	22.0	LBNL
Montgomery Ward	JSJ10625		7.9	13.6	20.2	24.0	LBNL
JVC	HR-J200U	1992	1.5	7.9	14.5	19.0	LBNL
Hitachi	VT-F462A	1993	12.8	18.3	21.4	28.0	LBNL
RCA	VKT-550	1991	11.1	25.5	34.5	36.0	LBNL
Average			**6.5**	**12.6**	**17.0**	**23.3**	