Electricity Consumption by Small End Uses in Residential Buildings

Final Report

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1. Executive Summary

The energy consumption characteristics of 16 small residential end uses were evaluated.

This investigation included the selection and evaluation of the energy-consumption characteristics of 16 small residential end uses:

- Automatic Coffee Maker
- Cable Box
- Clothes Washer
- Color Television
- Compact Audio System
- Computer
- Dehumidifier
- Dishwasher
- Furnace Fan
- Microwave Oven
- Pool Pump
- RACK Audio System
- Torchiere Lamp – Halogen
- Video Cassette Recorder
- Waterbed Heater
- Well Pump

Included are current estimates and future projections, comparisons to other published estimates, identification of additional data collection needs, and proposal of a revised categorization for the energy consumption of residential end uses. Most of these 16 small end uses belong in the larger, traditional end-use categories (such as furnace fans in space heating and torchiere lamps in lighting — see discussion below); but they were evaluated to guide possible, future RD&D efforts on their own merits.

A new categorization for residential end uses is proposed that provides insight into the nature of energy consumption by small end uses.

In recent years, several researchers have drawn attention to the fact that a large portion of household energy consumption is associated with end uses that are not captured by the traditional end-use categories[1]. Working closely with the Energy Information Administration (EIA), we developed an alternative categorization that expands the traditional categories to include other, related end uses and adds new categories to group better some of the remaining end uses. The categories proposed are:

- Space Heating
- Space Cooling
- Household Water Heating
- Recreational Water Heating
- White Goods
- Lighting
- Cooking
- Electronics
- Motor
- Miscellaneous Heating
- *Other Uses*

[1] The traditional end-use categories, as applied by the U.S. Department of Energy, Energy Information Administration, are: Space Heating, Space Cooling, Water Heating, Refrigeration, Cooking, Clothes Dryers, Freezers, and Lighting.

This re-categorization moves consumption to more descriptive and fitting categories, thus providing a more accurate representation of the energy consumption in the residential sector by which to judge RD&D priorities. The new *Other Uses* category (1.3 quad[2], or about 11% of residential electric consumption) is smaller relative to the AEO 1998 estimate (2.5 quad, or about 21%) and is in better proportion to the major end uses in the residential sector. It is our hope that the EIA and other researchers adopt (within time and budget constraints) the proposed new categorization.

The certainty with which national energy consumption impacts of small end uses can be estimated is limited by the level of documentation available from existing primary data sources.

While primary data are available from a range of sources regarding the energy-consumption characteristics of small end uses (90 sources are cited in this report), most of these data are not well documented. It is, therefore, often difficult to trace data to the original sources, and to determine how the data were measured or estimated. In some cases, multiple sources report the same or similar values, but these sources may not be independent. In other cases, there are large discrepancies in data obtained from various sources. These discrepancies may result from variations in product age, capacity, manufacturer, model, application, usage patterns, climate, etc. We selected the most credible data available for reporting estimates of energy consumption. In several cases, we used simple engineering or vintaging analyses either to verify an estimate, or as the basis for an estimate.

Our projections indicate that energy consumption for the 16 end uses evaluated will increase by only 6% between 1997 and 2010.

We estimate that the 16 end uses evaluated consumed 1.69 quad in 1997. This represents about 65% of the consumption estimated by LBNL[3] for 97 small end uses. We project this consumption will increase to 1.79 quad by 2010, barring any policy or regulatory changes. This growth is slower than previous forecasts by either EIA (in the AEO) or LBNL, and is in reasonable perspective (at about 0.45% per year) to the growth rates of major end uses in the residential sector (range is 0.1 to 0.7% annually in the AEO98 [EIA/AEO, 1998]).

The end uses for which 1997 consumption estimates exceed 100 TBtu/year are:

- Color Television (294 TBtu/year);
- Furnace Fan (183 TBtu/year);
- Waterbed Heater (177 TBtu/year);
- Halogen Torchiere Lamp[4] (172 TBtu/year);

[2] Quadrillion Btu, based on primary energy (i.e., accounting for electric generation, transmission, and distribution losses).
[3] Lawrence Berkeley National Laboratory, February 1998 draft report [LBL-40295]. LBNL estimates are for 1995, while ADL estimates are for 1997. In calculating the percentage, ADL's estimate for the 16 end uses were substituted for LBNL's estimates.
[4] Although it is included in the Lighting category, we evaluated Halogen Torchiere Lamps because their historical growth rate has far exceeded that for the Lighting category in general

- Microwave Oven (136 TBtu/year); and
- Dehumidifier (120 TBtu/year).

The end uses for which 2010 consumption projections exceed 100 TBtu/year are:

- Color Television (250 TBtu/year – 14% reduction relative to 1997);
- Furnace Fan (200 TBtu/year – 7% increase);
- Dehumidifier (180 TBtu/year – 48% increase);
- Halogen Torchiere Lamp (180 TBtu/year – 7% increase);
- Waterbed Heater (160 TBtu/year – 9% reduction);
- Microwave Oven (120 TBtu/year – 11% reduction); and
- Computer (110 TBtu/year – 77% increase).

We compared our results to those from LBNL and the Energy Information Administration (EIA) Annual Energy Outlook (AEO).

For the total of 16 end uses evaluated, LBNL's and ADL's estimates were in very good agreement for current energy consumption (1.72 quad in 1995 and 1.69 quad in 1997, respectively). However, LBNL projects total consumption in 2010 for the 16 end uses of 2.20 quad (28% growth), while ADL projects 1.79 quad in 2010 (6% growth). The differences in future consumptions projected by LBNL and ADL are largely due to differences in approach. First, LBNL assumed that Unit Energy Consumptions (UECs) remain constant, while ADL varied UECs based on anticipated changes in efficiencies and usage patterns. Second, LBNL utilized a mathematically rigorous approach to forecasting saturations (based on historical shipment data), while ADL relied more on applying subjective judgment to observed (and anticipated) qualitative trends.

The 16 end uses were estimated to consume 1.69 quad, which is about 65% of the consumption estimated by LBNL for 97 small end uses. Given that the energy consumption is concentrated in a few small end uses and the lesser amount of consumption is dispersed among 81 end uses, the strategic approach to RD&D planning should focus on these 16 end uses. Thus, potential, future RD&D actions are more tractable than previously thought.

For the total of five end uses (clothes washer, color television, dishwasher, computer, and furnace fan), the AEO 1998 estimates current energy consumption of 1.36 quad (in 1996), while ADL estimates 0.71 quad (in 1997) – a difference of 91%. The AEO 1998 projects total consumption in 2010 for the five end uses of 1.73 quad (27% growth), while ADL projects 0.76 quad (7% growth).

Overall, the AEO current estimates and future projections are high relative to ADL's. Further, the AEO estimates and projections are high relative to LBNL's for the grouping of 97 end uses investigated by LBNL (which includes virtually all the small electric end uses in the

residential sector). Despite differences in future projections, both LBNL and ADL estimate a smaller current consumption and slower growth in the future relative to the AEO.

Additional primary data collection is needed in several areas.

Some of the uncertainties in energy consumption are more important than others, depending on the impact on national energy consumption that the uncertainties might have. We suggest additional data collection efforts for the areas in which the uncertainties are large and for which there could be significant impacts on national energy consumption estimates, such as for:

- Cable Boxes;
- Color Televisions;
- Computers;
- Dehumidifiers; and
- Torchiere Lamps.

2. Introduction

Electricity consumption by small end uses has recently gained attention as the largest and fastest growing energy use in households.

If small, unrelated end uses in households are aggregated (in a rather contrived family), they consume a notable amount of energy on a national basis. Researchers frequently refer to such a family as "miscellaneous" end uses. As discussed in Section 4, re-categorization of residential end uses is recommended to provide more logical groupings of end uses.

Exhibit 2-1 shows U.S. residential energy consumption by fuel type, indicating that 11.91 quad of electricity were consumed by the residential sector in 1996. A recent study, completed by five U.S. Department of Energy (DOE) national labs[1], suggests that "miscellaneous" electricity consumption[2], including stand-by electric consumption[3], is the largest end use in the residential sector [Five-Lab Study, 1997; p. 3.8]. The DOE Energy Information Administration (EIA) estimates 1996 small electric end uses[4] at about 3.9 quad in the residential sector, growing to 6.3 quad in 2010 [EIA/AEO, 1998; Table A4]. LBNL estimated the annual electricity consumption of 97 small end uses at about 235 TWh/yr (site[5]) or about 2.6 quad, and project growth to 350 TWh/yr (about 3.6 quad) [LBL-40295, 1998; Table 1].

Other publications have focused on the stand-by consumption associated with certain small end uses [such as Rainer, 1996; Lamb, 1996; Meier, 1993; Molinder, 1997]. Even Newsweek magazine has noted the increase in energy consumption projected (by EIA) for "miscellaneous" household appliances [Newsweek, 1997; p. 15].

Previous studies have provided a broad overview of small-end-use consumption, and have identified data gaps.

Alan Meier [Meier, 1987] identified, at least a decade ago, the paucity of data on small-end-use energy consumption. LBNL [LBL-40295, 1998] provides the most recent, comprehensive review of small-end-use energy consumption for the residential sector. They, too, found reliable data sparse for many end uses.

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[1] Participating labs were: Argonne National Laboratory (ANL), Lawrence Berkeley National Laboratory (LBNL), National Renewable Energy Laboratory (NREL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest National Laboratory (PNNL). LBNL and ORNL co-lead the effort.

[2] The vast majority of small-end-use energy consumption is electric consumption. The consumption associated with other fuels is beyond the scope of this investigation.

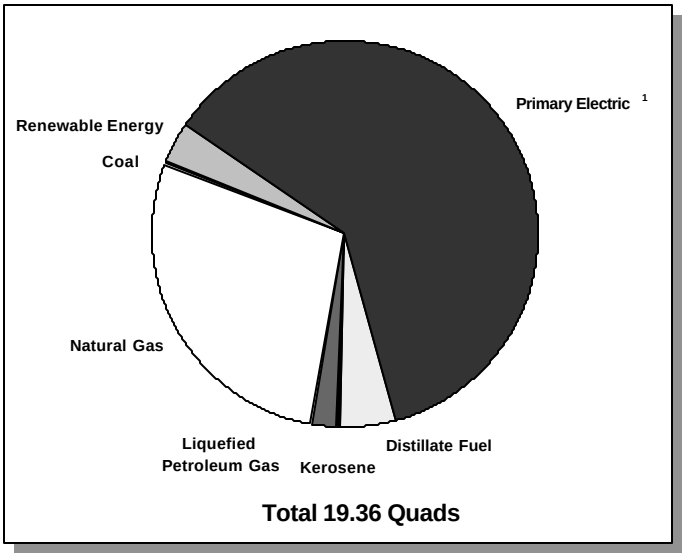
[3] Stand-by electric consumption, sometimes called leaking electricity, includes electric consumption of appliances while they are switched off and not in use. We use the term stand-by consumption to avoid confusion with electrical leaks to ground (electrical shorts).

[4] Includes Clothes Washers, Dishwashers, Color Televisions, Personal Computers, furnace Fans, and *Other Uses*. The Clothes Washers and Dishwashers estimates do not include central water heating.

[5] Site electricity does not include losses associated with generation, transmission, and distribution.

Exhibit 2-1: U.S. Residential Energy Consumption by Fuel Type (1996)

Category	Energy Consumption	
	Quads	Percent
Primary Electric[1]	11.91	61.5%
Distillate Fuel	0.89	4.6%
Liquefied Petroleum Gas	0.42	2.2%
Kerosene	0.08	0.4%
Natural Gas	5.39	27.8%
Coal	0.05	0.3%
Renewable Energy	0.61	3.2%
Totals	**19.36**	**100%**



1) Includes generation, transmission and distribution losses.

Source: [EIA/AEO, 1998; Table A2]

DOE/OBE needs an assessment of the consumption associated with small end uses to guide their R&D programs and market-conditioning initiatives.

The identification in the aforementioned studies of substantial (and rapidly growing) consumption in small-end-use electricity consumption has prompted DOE's Office of Building Equipment (DOE/OBE) to investigate implications relative to their R&D agenda and market-conditioning initiatives. To do so, DOE/OBE required a more detailed assessment of the consumption associated with small end uses. This need formed the basis for our investigation. Our investigation documents national energy consumption estimates in 1997 for 16 small residential end uses, and projects consumption for three future years (2000, 2005, and 2010).

This investigation was conducted to answer several questions related to DOE/OBE's needs:

- How should small end uses be categorized to provide the greatest insight into their energy consumption as it relates to DOE/OBE programs?
- What are the energy-consumption characteristics of the most important small end uses?
- What are the future trends associated with these end uses?

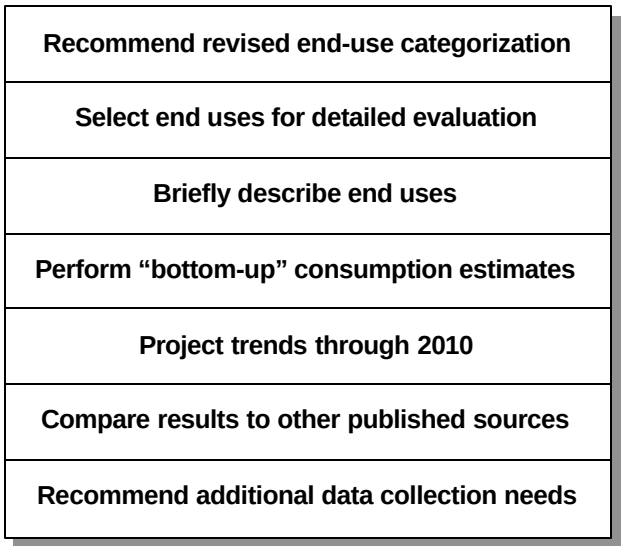
- How do these estimates/projections compare with other sources?
- What additional primary data collection is needed to fill gaps and address uncertainties?

3. Scope/Approach

This investigation focuses on the largest of the small electricity end uses in the residential sector, and proposes a revised categorization for those end uses.

Exhibit 3-1 outlines the scope/approach for this investigation.

Exhibit 3-1: Scope/Approach



One of the objectives of this work was to recommend a revised categorization of residential electric end uses. The recommended categorization (described further in Section 4) groups some small end uses with the traditional end-use categories as defined by EIA (where the fit is logical), and creates new categories for other small end uses (where they do not fit logically within the traditional categories). The purpose of this exercise is to obtain a better understanding of the energy use associated with the actual functions served by the various small end uses.

A second objective was to develop detailed energy consumption estimates for 12 to 15 small end uses. The larger 12 to 15 of the small end uses were selected for detailed evaluation based on estimates from previous studies and rough calculations, including consideration of future trends. To accomplish this, we first reviewed the top 25 small end uses identified by LBNL [LBL-40295, 1998]. As described further in Section 5, we narrowed this list to 16 end uses. We evaluated the energy consumption of these 16 end uses based on power draws, operating hours, and saturation levels[1]. We also developed brief descriptions to provide insight into the energy-consuming characteristics of each end use. We then forecast energy consumption trends for the years 2000, 2005, and 2010. To the extent possible, forecasts are

[1] "Saturation" is defined as the number of appliances of a particular type in use in the U.S. divided by the number of U.S. households. Saturation levels can be greater than 100% if the average household uses more than one of the appliances. See Section 6.3 for further discussion.

based on anticipated market growth, technology/market trends impacting energy consumption, and demographic trends impacting usage patterns. As with any study of this type, there are significant uncertainties in forecasts, and the results must be interpreted with this in mind.

We compared our results to other published data, primarily from EIA and LBNL. Where reliable data are particularly sparse, we have made recommendations for future data collection.

4. Categorization of Residential End Uses

The "miscellaneous" end-use category includes many end uses that are better categorized elsewhere. Most of the remaining "miscellaneous" end uses can be grouped under new, more descriptive categories.

The label "miscellaneous" should be reserved for end uses that are too small to be singly of interest, and too diverse to be otherwise categorized. Many of the so-called miscellaneous end uses investigated by other researchers should not be categorized as miscellaneous—in fact, some of those researchers have already pointed this out. For example, the Five-Lab Study suggests that, "It would be possible with more research to allocate some of the miscellaneous energy to the existing end-uses and to new ones; for example, electricity consumed by furnace fans should be treated as space heating..." [Five-Lab Study, 1997; p. 3.7]. In a more recent report, LBNL divides miscellaneous end uses among four categories: motors, electric resistance heating, consumer electronics, and lighting [LBL-40295, 1998].

We believe that the true nature and importance of small end uses would be better understood if the traditional categorization is revised.

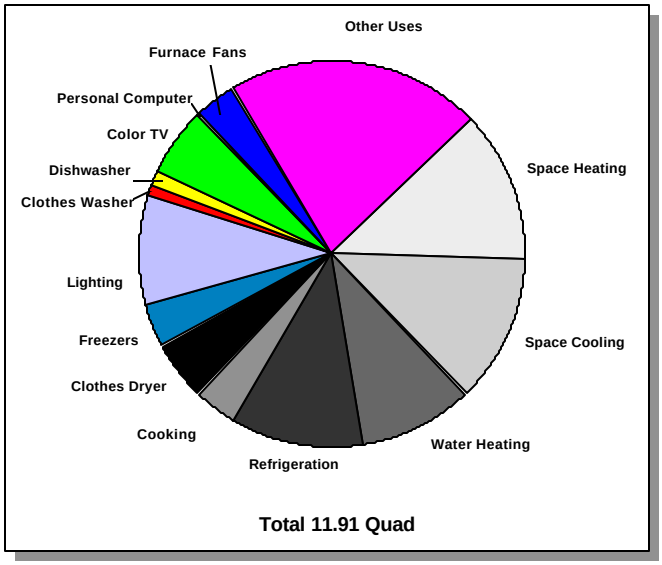
The EIA has recently begun the process of re-categorizing small residential end uses in the Annual Energy Outlook (AEO).

The traditional categorization (developed by the EIA) focuses on the major end uses and considers only the major fuel type supplying a single appliance. This categorization simplifies the conditional demand analysis EIA utilizes to make national energy consumption estimates and projections. The EIA, however, is now increasing the sophistication of their analysis to include additional end uses. Exhibit 4-1 shows the break out by end use of residential electric consumption based on the most recent EIA statistics [EIA/AEO, 1998]. This break out is based on the traditional end-use categories of Space Heating, Space Cooling, Water Heating, Refrigeration, Cooking, Clothes Dryers, Freezers, Lighting, and *Other Uses* as well as new categories of Clothes Washers[1], Dishwashers, Color Televisions, Personal Computers, and Furnace Fans. In previous publications of the AEO, the end uses in these new categories were included in the *Other Uses* category. The AEO 1998 categorization moves 1.13 quad of electricity consumption from the *Other Uses* category to new categories relative to AEO 1997.

[1] Energy consumption estimates for clothes washers and dishwashers do not include water heating energy, except for the energy consumed by booster heaters installed in the appliance.

Exhibit 4-1: U.S. Residential Primary Electric Consumption (1996) – Current EIA Categorization

Category	Primary Electric Consumption[1]	
	Quad	Percent
Space Heating	1.52	12.7%
Space Cooling	1.49	12.5%
Water Heating	1.16	9.8%
Refrigeration	1.33	11.1%
Cooking	0.42	3.5%
Clothes Dryers	0.61	5.1%
Freezers	0.42	3.5%
Lighting	1.09	9.2%
Clothes Washer	0.09	0.8%
Dishwasher	0.16	1.4%
Color TV	0.68	5.7%
Personal Computer	0.03	0.3%
Furnace Fans	0.38	3.2%
Other Uses	2.52	21.2%
Totals	**11.91**	**100%**



1) Based on 1996 typical generation, transmission and distribution efficiency of 31.0%

Source: [EIA/AEO, 1998; Table A4]

Starting with categorization suggestions from LBNL, and working closely with EIA, we developed a refined categorization that leads to a better understanding of energy consumption by small end uses.

Exhibit 4-2 and Exhibit 4-3 illustrate the recommended new categorization. Appendix A details the end uses suggested for each category[2]. The traditional categories of Space Heating, Space Cooling, Lighting, and Cooking have been expanded to include the small end uses that fit logically with these categories. New categories were created as well:

- *Household Water Heating:* Same as the current EIA Water Heating category, but renamed for clarity;
- *Recreational Water Heating:* Includes spas, hot tubs, and swimming pool heating;

[2] Appendix A does not necessarily include every imaginable residential end use. We simply added the miscellaneous end uses identified by LBNL [LBL-40295, 1998] to the main end uses, and then included a few additional (but trivial) end uses that were not cited by LBNL.

- *White Goods:* Includes the current EIA categories of Refrigeration, Clothes Dryers, Freezers, Clothes Washer, and Dishwasher;
- *Electronics:* Includes consumer electronics, such as color televisions, video cassette recorders, audio systems, computers, etc;
- *Motor:* Includes small end uses (not categorized elsewhere) in which motors are the major energy-consuming components, such as well pumps, pool pumps, trash compactors, etc.;
- *Miscellaneous Heating:* Includes small end uses (not categorized elsewhere) in which resistance heating elements are the major energy-consuming components, such as water beds, coffee makers, etc.; and
- *Other Uses:* This is an adjustment factor that accounts for the difference between a) the sum of consumptions for all end uses identified, and b) the total residential sector energy use. This category is about half as large (based on energy consumption) relative to the *Other Uses* category as currently defined by EIA.

We considered various approaches to categorization, including categorization based on household activities (such as food preparation, cleaning, home entertainment, etc.). In the end, the categorization suggested in Exhibit 4-3 seemed to fit best with the recommendations of past researchers and the categorization already begun by EIA in the AEO 1998. Most importantly, it seems logical, and places end uses in the categories in which they truly belong. EIA has reviewed this revised categorization, and is generally in agreement with it [Cymbalsky, 1997]. However, the extent to which EIA will incorporate this categorization (and the timing thereof) depends on several factors, not the least of which is resource availability.

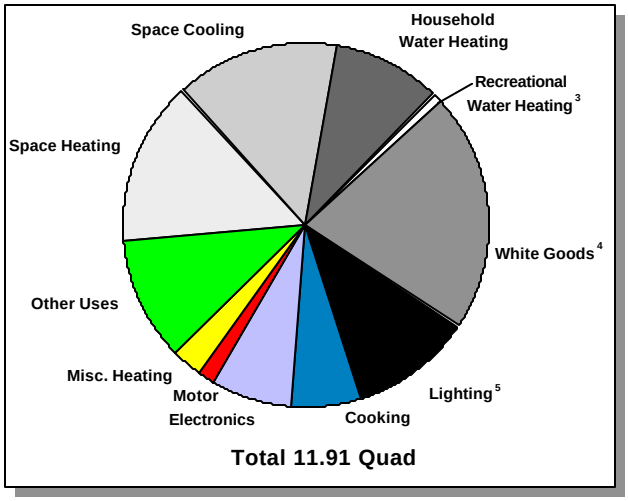
Exhibit 4-2: Recommended Reallocation of Small End Uses

Category/End Use	National Primary Energy Consumption[1] (Quad)	Recommended Changes
Space Heating	1.52	Add humidifier and furnace fan
Humidifier	0.014	
Furnace Fan	0.183	
	1.72	
Space Cooling	1.49	Add dehumidifier, evaporative cooler and various air circulating/ventilating fans[2]
Dehumidifier	0.12	
Evaporative Cooler	0.036	
Air Circulating/Ventilating	0.02	
Fans	1.74	
Household Water Heating	1.16	Same as current Water Heating category – renamed for clarity
Recreational Water Heating		New category
Spa/Hot Tub	0.05	
Swimming Pool Heater	0.06	
	0.11	
White Goods		Combination of current Refrigerator, Freezers, Clothes Dryers, Clothes Washers and Dishwasher categories. Lists new consumption estimates recommended for Clothes Washers and Dishwashers.
Refrigerator	1.33	
Freezer	0.42	
Clothes Dryer	0.61	
Clothes Washer	0.095	
Dishwasher	0.077	
	2.53	
Lighting	1.09	Add grow lamp and Aquaria. Assumes that 25% of halogen torchiere lamp consumption offsets other lighting and 75% is new lighting load
Torchiere Lamp	0.129	
Grow Lamp	0.004	
Aquaria	0.046	
	1.27	
Cooking	0.42	Add other cooking equipment[2]
Other Cooking Equipment	0.32	
	0.74	
Electronics		New category including color TV (with new consumption estimate) and other consumer electronics[2]
Color TV	0.294	
Other Electronics	0.572	
	0.865	
Motor	0.81	New category including small end uses (not categorized elsewhere) in which small motors are the major energy – consuming components[2].
Miscellaneous Heating	0.31	New category including small end uses (not categorized elsewhere) in which resistance heating elements are the major energy-consuming components[2]
Other Uses		Adjustment factor to account for the difference between a) the sum of electric energy consumption for the identifiable end uses, and b) the total residential electric consumption (11.91 quad)
End Uses Not Allocated Above	1.29	

1) Year of estimates range from 1995 to 1997, depending on source. See Appendix A for sources of energy consumption estimates.
2) See Appendix A for detailed list of end uses included.

Exhibit 4-3: Residential Primary Electric Consumption (1996) – Recommended Categorization

Category[1]	Primary Electric Consumption[2]	
	Quad	Percent
Space Heating	1.72	14.4%
Space Cooling	1.74	14.6%
Household Water Heating	1.16	9.7%
Recreational Water Heating[3]	0.11	0.9%
White Goods[4]	2.53	21.3%
Lighting[5]	1.27	10.7%
Cooking	0.74	6.2%
Electronics	0.87	7.3%
Motor	0.18	1.5%
Misc. Heating	0.31	2.6%
Other Uses	1.29	10.7%
Totals	**11.91**	**100%**



1) Refer to Appendix A for a detailed list of end uses associated with each category.
2) Based on 1996 typical generation, transmission and distribution efficiency of 31.0%. (Depending on source, actual years of estimates range from 1995 - 1997.)
3) While the electric consumption for recreational water heating is small, a separate category is recommended because this category will be larger when considering other fuels.
4) White Goods includes refrigerator, freezer, clothes dryer, clothes washer, and dishwasher.
5) Assumes that 25% of halogen torchiere lamp consumption offsets other lighting and 75% is new lighting load.

The so-called *Other Uses* category is more accurately described as an adjustment factor (to account for the discrepancy between the top-down and bottom-up consumption estimates), rather than unidentified end uses.

As shown in Appendix A, energy consumption has been estimated for 97 residential electric end uses (most estimates are from LBNL). Upon inspection of this list, one would be hard pressed to explain how enough end uses could have been overlooked to explain the 1.29 quad categorized under (the new) *Other Uses* in Exhibit 4-3. The 1.29 quad represents the net discrepancy between the bottom-up estimates (totaling 10.62 quad) and the top-down estimate (11.91 quad). This discrepancy is most likely the result of accumulated, bottom-up estimation errors, or top-down estimation error, or both. An alternative would be to eliminate the *Other Uses* category, and distribute the 1.29 quad among the remaining categories.

When implementing the proposed categorization, sufficient break out should be provided to allow comparisons of major end uses to data published previously.

There is an on-going need to compare current energy consumption estimates and projections to previous estimates and projections. These comparisons are important to identify trends and to evaluate the impact of programs targeting energy savings. When adopting the revised categorization, sufficient documentation is needed such that energy consumptions can be broken out by the major old categories (to compare current estimates with historical estimates on an apples-to-apples basis). The major old categories of interest are Space Heating, Space Cooling, Water Heating, Refrigeration, Cooking, Clothes Dryers, Freezers, and Lighting.

5. Selection End Uses for Detailed Evaluation

Existing consumption estimates were used to select 16 small end uses for more detailed analysis.

Our goal was to evaluate the largest 12 to 15 (by electric consumption) small residential end uses. We began by reviewing the top 25 small end uses identified by LBNL for 1995 and 2010 [LBL-40295, 1998]. We focused primarily on LBNL's largest 15 end uses projected for 2010. (End uses for which energy consumption is predicted to decrease were seen as less important to evaluate). From LBNL's top-15 list for 2010, we removed one item (crankcase heaters) and added two (well pumps and RACK audio). We did not include compressor crankcase heaters (which ranks thirteenth in national energy consumption among small end uses, per LBNL). Since crankcase heaters are an integral component in heat-pump systems for space conditioning, we concluded that they should not be categorized separately (any more than an evaporator fan motor in a refrigerator should be categorized as a separate load).

Although it clearly belongs in the Lighting category, we included the halogen torchiere lamps. The use of torchiere lamps has increased dramatically, resulting in a much greater consumption growth rate than seen by the Lighting category in general. Torchiere lamps probably offset other lighting end uses, but it is not known to what extent this offset occurs.

We added RACK audio because it fit logically with home entertainment consumer electronics that were included (compact audio, color television, VCR, cable box). Well pumps were added because we felt there was significant uncertainty in the energy-use estimates (as acknowledged by LBNL), and we were not comfortable with the large decrease in energy consumption projected for 2010 (dropping it off LBNL's top-25 list in 2010, from fourteenth in 1995).

Exhibit 5-1 shows the list of 16 end uses selected for detailed evaluation. This list is not claimed to be the largest 16 among small end uses. However, comparisons made in Section 8 would suggest that we included the largest 12 end uses, per our goal.

Exhibit 5-1: 16 Residential End Uses for Detailed Evaluation

Automatic Coffee Maker	Furnace Fan
Cable Box	Microwave Oven
Clothes Washer	Pool Pump
Color Television	RACK Audio System
Compact Audio System	Torchiere Lamp – Halogen
Computer	Video Cassette Recorder
Dehumidifier	Waterbed Heater
Dishwasher	Well Pump

6. Energy Consumption Estimates

National energy consumption estimates were built up based on typical power draws, operating hours, stand-by losses, and saturations to provide insight into the energy-consumption estimates.

As described below, we conducted a bottom-up analysis of the national energy consumption for most of the 16 end uses investigated (based on typical power draws, operating hours, stand-by losses, and saturation levels). The exceptions are cases where the most reliable data were from metered studies that actually recorded unit energy consumptions (UECs) in field settings, but did not necessarily record power draws or operating hours. In these cases typical operating hours were deduced based on typical power draws and UECs.

6.1 Technology Descriptions

Brief technology descriptions were developed for the 16 end uses investigated to define clearly those end uses and to provide insight into how each end use utilizes electricity. Market share data, where readily available, are also included to identify some of the key industry stakeholders.

Automatic Coffee Maker (Cooking)
Automatic coffee makers have two cycles. The first cycle brews the coffee by boiling the water and dripping it through the filter. This cycle has a relatively short operating time and normally stops when all the water in the reservoir has boiled off. The second cycle utilizes the warming plate, which is thermostatically controlled and uses a simple resistance heater. If left on for an extended length of time, the warming plate is the major source of energy consumption within the unit.

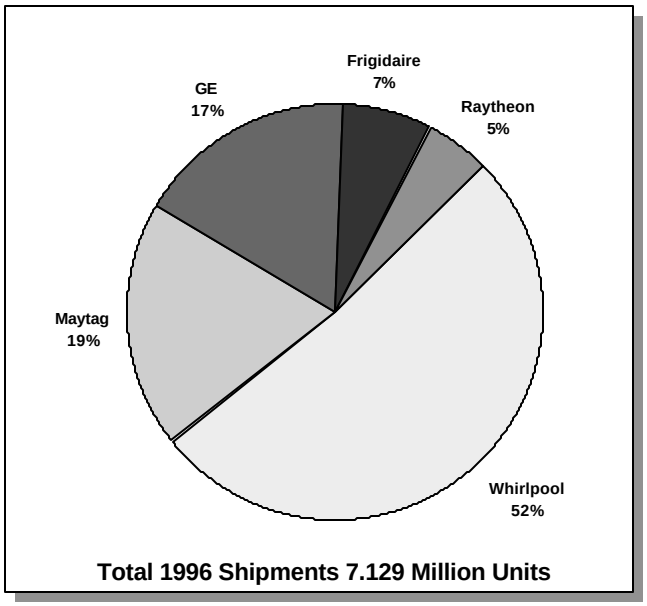
Cable Box (Electronics)
A cable box is basically a cable television channel selector and decoder. A large number of encoded signals enter the box and a select number are decoded according to the customer's contract with the cable provider. Cable boxes have a fairly low power draw, but because they have approximately the same hours of usage as the television and because they draw power even when not in use, they have a larger-than-expected annual consumption.

Clothes Washer (White Goods)
A clothes washer typically has several selectable wash options. The first cycle is the wash cycle, followed by one or more rinse and spin cycles. A few, premium models have internal booster heaters, but this is very rare. The energy consumption associated with external water heating is categorized separately. The clothes washer alone consumes electricity primarily

through the motor that drives the basket movement, but also through a water pump to drain the machine.

Exhibit 6-1 shows the U.S. market share for clothes washers. Whirlpool has over half of the 7.1 million unit-per-year market.

Exhibit 6-1: U.S. Market Share for Clothes Washers



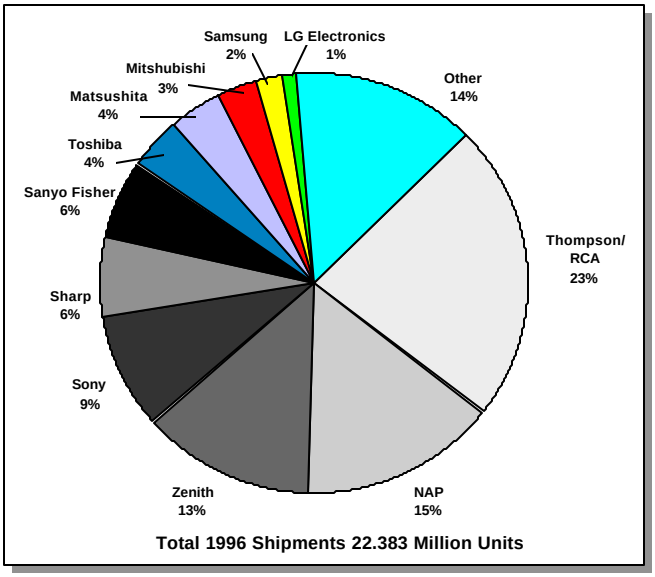
Source: [Appliance2, 1997; p. 83]

Color Television (Electronics)

Most televisions have a cathode ray tube (CRT) that projects an electron beam onto a phosphor-coated screen. The beam of electrons is deflected by a magnetic field to shape the image. Most common color televisions using a CRT range in size from 19" to 32" screen [CMPCO, 1997; and Sony, 1997]. In general, the larger the screen size, the more power the set draws.

Exhibit 6-2 shows U.S. market shares for color televisions. Thompson/RCA has the largest share (23%, based on unit shipments, of the 22.4 million unit-per-year market).

Exhibit 6-2: U.S. Market Share for Color Televisions



Market share data are not available for Victor Corporation of Japan (JVC), therefore JVC is not included.

Source: [Appliance2, 1997; p. 82]

Compact Audio System (Electronics)

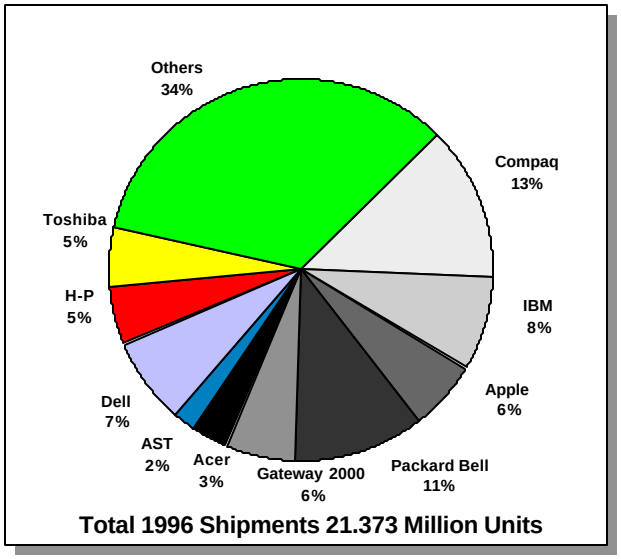
A compact audio system is classified as a minisystem. This audio system typically contains a dual tape deck, a CD player with single- or multiple-disc capacity. Although the wattage of the system is often published as 30 to 100 W per channel, this is the peak power handling capacity of the system and these power levels are only attained during the loudest passages of the music. Features such as the display, memory of user settings, and remote-control ready contribute to the unit's stand-by energy consumption.

Computer (Electronics)

A personal computer generally consists of a monitor and a separate processing and storage unit. Computer use (and, therefore, the net effect on national power consumption) has increased dramatically in recent years. Newer models have low-power (idle, or sleep) modes that consume only a few watts of power. Additionally, the newer models turn off monitors and disc drives after a preset time. Printers and other computer peripherals are accounted for separately.

Exhibit 6-3 shows market shares for personal computers. The largest single manufacturer, Compaq, has only 13% (based on units shipped) of the 21.4 million unit-per-year market.

Exhibit 6-3: U.S. Market Share for Computers



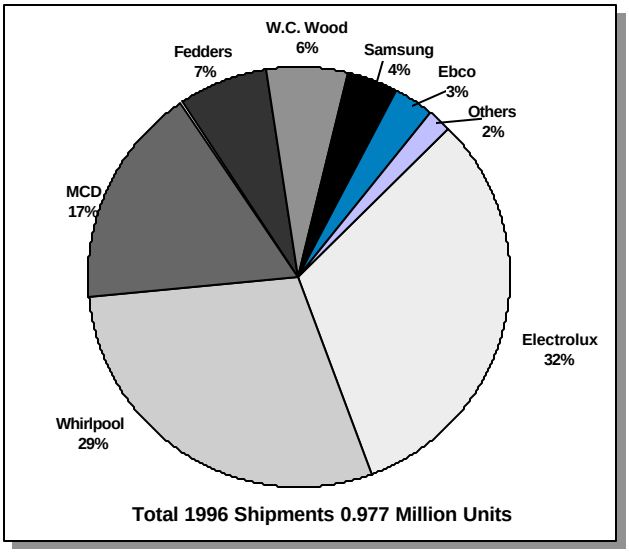
Source: [Appliance2, 1997; p. 82]

Dehumidifier (Space Cooling)

A dehumidifier uses a typical vapor-compression refrigeration cycle. A fan is used to draw room air through an evaporator (consisting of coils of cold tubing) that cools the air to the dew point, causing moisture to condense. The condensate drains into a receptacle or directly to a drain. The cooled and dried air then flows through the condenser, where it is reheated and introduced back into the room. The compressor motor and fan are the main sources of energy consumption in the system.

Exhibit 6-4 shows the U.S. market shares for dehumidifiers. Electrolux and Whirlpool each have almost a third of this one million unit-per-year market.

Exhibit 6-4: U.S. Market Share for Dehumidifiers



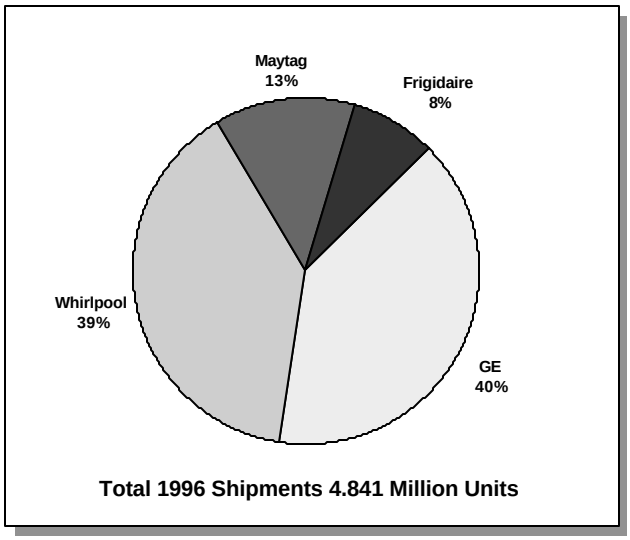
Source: [Appliance2, 1997; p. 82]

Dishwasher (White Goods)

Similar to the clothes washer, the energy associated with central water heating is accounted for separately. Most models contain a booster heater that either maintains the initial high water temperature or raises the temperature above that available from the central-hot-water source (for sterilization). A hot-air drying is often included as a feature, utilizing the booster heater to heat the dishes (after the wash cycle) until they are dry. The other main energy-consuming component is a water-circulation pump.

Exhibit 6-5 shows U.S. market shares for dishwashers. Whirlpool and GE each have about 40% of the 4.8 million unit-per-year market.

Exhibit 6-5: U.S. Market Shares for Dishwashers



Source: [Appliance2, 1997; p. 83]

Furnace Fan (Space Heating)

A furnace fan, controlled by a thermostat, circulates the air throughout the house in a forced-warm-air central heating system. The motors powering these fans are typically 1/4 to 1/2 horsepower. Duty cycle varies as a function of the outside air temperature and furnace capacity. Furnace fans operate while the furnace is firing and continue to run for a period after the furnace stops firing. While the furnace fan is a component in a central, forced-air furnace, its energy consumption is not currently accounted for in the furnace efficiency rating. Furthermore, the EIA Space Heating category does not currently include the energy consumption associated with furnace fans. The furnaces in which furnace fans are used may be fueled by natural gas (most common) or fuel oil. In this investigation we consider only furnace fans used with fossil-fueled furnaces. Although there are electric resistance warm-air furnaces (usually combined with central air-conditioning systems), the fans (or blowers) associated with those furnaces operate using the same fuel, and at the same heating efficiency, as the resistance furnace itself[1]. Hence, from an energy-consumption viewpoint, those furnace fans are indistinguishable from the furnace itself.

Microwave Oven (Cooking)

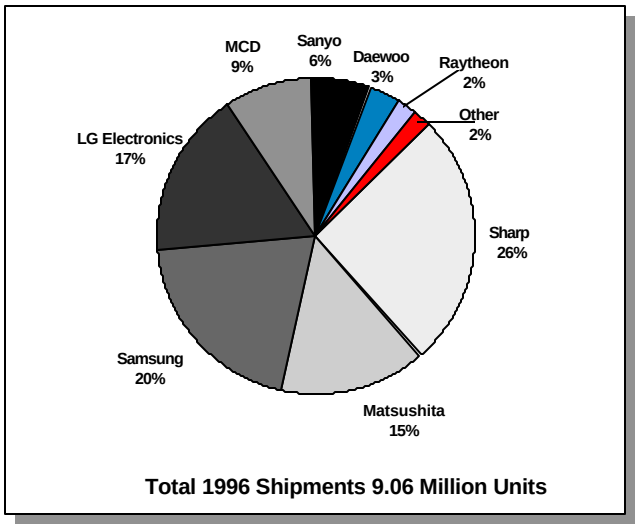
The power supply converts line power to the voltages required by the magnetron. The magnetron is a vacuum tube that, with the help of magnets and a wave guide, emits a beam of high-frequency energy. Food (containing water) is heated by this energy beam. Microwave ovens are very efficient relative to conventional electric ovens, since only the food rather than

[1] There is no efficiency difference between warming air with an inefficient fan motor or warming it with resistance heat.

the surroundings are heated. However, there are stand-by losses associated with the unit's display. Microwaves have become common in almost every residential household. It is currently taking on part of the role of the conventional range and oven.

Exhibit 6-6 shows U.S. Market shares for microwave ovens. The 9.1 million unit-per-year is dominated by Japanese manufacturers.

Exhibit 6-6: U.S. Market Share for Microwave Ovens



Source: [Appliance2 1997; p. 83]

Pool Pump (Motor)

A pool pump is used to circulate pool water through a filter. A National Sanitation Foundation (NSF) regulation dictates that a residential pool pump must "turn over" the pool water at least once every eight hours. Pool pumps are generally operated manually, but some operate on a timer. They typically use 1/2 to 3/4 Hp motors.

RACK Audio System (Electronics)

A RACK audio system is larger than the compact audio system previously described, but contains many of the same components, such as a CD changer, tape deck, or tuner. Unlike the compact audio system, these components are packaged separately, and the system is built up from a selection of components. These units generally have larger speakers and power amplifiers (80 to 120 W/Channel) relative to compact audio systems.

Torchiere Lamp — Halogen (Lighting)

In recent years, torchiere lamps (so named because they resemble torches) having halogen bulbs have become popular due to their very low cost. The halogen bulb has a quartz outer shell instead of the glass used in incandescent bulbs. The bulb is filled with halogen gases that

allow a higher filament operating temperature, giving the light a bluish white color (rather than the yellowish tinge characteristic of incandescent bulbs.) Since most of these bulbs are low voltage, a transformer is used to control the voltage. By controlling the voltage, light output can be varied on lamps equipped with a dimmer feature. These lamps provide an adequate amount of light, however, they typically consume more energy than conventional incandescent lamps, (unlike other types of incandescent alternatives such as fluorescent, which save energy relative to incandescent). Also, the high operating temperature of the halogen bulb can present a fire hazard.

Video Cassette Recorder (Electronics)

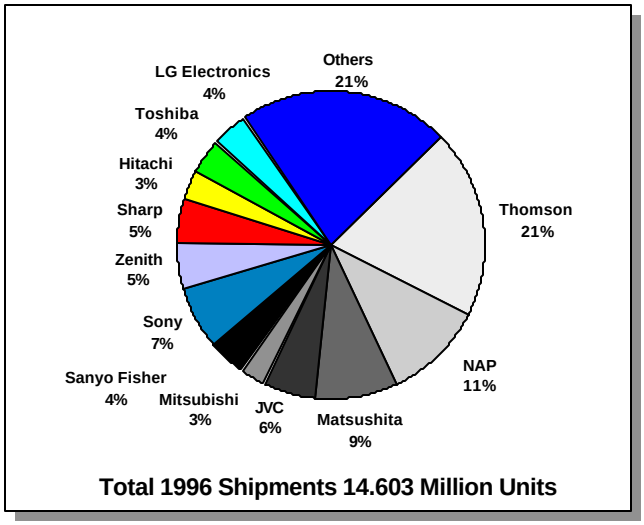
VCRs perform three main functions:

1. Volume control and channel selection (for normal television viewing);
2. Playing a video cassette; and
3. Recording a television program for later viewing.

Stand-by power draw is typically associated with the VCR display, memory of user settings, and "remote ready".

Exhibit 6-7 shows U.S. market shares for VCRs. Thomson, the largest manufacturer, has 21% (based on unit shipments) of the 14.6 million unit-per-year market.

Exhibit 6-7: U.S. Market Share for VCRs



Source: [Appliance2, 1997; p. 82]

Waterbed Heater (Miscellaneous Heating)

A waterbed heater is a pad-type, electric resistance heater that is used to warm the water in the waterbed. The heater is thermostatically controlled to assure that the waterbed maintains a

specified temperature – typically between 84 and 95°F. Therefore, if the bed is not insulated, (by blankets and other covers or by providing insulation around the sides of the bed), the heater will consume additional electricity in order to maintain the specified temperature. Typical heater capacities are 150 W, 330 W, and 380 W. Heater selection depends on waterbed size and fill-depth of the mattress.

Well Pump (Motor)

A well pump is used to pump water from a well to a pressurized holding tank. A pressure switch operates the pump to maintain the tank pressure. The deeper the well the more energy required to lift the water to the surface. The well pump must also overcome the pressure in the holding tank (typically 30 to 50 psi).

6.2 Unit Energy Consumption Estimates

Unit energy consumptions for typical appliances were estimated based on best available data (and, in some cases, engineering calculations and/or vintaging analyses), and account for consumption in both operating and stand-by modes.

Exhibit 6-8 lists unit energy consumption (UEC) estimates for the 16 end uses investigated[2]. Appendix B lists the various sources of operating hour, power draw, and UEC data uncovered in this study. Selection of data sources for Exhibit 6-8 are briefly explained below. Depending on the source, estimates may be based on the year 1995, 1996, 1997, or early 1998. For simplicity, we assumed all estimates apply to 1997. The errors introduced by this assumption will be small.

Automatic Coffee Maker (Cooking)

Power-Draw estimates range from 860 W [CEC, 1997] to 1500 W [HEI, 1997; LBL-40295, 1998], with most sources citing 1100 W (which we used) [CMPCO, 1997; PS/HB, 1997; AHAM SPDSHT, 1997]. Two sources for warming plate power draw cited 70 W [HEI, 1997; CEC, 1997]. One estimate (200 W) seemed excessive since the warming plate need only offset heat loss, rather than heat cold coffee. The operating hour estimate (61 hours/year) is based on one, 10-minute-per-day, brewing cycle [LBL-40295, 1998]. Hawaiian Electric also estimated one brew cycle per day, but estimated the typical brew cycle at 8 minutes [HEI, 1997]. We used LBNL's estimate of 360 hours/year warming plate usage [LBL-40295, 1998]. (Hawaiian Electric estimated 2 hours/day, which appeared high to us.)

[2] In Exhibit 6-8, a "stand-by mode" is shown for all end uses, whether or not the end use has stand-by losses. Some researchers refer to this mode as the "off mode" for end uses not having stand-by losses.

Exhibit 6-8: Unit Energy Consumption Estimates for 16 Residential End Uses (1997)

End Use	Typical Power Draw (W, unless indicated otherwise)		Typical Operating Time (hrs/yr, unless indicated otherwise)		Typical Unit Energy Consumption (kWh/yr)[1]
	Operating	Stand-By	Operating	Stand-By	Total
Auto Coffee Maker	1100[2]/70[3,4]	0	61[5]/360[4,5]	8339	92.3
Cable Box	20[5]	11.6[6]	1456[5]	7304	114.
Clothes Washer[7]	0.276 kWh/cycle[8,9]	0	392 cycles/yr[8]	8564[10]	108.
Color TV	60[11]	4[6]	1456[12]	7304	117.
Compact Audio	15[5]	10.6[6]	365[13]	8395	94.5
Computer	182/30[14,15]	0	1337[5]/632[15]	6791	262.
Dehumidifier	600[16]	0	1620[17,18]	7140	972.
Dishwasher[7]	0.332 kWh/cycle[9]	0	365 cycles/yr[18]	8456[20]	121.[19]
Furnace Fan	295[18]	0	1350[21]	7410	398.
Microwave Oven	1500[3]	3.1[6]	72[18]	8688	135.
Pool Pump	1000[22]	0	792	7968	792.
RACK Audio	60[5]	5.8[6]	365[13]	8395	70.6
Torchiere Lamp-Halogen	300[23]	0	1460[24]	7300	438.
VCR	10.7/15.7/15.7[5, 25]	5.6[6]	1255[12]/182[26]/78[25,26]	7245	56.6
Waterbed Heater	350[18]	0	3051[18,27]	5709	1070.
Well Pump	725[28]	0	115[29]	8645	83.4

1) Site energy consumption - does not include generation, transmission, and distribution losses.
2) [PS/HB, 1997]
3) [CEC, 1997, p. 5]
4) Brewing mode/warming plate
5) [LBL-40295, 1998] converted to saturation based on 99.06 million households in 1995 [EIA/AEO, 1998]
6) [Huber, 1997]
7) Does not include central water heating
8) [Dieckmann, 1997]
9) Calculated, based on UEC and cycles/year.
10) Estimated based on 30 min/cycle
11) [Thomson, 1997]
12) [Webber, 1997; p. 1]
13) [Suozzo, 1997]
14) [IBM, 1997]
15) Active/Idle (harddrive & monitor)
16) [Whirlpool, 1998]
17) Modified by ADL per Appendix B
18) [CMPCO, 1997; pp. 1, 2, 6]
19) [BPA, 1992]
20) Estimated based on 50 min/cycle
21) 270 hr/mon [CMPCO, 1997] multiplied by 5 month (typical heating season)
22) [So. Power, 1997; p.5]
23) [Calwell, 1998]
24) [RGTC, 1994]
25) On/play/record
26) [CM, 1997; p. 2]
27) Assumes queen size
28) Calculated, based on UEC and operating hours
29) Engineering Estimate (see Section 6.2)

Cable Box (Electronics)

We used LBNL's values for power draw (both operating and standby) [LNBL-40295, 1998] since they are based on measured data and no other independent, measured sources were found. Operating hours were assumed to be the same as color television operating hours.[3]

[3] Cable box operating hours may actually be slightly less than television hours since the cable box isn't needed when viewing a video cassette.

Clothes Washer (White Goods)

While we were able to assemble a number of sources for clothes washer data, we chose to base our consumption estimate on Arthur D. Little (ADL) laboratory testing, which provided a range from 0.25 to 0.30 kWh/cycle (we used the mid point) [Dieckmann, 1997]. This consumption estimate does not include energy used for water heating. While these tests were conducted on newer machines relative to the current inventory average age, we felt the mechanical-energy-consuming characteristics of clothes washers have not changed significantly in recent years. Our usage estimate (392 cycles/year) is from an October 1997 DOE workshop [DOE, 1997].

Color Television (Electronics)

Color television power draws vary significantly, not only with screen size, but from model to model and manufacturer to manufacturer. We selected the mid point (60 W) of the range of power draws (45-75 W) for the most common screen sizes, as indicated by the manufacturer having the largest market share in the U.S. (Thompson Consumer Electronics) [Thompson, 1997]. There is, however, significant uncertainty in any power-draw estimate. As shown in Appendix B, some televisions draw as much as 200 W or more. Also, this estimate reflects new products, so there is some additional uncertainty in applying it to the current inventory. Stand-by power draw was taken from the same source as referenced by LBNL, as it is the only independent, metered data available [Webber, 1997].

Usage estimates varied from 1456 hr/yr [Weber, 1997; p. 1] to 2616 hr/yr [EDSB, 1997]. Veronis, Suhler and Associates reported 1616 hrs/yr *per person* (for 1996)[4]. Based on an estimated 2.3 televisions/household and an average household size of 2.63 persons, usage hours per television could range from 700 (if all household members watch together) to 1800 (if all household members watch separately).[5] Therefore, we concluded that LBNL's estimate of 1456 hr/yr (4 hours/day) is the most realistic. Other available estimates were higher than the range estimated above.

Compact Audio System (Electronics)

We used power-draw estimates based on metered data collected by Huber [Huber, 1997]. Operating hours (365 hrs/yr) were estimated by two different sources [LBL-40295, 1998; Suozzo, 1997]. Veronis, Suhler & Associates estimated radio and recorded music listening times to be 1091 hrs/person/yr and 289 hrs/person/yr, respectively [Veronis, 1997]. These estimates, however, a) include listening time outside the home (such as in automobiles), b) do

[4] Average viewing hours per person per year is 1567, plus 49 hours home video, for a total of 1616 hours per person per year for 1996. [Veronis, 1997].

[5] Average household size is 2.63 persons [Stat-Abs, 1992, p. 51]. Average number of televisions per household is 2.3 [MD-TVD, 1998]. Therefore, if all household members watch together: 1616 hrs/2.3 TVs = 700 hrs/yr/TV. If all household members watch separately: 2.63 persons x 1616 hours/2.3 TVs = 1800 hrs/yr/TV.

not indicate the number of persons listening to a single audio system, and c) include all types of audio systems (not just compact systems). Therefore, these estimates may be completely consistent with the estimates we used.

Computer (Electronics)

We used manufacturer data for computer power draws [IBM, 1997]. Although these values are for new products, the turnover rate in computers is fairly high[6], so these data are reasonably representative of the national inventory. We split power draw into the "active" and "idle" modes. Idle mode is when the computer is switched on, but is not in use, and the monitor powers down. There is no stand-by power draw (when the computer is switched off). Hard data on computer usage were not found. Estimates ranged from 1337 [LBL-40295, 1998] hours/year to 2080 hours/year [Nore, 1994; HEI, 1997]. We used the low end of the range (1337 hours/year) because, in our judgment, 2080 hours/year (8 hours/day, 5 days/week) seemed extremely high, except for the case of home offices.

Dehumidifier (Space Cooling)

Power draw and annual operating hours vary significantly depending on product, climate, user settings, and location in home. Therefore, any estimate of UEC will be uncertain. We based our power-draw estimates on an average of three Whirlpool products (600W)[7] [Whirlpool, 1998]. One manufacturer estimated the typical length of the "dehumidification season" to be about six months (March or April until September). We assumed Central Main Power's [CMPO, 1997] usage data to be typical of peak dehumidification periods, and further assumed that the peak dehumidification period lasts three months (at 360 hours/month) and that the dehumidifier runs half as frequently (180 hours/month) during the remaining three months, totaling 1620 hours/year. These assumptions put our UEC estimate within the range reported by other sources, but near the upper end of that range.

Dishwasher (White Goods)

In the case of dishwashers, the best data available comes from the ELCAP study, which measured UEC directly (121 kWh/yr) [BPA, 1992]. For informational purposes, Exhibit 6-8 also shows estimates of usage and energy consumption per cycle, which are based on this UEC. Usage estimates available range from 322 cycles/year [EDSB, 1997] to 365 cycles/year (HEI, 1997; CEC, 1997]. We used 365 cycles/year and calculated the energy consumption per cycle.

Furnace Fan (Space Heating)

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[6] A personal computer has an average life expectancy of 6 years [Appliance 2, 1997], so the average age of a computer is about 3 years.

[7] Engineering calculations based on manufacturer data verified this estimate.

Central Maine Power [CMPCO, 1997] provided metered data for average power draw and monthly operating hours, which were not available from other sources. We assumed a five-month heating season (representative of the U.S.) to convert Central Maine Power's monthly operating hours (270 hours/month) to annual operating hours (1350 hours/year).

Microwave Oven (Cooking)

Power-draw estimates for microwave ovens ranged from 1400 W [So. Power, 1997] to 1600 W [SCL, 1997]. We used an average of the range (1500 W). The two estimates of typical stand-by power draw (associated with the display) were 3.1 W [Huber, 1997] and 3.7 W [Suozzo, 1997]. We used 3.1 W. We used Central Main Power's estimate of 72 hours/year usage as it is based on customer survey data [CMPCO, 1997]. Other estimates available did not appear to be based on metered data or surveys.

Pool Pump (Motor)

Power-draw estimates generally range from 1000 W [So. Power, 1997] to 1100 W [SCL, 1997][8]. We used 1000 W. An engineering estimate, based on manufacturer inputs, confirms this value[9]. Operating-hour estimates varied from 4 hr/day [RGTC, 1994] to 12 hr/day [Walton EMC, 1997]. We used an estimate of 792 hr/yr[10] (which corresponds to an average of about 6.5 hr/day for a four-month season).

RACK Audio System (Electronics)

We used power-draw estimates that were based on metered data [Huber, 1997]. Huber reports the average stand-by power draw to be 5.8W. Although they cite the same source, LBNL eliminated some of Huber's measurements that they judged to be non-representative and, hence, arrived at a different value (7W) [LBL-40295, 1998]. Operating hours (365 hrs/yr) were estimated by two different sources [Suozzo, 1997; LBL-40295, 1998]. See also the discussion above (under Compact Audio System) regarding listening-time estimates.

Torchiere Lamp – Halogen (Lighting)

Although some older torchiere lamps draw up to 600 W, virtually all torchiere lamps sold since early 1997 draw 300 W or less [Calwell, 1998]. Calwell recommends 300 W as a typical draw [Calwell, 1998]. Two independent sources estimate torchiere usage at 4 hrs/day, which we used [RGTC, 1994 and LBL-40295, 1998]. One source estimated 39 hours/week (5.6 hours/day) for torchiere lamps used in dorm rooms [ECOS, 1998]. However, dorm-room

[8] We discounted one source, 746 W [CMPCO, 1997], as it appeared to neglect motor efficiency.

[9] One manufacturer estimated typical pool-pump capacity of 50 to 60 gpm [Essig, 1998]. Another estimated 82 gpm [Ace Pump, 1998]. We assumed 70 gpm. Also assuming a 50% pump/motor efficiency and 15 psi pressure drop, this results in a power draw of 910 W.

[10] Based on 8 hr/day pump operation for one month and 6 hr/day for three months.

use represents only an estimated 10% of torchiere lamp use[11], so we did not use this estimate. For comparison, the typical residential incandescent socket is used only about one hour/day [EDSB, 1997; p. 109].

Video Cassette Recorder (Electronics)

In our judgment, the best sources available for VCR operating-mode power draws are provided by LBNL, which are based on metered data [LBL-40295, 1998]. For stand-by power, we used Huber's estimate of 5.6W [Huber, 1997]. This agrees well with the stand-by power-draw estimate from Media Facts (5.4W) [CM, 1997, p. 2]. Usage estimates are also from Media Facts [CM, 1997] for play and record. The "on" time estimate is from Carrie Webber [Webber, 1997]. "On" time is the time the VCR is on for TV viewing, but not in use to play or record.

Waterbed Heater (Miscellaneous Heating)

Our typical power-draw and operating-hour estimates are from Central Main Power [CMPCO, 1997]. The power-draw estimate is consistent with other sources. No other source was available for operating hours, but the resulting UEC (1070 kWh/yr) is in the range estimated by other sources (toward the low end of the range) (see Appendix B).

Well Pump (Motor)

As shown in Appendix B, relatively little data are available for well pumps. The Consumer Guide to Home Energy Savings estimated a broad range of power draws (500-2000 W) [ACEEE, 1996]. The American Council for an Energy Efficient Economy estimates pump operation of "a few hours a day, at most" [ACEEE-2, 1997]. However, an engineering estimate puts the annual consumption at 83 kWh/yr[12], which is far lower than other sources would suggest (see Appendix B). We elected to use the engineering estimate, since it is based on reasonable and traceable estimates of water usage and pump efficiency pump. There is, however, some uncertainty in this estimate, as the average well depth is not known. We then backed out estimates of operating time and power draw, assuming a 10 gpm pump flow rate.

6.3 National Energy Consumption Estimates

National energy consumptions were estimated based on the unit energy consumption estimates and appliance saturation levels. However, for many end uses, there are significant uncertainties in saturation levels.

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[11] Based on 15.1 million students pursuing a post-secondary education [NCHR, 1995]. We assumed 33% of students reside in dormitories. 81% of dormitory rooms contain torchiere lamps [ECOS, 1998]. We assumed each dormitory that contains a torchiere lamp, has one torchiere lamp.

[12] Based on 2.7 persons/rural household [Stat-Abs, 1992] using an estimate of 70 gal/person/day, with 83.4 psi pressure (due to an assumed avg. well depth of 100 ft and average storage tank pressure of 40 psi) with a combined pump/motor efficiency of 50% [Marley, 1998].

Exhibit 6-9 lists the national energy consumption estimates for the 16 end uses investigated. These estimates are built up from the UEC estimates in Exhibit 6-8, plus saturation estimates. Depending on the source, saturation estimates may be based on the year 1995, 1996, 1997, or early 1998[13]. For simplicity, we assumed all saturation estimates apply to 1997. The errors introduced by this assumption will be small. We do, however, account for growth in housing stock between 1995 (or 1996) and 1997 when calculating national energy consumption. As discussed in Section 3, saturation is defined as the number of appliances in use divided by the number of households. Therefore, saturations can exceed 100% for some appliances (such as televisions). Often, available data are reported in terms of the percentage of households using at least one of the appliance. We refer to this as "penetration" to avoid confusion. In many cases, most households will have only one of a particular appliance, so there is little numerical difference between the saturation and the penetration.

Exhibit 6-9: Estimated National Energy Consumption for 16 Residential End Uses (1997)

End Use	Typical Unit Energy Consumption		Saturation		National Primary Energy Consumption (TBtu/yr)		
	Site[1] (kWh/yr)	Primary[2] (MMBtu/yr)	Units per Household	Number of Units[3] (Millions)	Operating	Stand-By	Total
Auto Coffee Maker	92.3	1.02	0.82[4]	82.9	84.2	0	84.2
Cable Box	114	1.25	0.45[5]	45.8	14.7	42.7	57.3
Clothes Washer[6]	108	1.19	0.78[7]	79.7	94.9	0	94.9
Color TV	117	1.28	2.25[8]	229	220	73.6	294.
Compact Audio	94.5	1.04	0.54[4]	54.6	3.29	53.5	56.8
Computer	262	2.89	0.21[4]	21.4	61.7	0	61.7
Dehumidifier	972	10.7	0.11[9]	11.2	120	0	120.
Dishwasher[6]	121	1.33	0.57[10]	57.9	77.2	0	77.2
Furnace Fan	398	4.38	0.41[11]	41.7	183	0	183.
Microwave Oven	135	1.49	0.90[10]	91.5	109	27.1	136.
Pool Pump	792	8.71	0.05[11]	5.08	44.3	0	44.3
RACK Audio	70.6	0.78	0.55[7]	56.0	13.5	30.0	43.5
Torchiere Lamp-Halogen	438	4.82	0.35[12]	35.6	172	0	172.
VCR	56.6	0.62	1.21[8]	123	23.7	52.9	76.5
Waterbed Heater	1070	11.8	0.15[13]	15.1	177	0	177.
Well Pump	83.4	0.92	0.13[11]	13.6	12.5	0	12.5
				Totals	**1410**	**280**	**1690**

1) From Exhibit 6-8. Does not include generation, transmission, and distribution losses.
2) Based on 1996 typical generation, transmission and distribution, efficiency of 31.0% [EIA/AEO, 1998]
7) [Appliance2, 1997]
8) [MD-TVD, 1998] modified by ADL per Sect. 6.3
9) Based on [RECS-HC, 1993] and vintaging analysis. See Appendix B for details.
10) [AHAM, 1997]

[13] 1993 estimates were used for three saturation levels: pool pumps, furnace fans, and well pumps. A 1994 estimate was used for waterbed heater saturation. See discussions below for justifications.

3) Based on 101.67 million households in 1997 [EIA/AEO, 1998]
4) 1995 estimate [LBL-40295, 1998], converted to saturation based on 99.06 million households in 1995 [EIA/AEO, 1998]
5) [Suozzo, 1997]
6) Does not include energy associated with central water heating
11) [RECS-HC, 1993]
12) [CPSC, 1996]
13) [HE-2, 1994]

Determining the number of appliances actually "in use" can be problematic. Many smaller appliances (such as blenders or crock pots) sit virtually unused (in cupboards, closets, and attics) in many households. Fortunately, the larger of the small end uses investigated in this study tend not to fall into this category.

We found much discrepancy in saturation estimates, varying by as much as a factor of two. As discussed further in Section 9, this points to the need for more primary data collection to reduce the uncertainty in saturation estimates. As discussed in Section 8, however, agreement is generally good among saturation estimates used by EIA, LBNL, and ADL.

Appendix B lists the sources found for saturation estimates. Brief explanations of the sources used in Exhibit 6-9 follow.

Automatic Coffee Maker (Cooking)
Saturation data ranged from 82% [LBL-40295, 1998] to 89% [AHAM SPDSHT, 1997]. Appliance Magazine estimated a penetration of 74.5% [Appliance2, 1997], which might suggest that some households have more than one automatic coffee maker. We chose a saturation of 82%.

Cable Box (Electronics)
Estimating the saturation of cable boxes is complicated by several factors:

- Department of Commerce shipment statistics lump cable boxes with other equipment types;
- Cable boxes are only needed for premium channels or Pay Per View (PPV), so cable television saturation does not equate to cable-box saturation;
- During promotions, cable companies often install cable boxes and offer limited-duration free service (typically one month). Even if the end user discontinues the service, the cable box is frequently left in place; and
- Some end users have illegal cable boxes (not supplied by cable companies).

We assume that the saturation of cable boxes is equal to the saturation of pay cable[14]. If we further assume that few households have more than one cable box, then the saturation of cable boxes is about equal to the penetration of cable boxes. One source estimates pay-cable penetration to be 27% [MD-TVD, 1998]. Another source estimated the number of pay-cable subscriptions for 1997 to be 49,130,000 [NTCA, 1997; p. 1]. While this is numerically equivalent to about 50% of households, some households have multiple subscriptions. It does, however, represent an upper limit on saturation. We elected to use a cable-box saturation estimate of [45% Suozzo, 1997], which is within the range of the other estimates. However, there is significant uncertainty in this estimate.

Clothes Washer (White Goods)

We used the penetration estimate from Appliance Magazine (78%) [Appliance2, 1997], which is in good agreement with both the EIA RECS's [RECS-HC, 1993] and LBNL's [LBL-40295, 1998] saturation estimates (77%). This would suggest that few households have multiple clothes washers, since penetration and saturation estimates are about equal.

Color Television (Electronics)

Saturation estimates range from about 188% [LBL-40295, 1998] to over 225%[15]. We selected 225%, as it is from the sources closest to the industry[16]. In any case, our national energy consumption estimate is somewhat insensitive to the saturation, since our estimate of television operating hours was bracketed based on saturation (as discussed in Section 6.2).

Compact Audio System (Electronics)

Estimates range from a saturation of 54% [LBL-40295, 1998] to a penetration of 70% [Appliance2, 1997; p. 87]. We used the 54% estimate, suspecting that the 70% estimate is based on optimistic thinking (see discussion in Section 9, second paragraph). Shipment data (presented in Section 7) indicate that roughly 40 million systems were shipped between 1987 and 1996 [Appliance 1997]. Based on an average life of seven years [Appliance2, 1997], this would suggest that even the low end of the saturation estimate range may be somewhat high (see vintaging analysis in Appendix B).

Computer (Electronics)

Estimates range from a saturation of 21% [LBL-40295, 1998] to a penetration of 40% [Appliance2, 1997; p. 87] to a penetration of 42% [NPR Broadcast, 1998]. There is definitely a lot of industry hype about the computer market and we suspect this may have influenced the later two sources. We chose 21% saturation, but there is large uncertainty in this estimate.

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[14] Pay cable includes premium channel services and/or Pay Per View.

[15] Based on 98% (plus) penetration and an average of 2.3 sets per TV household [MD-TVD, 1998]

[16] Media Dynamics' sources include A.C. Nielsen Co., U.S. Census, Television Bureau of Advertising, and Statistical Research, Inc.

Dehumidifier (Space Cooling)
Saturation estimates range from 11% [LBL-40295, 1998] to 18% [Appliance2, 1997]. We based our estimate on the EIA Residential Energy Consumption Survey (RECS) [RECS-HC, 1993]. The RECS saturation estimate for 1993 is 9.4%. Since saturation of dehumidifiers has been growing historically, we performed a simple vintaging analysis to adjust this estimate to 1997 (see Appendix B for details), resulting in a saturation estimate of 11%.

Dishwasher (White Goods)
Saturation estimates range from 38%[17] [ACEEE, 1996] to 57% [AHAM, 1997]. Most estimates are above 45%. We selected the 57% estimate since it was based on a study commissioned by a well-established manufacturers' association.

Furnace Fan (Space Heating)
Saturation/penetration estimates for central, warm-air furnaces (natural gas and fuel oil only) ranged from 41% [RECS-HC, 1993] to 80% [Appliance2, 1997]. We selected 41%. The saturation of central, warm-air furnaces has been fairly stable in recent years, therefore, the uncertainty introduced by applying the 1993 saturation to 1997 is small. The penetrations in Appliance Magazine appear to be exaggerated relative to other sources and, hence, were not used.

Microwave Oven (Cooking)
Estimates range from a saturation of 70-90% [ACEEE, 1996] to a penetration of 91% [Appliance2, 1997.] The more recent estimates tend to be at the higher end of the ranges. (Appliance Magazine estimates show penetrations increasing from about 85% in 1992 to about 91% in 1996 [Appliance2, 1997].) We selected 90% saturation [AHAM, 1997].

Pool Pump (Motor)
Estimates of swimming pool saturations are generally between 4% and 5% [LBL-40295, 1998; RECS-HC, 1993]. We selected 5%. Although the 5% saturation estimate is based on the year 1993, historically pool pump saturations have not changed rapidly, therefore, the uncertainty introduced by applying the 1993 saturation estimate to 1997 is small. We did account for the growth in housing stock between 1993 and 1997.

RACK Audio System (Electronics)
Both sources available estimated 55% saturation [Appliance2, 1997; LBL-40295, 1998].

Torchiere Lamp – Halogen (Lighting)

[17] The source [ACEEE, 1996] estimates a range from 38 to 50%.

Saturation estimates range from 31% [LBL-40295, 1998] to 40% [HE, 1997]. We selected 35%, based on an estimated 35 to 40 million lamps in stock [CPSC, 1996]. There is some uncertainty in this estimate, however, since these lamps are so inexpensive that they may be discarded when no longer needed (such as when a student moves out of a dorm room).

Video Cassette Recorder (Electronics)
The best documented data available comes from Media Dynamics [MD-TVD, 1998]. They estimate 1997 penetration at 87% and saturation at about 121%[18] . The 121% saturation estimate agrees almost exactly with LBNL's estimate [LBL-40295, 1998].

Waterbed Heater (Miscellaneous Heating)
Saturation estimates range from 12% to 20% [ACEEE, 1996]. We selected 15%, which is near the median of the estimates available, and which is also at the low end of the range estimated by Home Energy [HE-2, 1994; p. 1].

Well Pump (Motor)
Most saturation estimates range from 10% to 15%. We selected EIA's estimate (13.4% for 1993) [RECS-HC, 1993]. The stock of well pumps has been fairly stable for some time, therefore, applying the 1993 saturation estimate to 1997 introduces little uncertainty.

[18] The source reports that 89% of TV households have at least one VCR. The source also reports 98% (plus) of households have TVs, which means VCR penetration is 87% (of total households). The source reports 54% of TV households (3% of total households) have one VCR and 35% of TV households (34% of total households) have two or more VCRs [MD-TVD, 1998]. Assuming that very few households have three or more VCRs: (1) (53%) + (2) (34%) = 121%.

7. Energy Consumption Trends

Our energy consumption forecasts are based on expected trends and technology changes. Our projections suggest that energy consumption for the 16 end uses evaluated will increase by only 6% between 1997 and 2010 (from 1.69 to 1.79 quad/year), even without the benefit of additional voluntary or mandatory energy-saving measures.

Exhibit 7-1, Exhibit 7-2, and Exhibit 7-3 indicate projected national energy consumptions for the 16 residential end uses for 2000, 2005, and 2010, respectively. Projections account for expected changes in saturations, number of households, usage patterns, projected improvements in electric generation efficiency, as well as expected end-use technology changes that will impact energy consumption. Projected increases in number of households and in generation efficiency are from the AEO 1998 reference case [EIA/AEO, 1998]. The AEO projects about a 15 percent increase in number of households and about a seven percent increase in generation efficiency between 1997 and 2010.

Projections are based on a "business-as-usual" scenario, that is, they assume no major policy or regulatory changes that would impact energy consumption.

Exhibit 7-4 summarizes the projected energy consumptions. For comparison, the EIA projects a 28% increase from 1996 to 2010 for five small end uses (clothes washers, dishwashers, color televisions, personal computers, and furnace fans), and an 80% increase for their current *Other Uses* category. Exhibit 7-5 and Exhibit 7-6 graphically illustrate our projected trends in energy consumption. Exhibit 7-5 shows the end uses projected to have negative growth rates (four end uses) and low growth rates (seven end uses). Exhibit 7-6 shows the remaining five end uses, which are projected to have moderate-to-high growth rates.

Projections for each end use are discussed below. In general, our approach was to identify current and future trends influencing the energy consumption of each end use. We used credible, quantified projections when available, and applied subjective judgment, based on identified trends, when quantified projections were not available. While not mathematically rigorous, we believe these are reasonable techniques for making projections. However, any approach to long-range projections of this type is subject to significant uncertainties. These uncertainties must be kept in mind when drawing conclusions from the results.

The descriptions below reference exhibits of penetration trends published by Appliance Magazine [Appliance 2, 1997]. We include these exhibits as they are from the only source available that shows penetration trends. However, the absolute values of saturations used in our calculations do not necessarily match the Appliance Magazine estimates, when we felt another estimate was more appropriate. We have noted these discrepancies where appropriate.

Exhibit 7-1: Year-2000 Projected National Energy Consumption for 16 Residential End Uses

End Use	Typical Unit Energy[1] Consumption		Saturation[1]		National Primary Energy Consumption[1] (TBtu/yr)			
	Site[2] (KWh/yr)	Primary[3] (MMBtu/yr)	Units per Household	Number of Units[4] (Millions)	Operating	Stand-by	Total	Growth Relative to 1997
Auto Coffee Maker	92	1.0	0.82	86	87	0	87	3%
Cable Box	110	1.2	0.51	53	17	49	66	15%
Clothes Washer[5]	110	1.2	0.78	83	100	0	100	3%
Color TV	120	1.3	2.3	240	230	76	300	2%
Compact Audio	95	1.0	0.54	57	3.4	55	58	3%
Computer	260	2.9	0.25	26	75	0	75	22%
Dehumidifier	970	11	0.12	12	130	0	130	11%
Dishwasher[5]	120	1.3	0.59	63	83	0	83	8%
Furnace Fan	400	4.4	0.41	43	200	0	200	3%
Microwave Oven	120	1.3	0.91	96	98	28	130	-7%
Pool Pump	790	8.7	0.05	5	46	0	46	3%
RACK Audio	71	0.77	0.55	58	14	31	45	3%
Torchiere Lamp	440	4.8	0.35	37	180	0	180	3%
VCR	59	0.64	1.3	140	26	61	88	12%
Waterbed Heater	1070	12	0.14	15	170	0	170	-3%
Well Pump	83	0.91	0.13	14	12	0	12	-1%
				Totals	**1450**	**300**	**1750**	**4%**

1) See Section 7 for an explanation of projections
2) Does not include generation, transmission, + distribution losses.
3) Based on generation, transmission, + distribution efficiency of 31.2% projected for 2000 [EIA/AEO, 1998]
4) Based on 105.34 million households projected for 2000 [EIA/AEO, 1998].
5) Does not include energy associated with central water heating

Exhibit 7-2: Year-2005 Projected National Energy Consumption for 16 Residential End Uses

End Use	Typical Unit Energy[1] Consumption		Saturation[1]		National Primary Energy Consumption[1] (TBtu/yr)			
	Site[2] (KWh/yr)	Primary[3] (MMBtu/yr)	Units per Household	Number of Units[4] (Millions)	Operating	Stand-by	Total	Growth Relative to 1997
Auto Coffee Maker	93	0.98	0.82	91	89	0	89	5%
Cable Box	110	1.2	0.56	62	19	55	74	29%
Clothes Washer[5]	110	1.2	0.78	87	100	0	100	5%
Color TV	100	1.1	2.3	250	230	39	270	-9%
Compact Audio	95	1.0	0.54	60	3.5	56	60	5%
Computer	260	2.7	0.33	37	100	0	100	65%
Dehumidifier	970	10	0.13	15	150	0	150	28%
Dishwasher[5]	120	1.3	0.64	71	91	0	91	18%
Furnace Fan	400	4.2	0.41	46	190	0	190	5%
Microwave Oven	110	1.2	0.91	100	91	29	120	-12%
Pool Pump	790	8.4	0.05	5.6	47	0	47	5%
RACK Audio	71	0.75	0.55	61	14	32	46	5%
Torchiere Lamp	440	4.6	0.35	39	180	0	180	5%
VCR	38	0.40	1.40	160	29	33	63	-20%
Waterbed Heater	1070	11	0.13	14	160	0	160	-11%
Well Pump	83	0.88	0.12	14	12	0	12	-4%
				Totals	**1510**	**240**	**1750**	**4%**

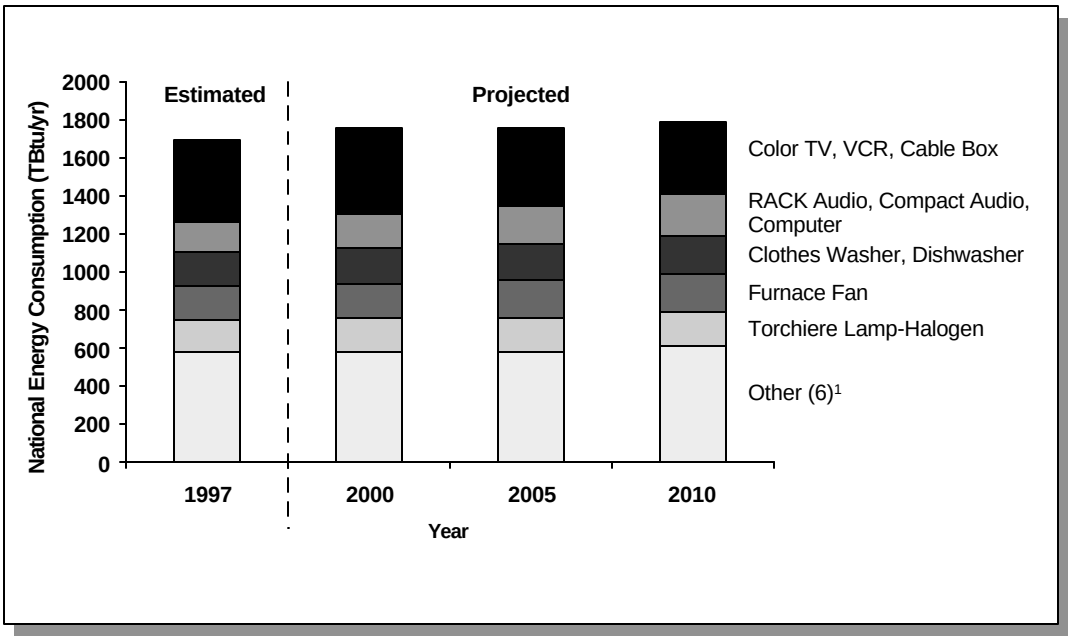
1) See Section for an explanation of projections
2) Does not include generation, transmission, + distribution losses.
3) Based on generation, transmission, + distribution efficiency of 32.2% projected for 2005 [EIA/AEO, 1998]
4) Based on 111.08 million households projected for 2005 [EIA/AEO, 1998]
5) Does not include energy associated with central water heating

Exhibit 7-3: Year-2010 Projected National Energy Consumption for 16 Residential End Uses

End Use	Typical Unit Energy[1] Consumption		Saturation[1]		National Primary Energy Consumption[1] (TBtu/yr)			
	Site[2] (KWh/yr)	Primary[3] (MMBtu/yr)	Units per Household	Number of Units[4] (Millions)	Operating	Stand-by	Total	Growth Relative to 1997
Auto Coffee Maker	92	0.95	0.82	95	90	0	90	7%
Cable Box	110	1.1	0.59	69	20	58	78	37%
Clothes Washer[5]	110	1.1	0.78	92	100	0	100	7%
Color TV	93	0.96	2.3	260	230	20	250	-14%
Compact Audio	94	0.97	0.54	63	3.5	57	61	7%
Computer	200	2.1	0.45	52	110	0	110	77%
Dehumidifier	970	10	0.15	18	180	0	180	48%
Dishwasher[5]	120	1.2	0.69	81	100	0	100	30%
Furnace Fan	400	4.1	0.41	48	200	0	200	7%
Microwave Oven	110	1.1	0.91	110	91	30	120	-11%
Pool Pump	790	8.1	0.05	5.9	47	0	47	7%
RACK Audio	71	0.72	0.55	64	14	32	47	7%
Torchiere Lamp	440	4.5	0.35	41	180	0	180	7%
VCR	28	0.29	1.5	170	32	18	50	-37%
Waterbed Heater	1070	11	0.13	15	160	0	160	-9%
Well Pump	83	0.85	0.12	14	12	0	12	-7%
				Totals	**1570**	**220**	**1790**	**6%**

1) See Section 7 for an explanation of projections.
2) Does not include generation, transmission, + distribution losses.
3) Based on generation, transmission, + distribution efficiency of 33.2% projected for 2010 [EIA/AEO, 1998]
4) Based on 117.04 million households projected for 2010 [EIA/AEO, 1998].
5) Does not include energy associated with central water heating

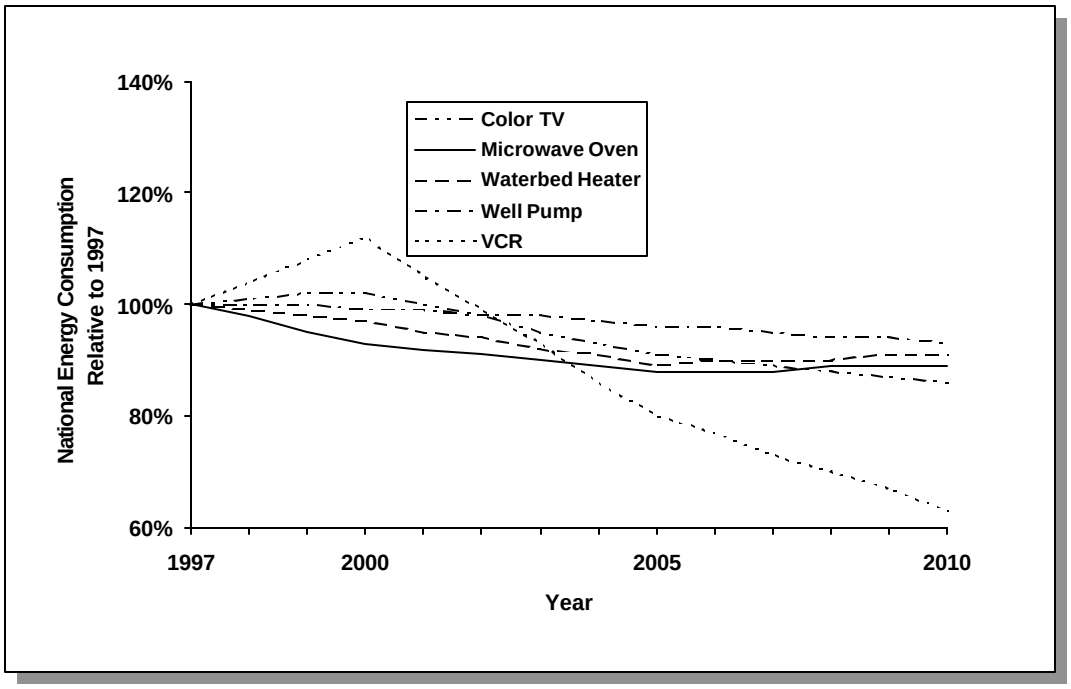
Exhibit 7-4: Summary of National Energy Consumption Trends for 16 Residential End Uses



1) Auto Coffee Maker, Dehumidifier, Microwave Oven, Pool Pump, Waterbed Heater, Well Pump

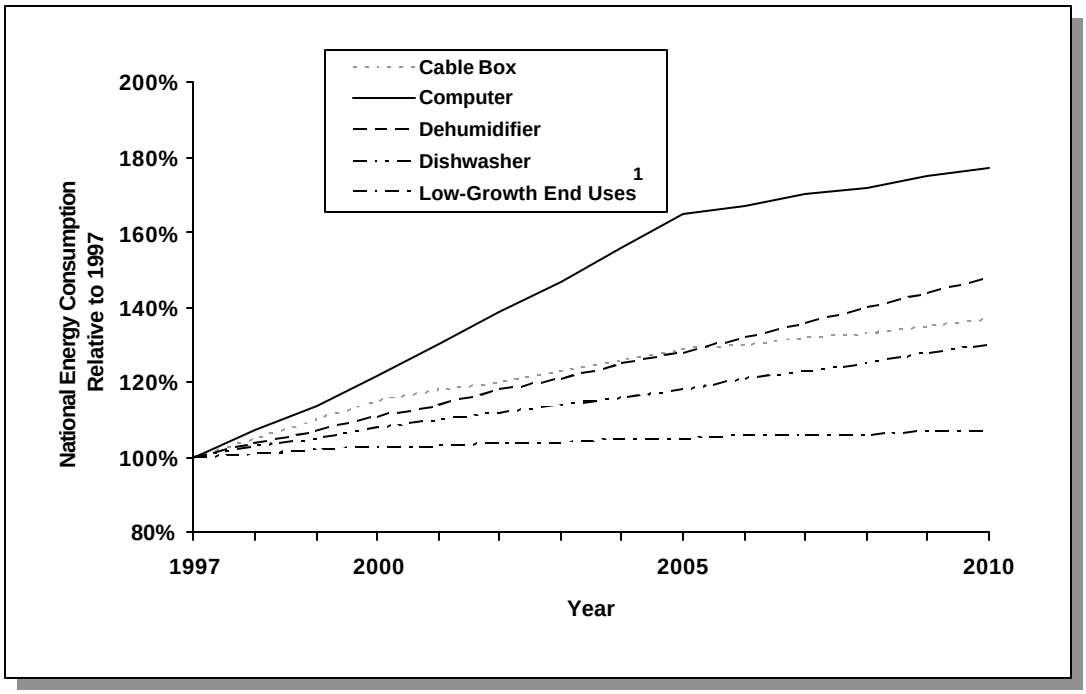
Sources: Exhibit 6-9, Exhibit 7-1, Exhibit 7-2, Exhibit 7-3

Exhibit 7-5: Projected Total Percent Change in National Energy Consumption for End Uses Negative Growth Rates



Sources: Exhibit 6-9, Exhibit 7-1, Exhibit 7-2, Exhibit 7-3

Exhibit 7-6 Projected Total Percent Change in National Energy Consumption for End Uses Having Positive Growth Rates



1) Includes Auto Coffee Makers, Clothes Washers, Compact Audio Systems, Furnace Fans, Pool Pumps, RACK Audio Systems, and Torchiere Lamps

Sources: Exhibit 6-9, Exhibit 7-1, Exhibit 7-2, Exhibit 7-3

Product characteristics, especially for consumer electronics, may change with time. Therefore, some of the products investigated may be partially replaced by new products by 2010.

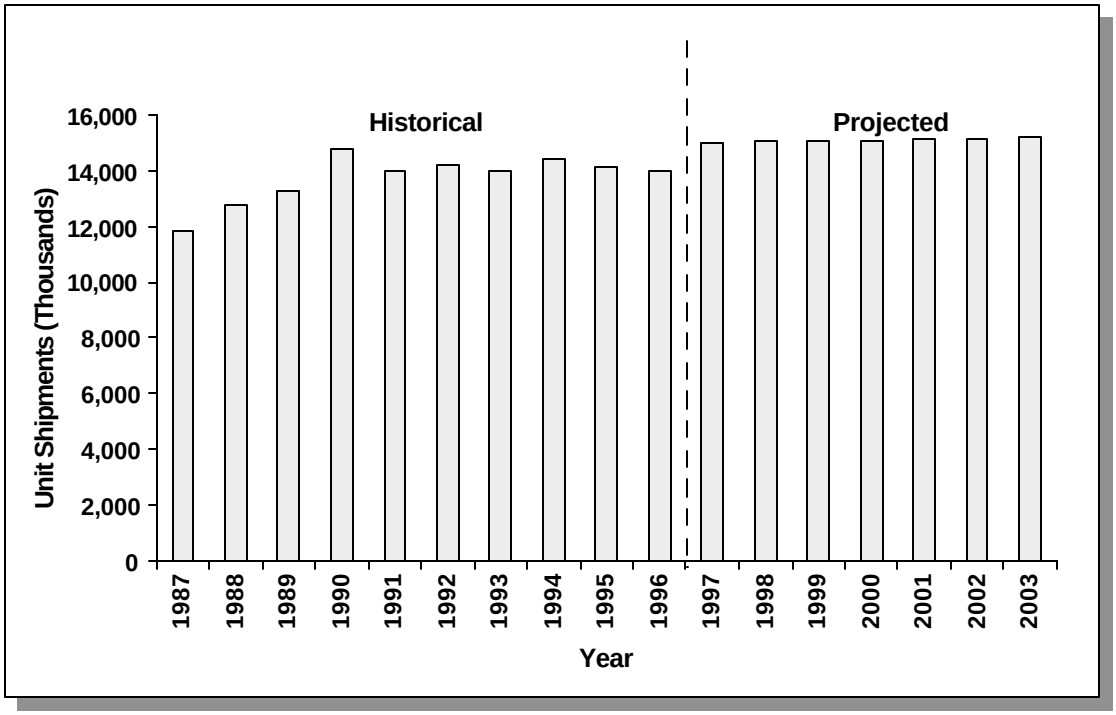
Consumer electronics evolve at an alarming rate. Products are constantly being redesigned or even replaced. There is fierce competition among manufacturers and service providers. For example, digital video disk (DVD) players may displace VCRs, or cable modems may make cable boxes obsolete. However, in almost all cases, the new products will have similar energy consumption characteristics to the products they are displacing. Even if a new product doesn't completely displace an existing product, end users only have so much disposable time – a new gadget in the home means less time spent using (and less energy consumption by) existing gadgets. Therefore, the overall impact on energy consumption of new products is less dramatic than one might initially expect.

Automatic Coffee Maker (Cooking)

Projected shipment trends and historical penetration levels (Exhibit 7-7 and Exhibit 7-8, respectively) suggest that the saturation of coffee makers has stabilized. No technology changes

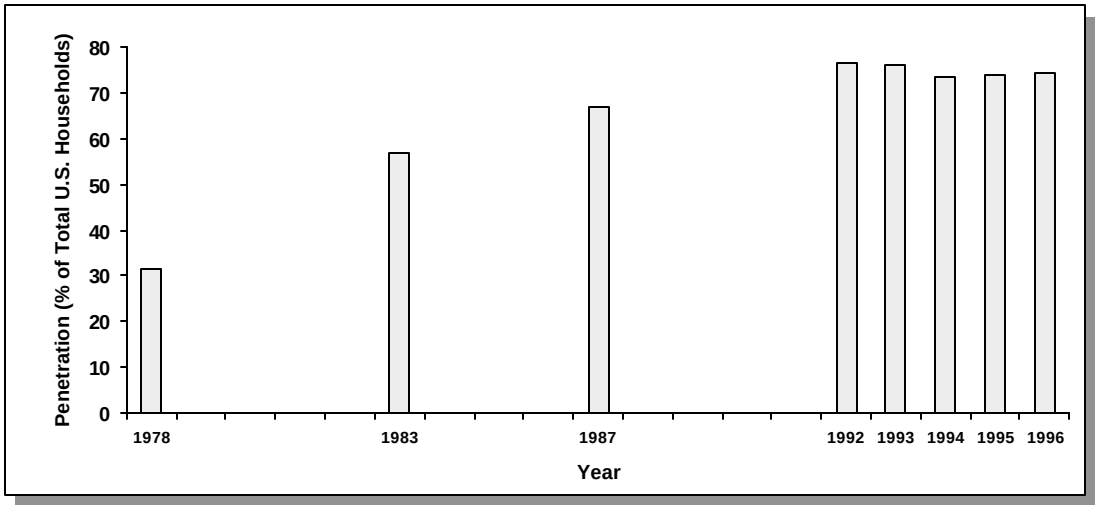
are anticipated, either. Therefore, our projections assume no changes in saturation, operating hours, or power draws through 2010.

Exhibit 7-7: U.S. Shipments for Automatic Coffee Makers



Sources: [Appliance, 1997; p. 39 and Appliance3, 1998; pp. 48, 55]

Exhibit 7-8: U.S. Penetrations for Automatic Coffee Makers



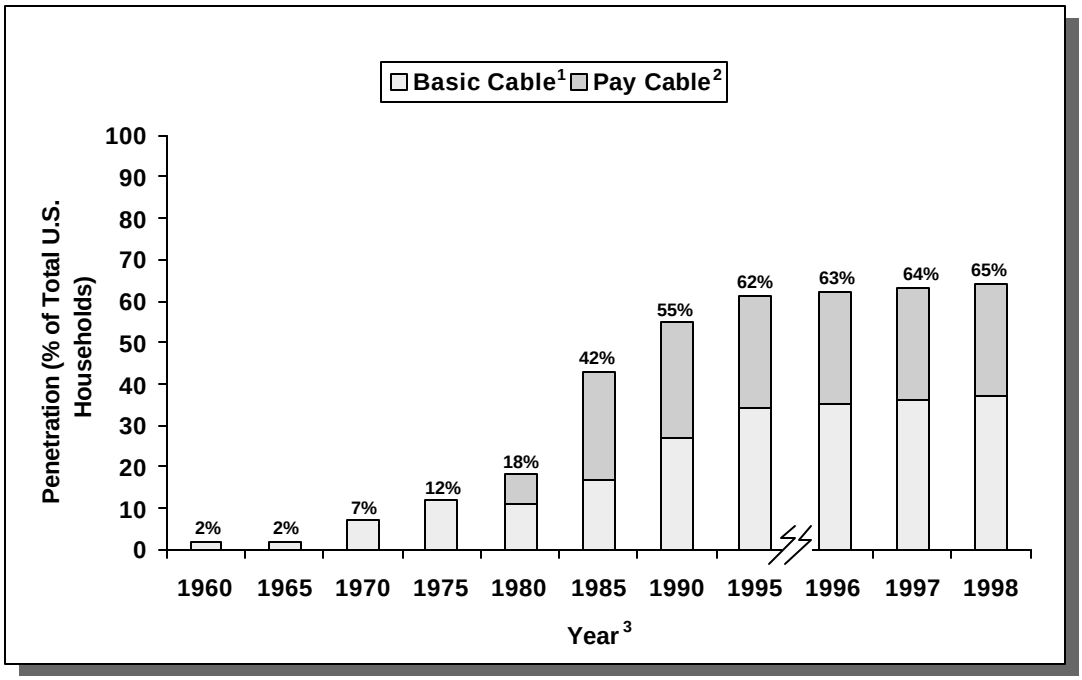
Data not provided by source for years not shown.

Source: [Appliance2, 1997; p. 86]

Cable Box (Electronics)

Exhibit 7-9 shows historical penetration trends. Since 1995, the penetration of cable television has increased about 1.5% per year, while the penetration of pay cable has remained relatively constant. As noted in Section 6.3, however, there are inconsistencies among sources as to the penetration of pay cable, and uncertainties as to how the penetration of pay cable correlates with the saturation of cable boxes. Another source reports that viewing time (hours per person per year) of "premium channels" remained about constant from 1991 to 1996 (-0.2% compound annual growth), but projects 4.1% compound annual increased in viewing time between 1996 and 2001 [Veronis, 1997; p. 36]. However, increases in viewing time can result from some combination of a) increased viewing hours in households already having premium channel and b) increased number of households subscribing to premium channels. No projections were available for the post-2001 time period.

Exhibit 7-9: U.S. Cable Television Penetration Trends



1) Basic cable includes regular cable service, which a price is paid for a standard set of channels. A cable box is not necessary.

2) Pay cable includes premium channels, and/or Pay Per View service. The use of a cable box is necessary.

3) Penetration is given for month of January in each year except for 1970 and 1975 where September is used.

See Appendix C for tabulated data
Source: [MD-TVD, 1998]

Based on the above, we assumed the following saturation trends:

- 4% annual growth in cable box saturation between 1997 and 2000;
- 2% annual growth between 2000 and 2005; and
- 1% annual growth between 2005 and 2010.

These assumptions are somewhat uncertain, however, given the discrepancies between projections and historical trends.

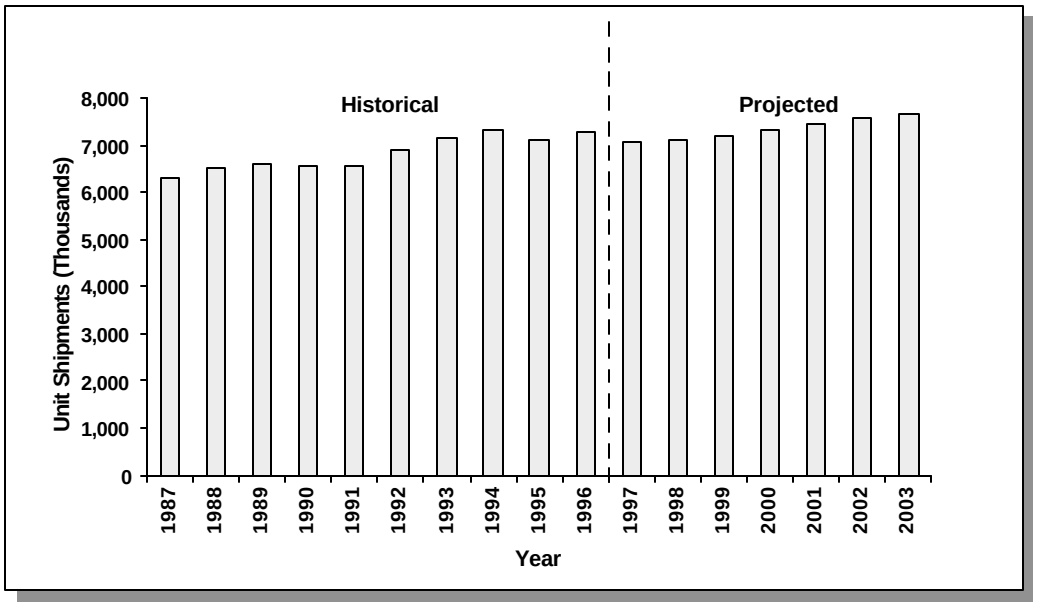
We assumed that operating hours would be the same as for color television (see discussion under Color Television). We assumed no change in power draws.

Clothes Washer (White Goods)

Exhibit 7-10 and Exhibit 7-11 show shipment trends and historical penetrations, respectively. Both penetrations and shipments increased by about 1.5% annually between 1992 and 1996[1]. Shipments are also projected to increase by 1.5% annually between 1997 and 2003. These trends are consistent with the forecast growth in number of households. Therefore, we assumed that the projected growth in number of households will reflect the increase in number of clothes washers, with no change in saturation. We assumed this trend will continue through 2010, although no projections beyond 2003 are available.

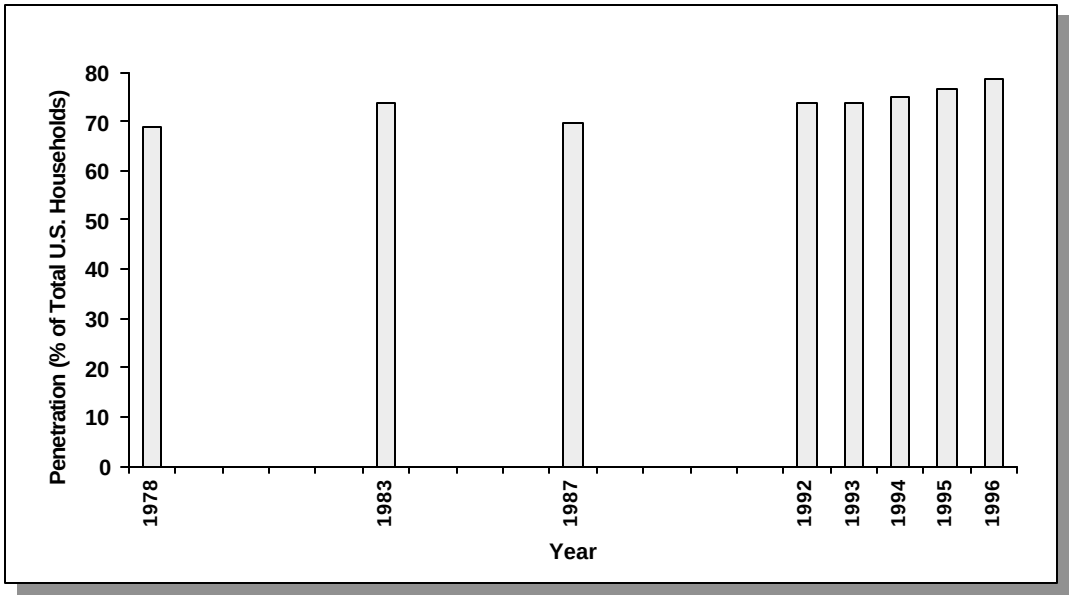
Exhibit 7-10: U.S. Shipments for Clothes Washers

[1]Normally, one would not expect the growth in shipments to equal the growth in penetration, given that the number of households also increased. However, the time period here is short enough that such anomalies can be expected.



Source: [Appliance, 1997; p. 37 and Appliance3, 1998; pp. 46, 53]

Exhibit 7-11: U.S. Penetrations for Clothes Washers



Source: [Appliance2, 1997; p. 86]

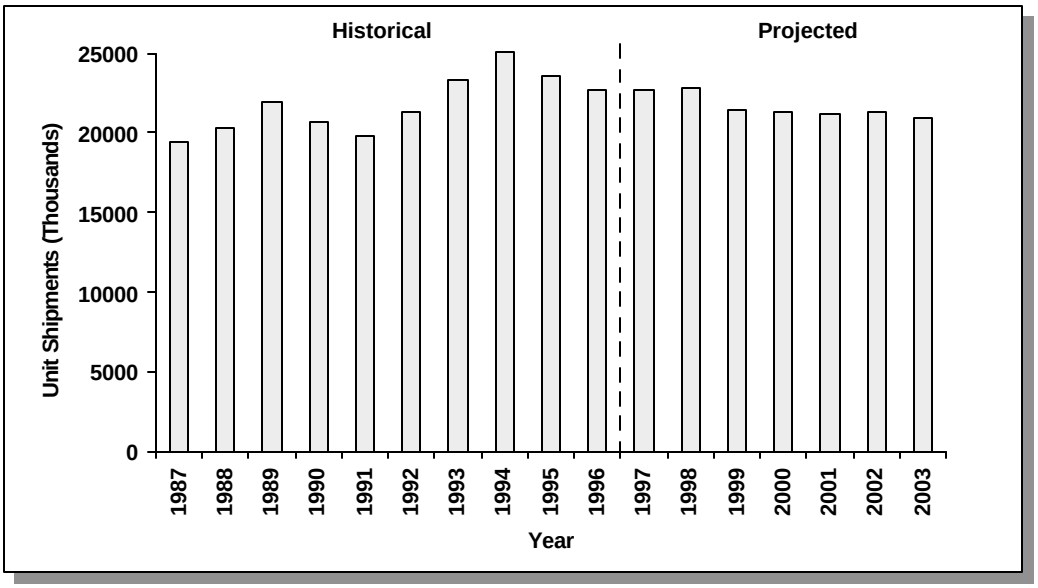
Significant technology developments are taking place in the residential clothes washer industry. New, horizontal-axis washers have been introduced to the market, and significant transformation of the market is expected over the next several years. While horizontal-axis clothes washers save energy, they do so largely through reducing the amount of water used. Since our investigation includes only mechanical energy (as discussed in Section 6.1), we have assumed no change in energy consumption due to technology change. While some recently introduced products have stand-by losses, we assumed they will not achieve large market penetration by 2010. We have assumed no change in usage patterns (number of cycles per year) as well.

Color Television (Electronics)

Trends are shown in the following exhibits:

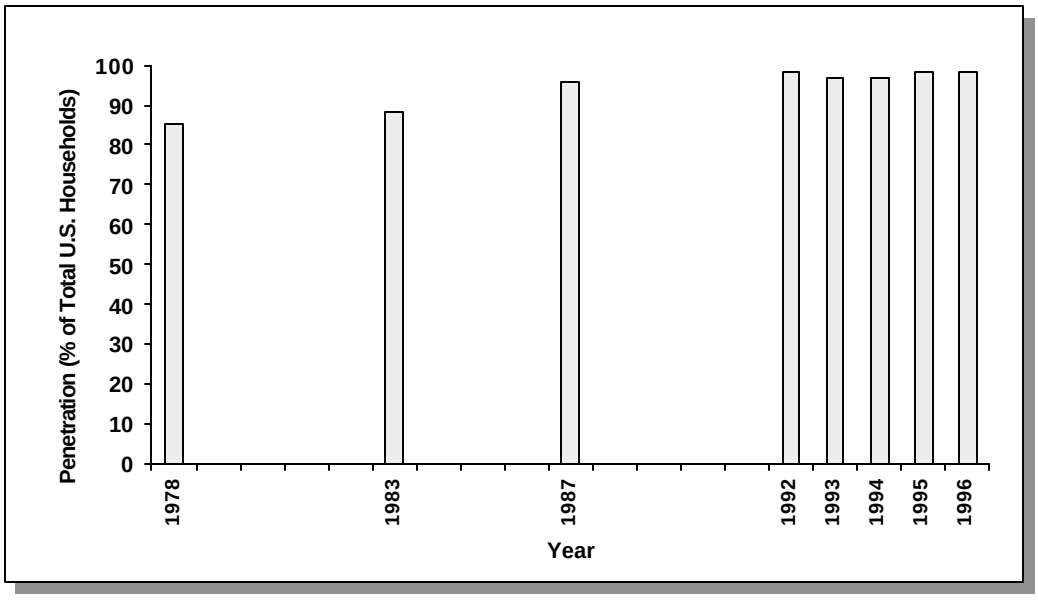
- Exhibit 7-12: Historical and projected shipments;
- Exhibit 7-13: Historical penetrations;
- Exhibit 7-14: Viewing trends; and
- Exhibit 7-15: Number of sets per household

Exhibit 7-12: U.S. Shipments for Color Televisions



Source: [Appliance, 1997; p. 38 and Appliance3, 1998; pp. 52, 58]

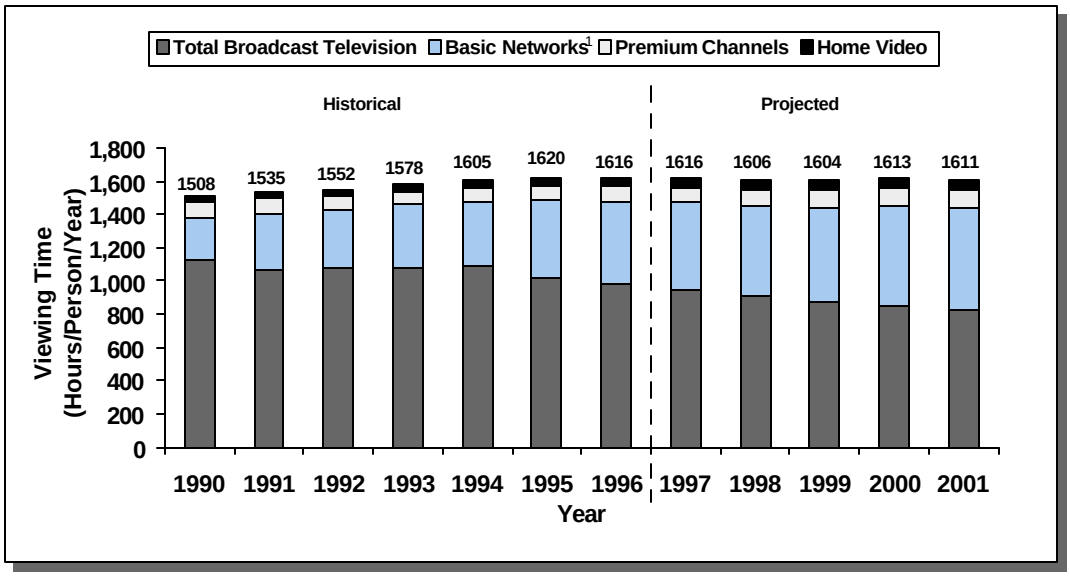
Exhibit 7-13: U.S. Penetrations for Color Televisions



There is a significant difference between color television “penetration” and “saturation”, since the typical household has multiple televisions.

Source: [Appliance2, 1997; p. 87]

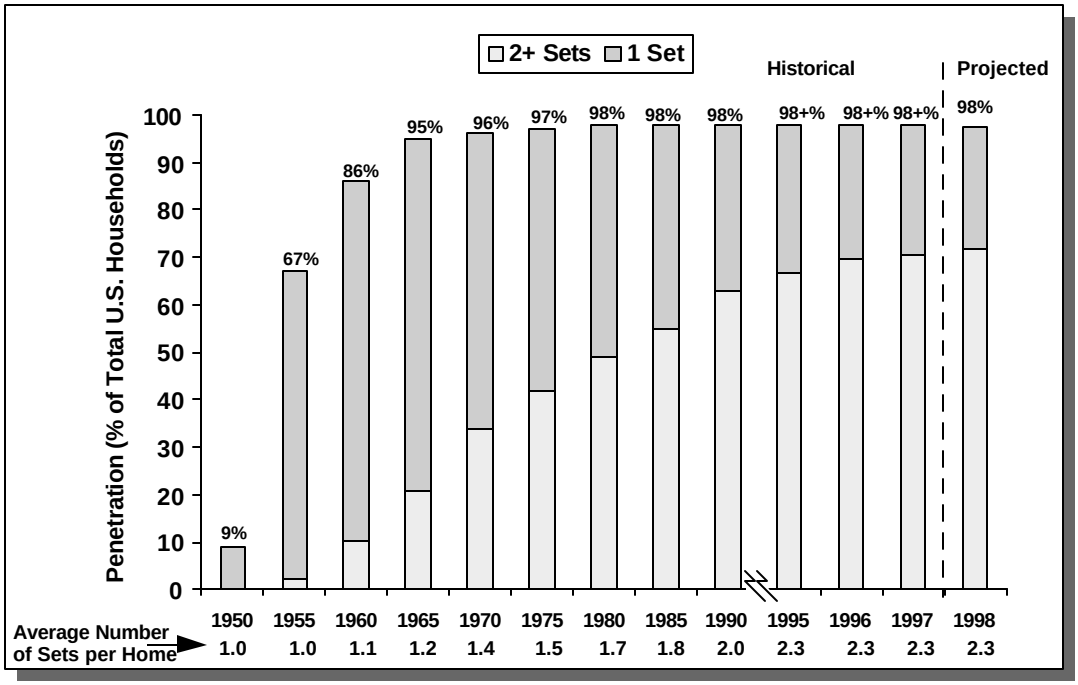
Exhibit 7-14: U.S. Television Viewing Trends



1) Includes TBS beginning in 1992

Data is tabulated in Appendix C
Source: [Veronis, 1997; pp. 34-35]

Exhibit 7-15: U.S. Television Penetration Trends



1) Penetration is given for month of January of each year, except for 1970 and 1975 where September is used.

Data is tabulated in Appendix C.
Source: [MD-TVD, 1998]

Shipments are projected to decrease by about 1.3% annually between 1997 and 2003. Penetration of televisions has been fairly steady for at least four years at over 98%.

Exhibit 7-15 indicates that saturation has been steady (225%) for four years. We assumed that, at 225%, saturation of color television has plateaued, and our projections are based on no increase in saturation through 2010.

Viewing time per person (Exhibit 7-14) is projected to decrease slightly from 1996 to 2001 (with an average annual growth rate of -0.2%). We assumed that this rate of decrease corresponds to a similar decrease in operating hours, and that it will continue through 2005. We assumed no further decrease in operating hours between 2005 and 2010.

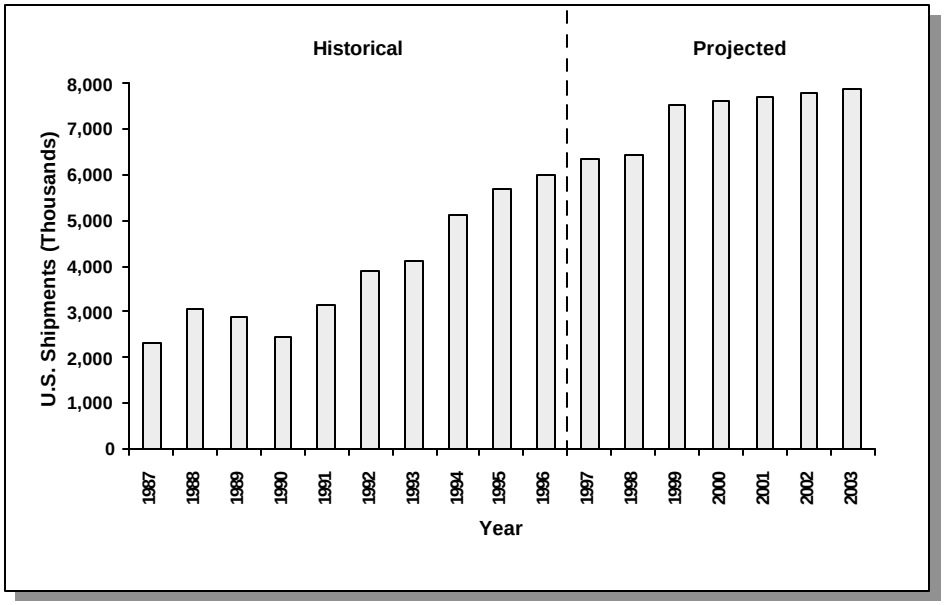
While television screen sizes are increasing, the trend in operating power draw is not clear. Increasing screen size tends to increase operating power draw, but technology improvements are offsetting these increases. We assumed no change in operating-mode power draw through 2010. Manufacturers are working to reduce stand-by losses to under one watt [Sylvan, 1998]. Some major manufacturers already offer products having stand-by losses between one and two watts. We assumed that color television stand-by losses drop gradually through 2010 (to account for time required for newer products to penetrate the existing stock) as follows:

- 1997: 4 W stand by (from Exhibit 6-8);
- 2000: 4 W stand by;
- 2005: 2 W stand by; and
- 2010: 1 W stand by.

Compact Audio System (Electronics)

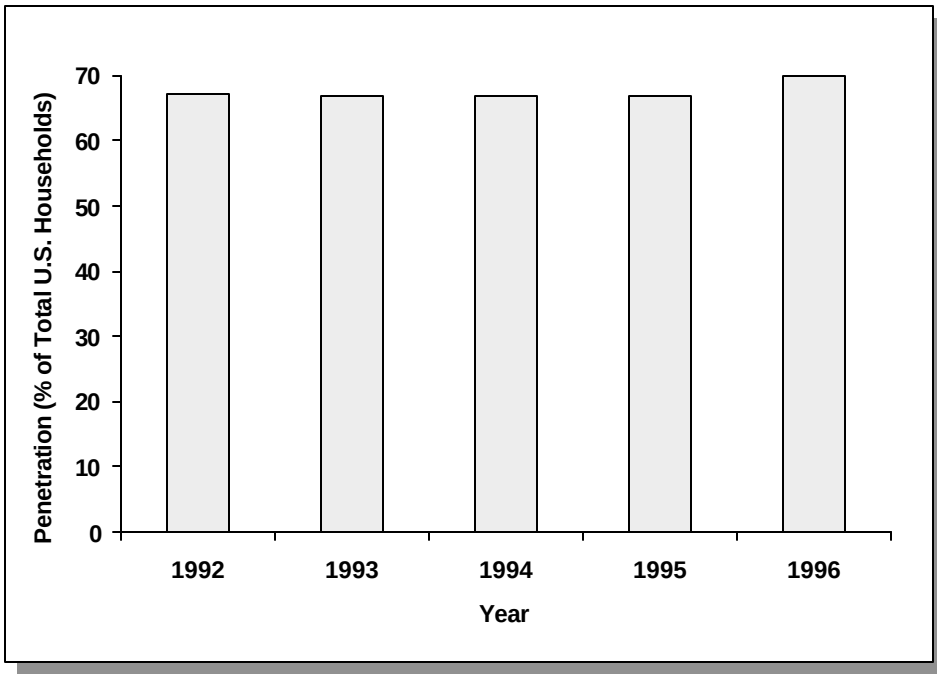
Exhibits 7-16 and 7-17 indicate shipment trends and penetration history, respectively. Between 1992 and 1996 shipments increased over 10% annually, but the growth rate is slowing. Between 2000 and 2003, shipment growth is projected to be only 1.2% annually.

Exhibit 7-16: U.S. Shipments for Compact Audio Systems



Source: [Appliance,1997; p. 38 and Appliance3, 1998; pp. 52, 53]

Exhibit 7-17: U.S. Penetrations for Compact Audio Systems

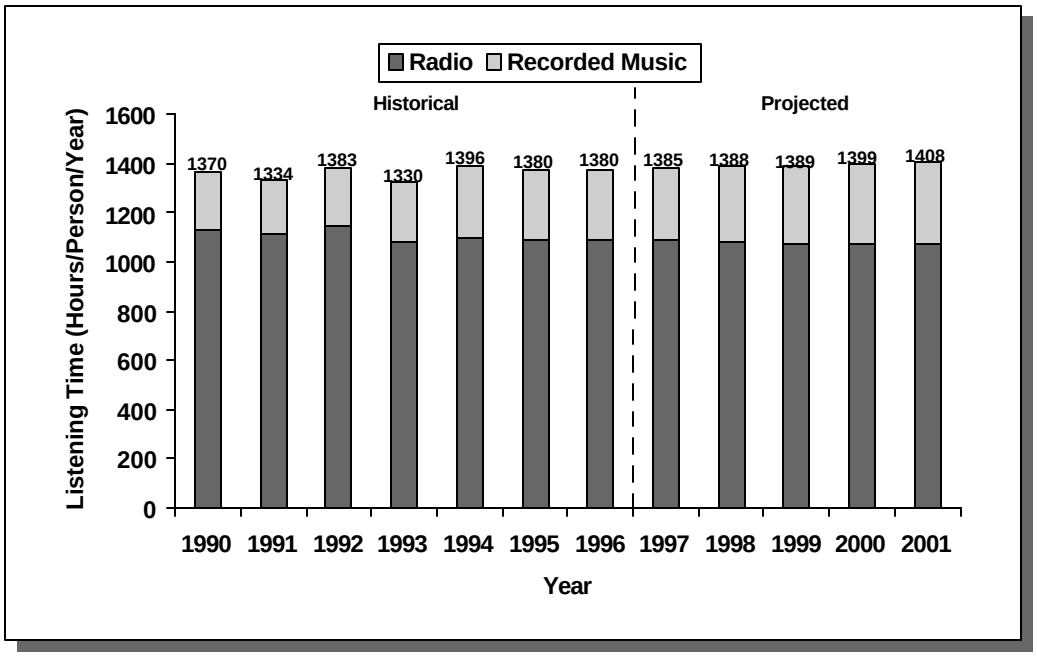


The 1997 saturation used in Exhibit 6-9 is lower than suggested by this source.
Source: [Appliance2,1997; p. 87]

Exhibit 7-18 shows radio and recorded music listening trends and projections. Unfortunately, these data include other types of equipment such as automobile radio and audio systems and

RACK audio systems, but we have assumed that they are indicative of trends for compact audio systems. These data suggest little change is expected in radio and recorded music listening time per person per year through 2001. (Recorded music listening time increases some, but largely at the expense of reduced radio listening time.)

Exhibit 7-18: U.S. Radio and Recorded Music Listening Trends



Radio and recorded music listening time includes listening outside the home (such as in automobiles) automobiles.

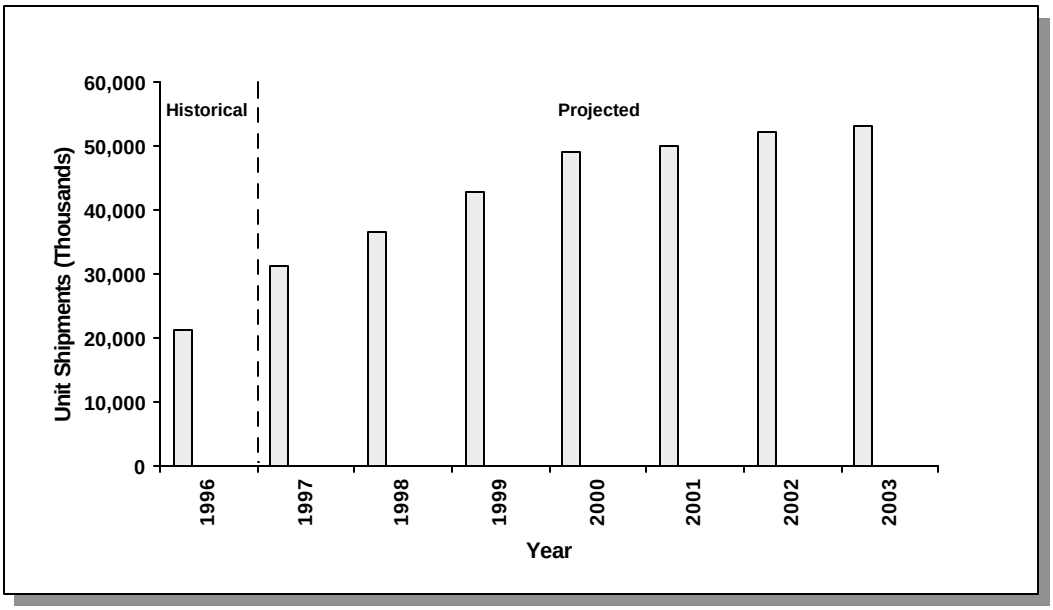
See Appendix C for tabular data
Source: [Veronis, 1997; pp. 34-35]

Listening time per person appears to be remaining steady (at least as far as available projections extend into the future). We assumed that saturation will remain constant through 2010. (As shown in Appendix B, we performed a vintaging analysis based on shipment data to project future saturations. We did chose not to use this analysis, however, because the resulting 1997 saturation was inconsistent with other estimates, as noted in Section 6.3). Furthermore, we do not anticipate any technology changes that would significantly change the power draw of compact audio systems. Therefore, we have assumed that national energy consumption will grow in proportion to the projected increase in number of households and projected increases in electric generation efficiency.

Computer (Electronics)

Exhibits 7-19 and 7-20 show shipment projections and penetration trends, respectively, for household computers. (Historical shipment data are not shown because available data included only laptop computers.) As noted in Section 6.3, there is a wide range in estimated saturations. In fact, the source for the data in Exhibits 7-19 and 7-20 (Appliance Magazine) has, in our judgment, over estimated penetration of computers in U.S. households. This source also suggests that penetrations will increase from 40 million (about 40%) in 1997 to 70 million (about 70%) by 2000 – an annual increase of about 21% [Appliance, 1998; p. 56]. Another source suggests that the penetration will increase from 42% currently (1998) to 60% by 2000 – an annual increase of about 20% [NPR Broadcast, 1998].

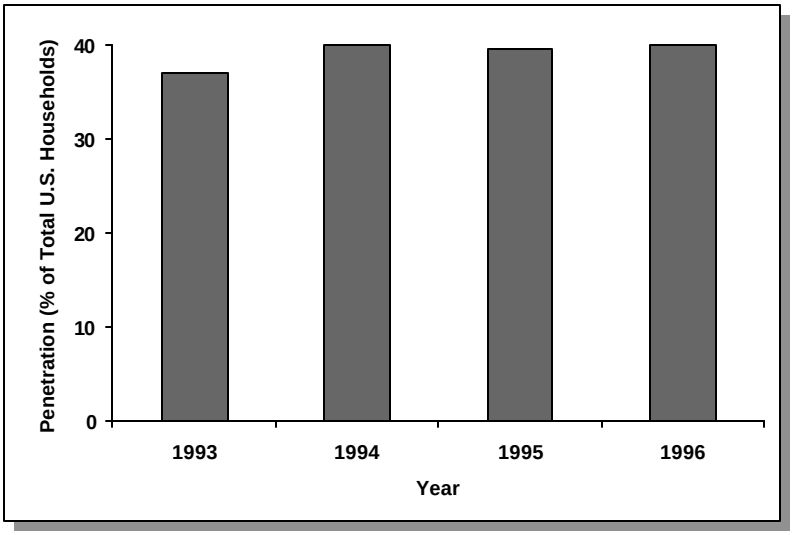
Exhibit 7-19: U.S. Shipments for Computers



Source: [Appliance3, 1998: pp. 52, 58]

Although purchase prices are falling and the Internet is becoming increasingly popular, we suspect some excessive optimism in the projected growth rates. Exhibit 7-20 shows that penetrations of computers increased from 37.0% in 1993 to 40.1% in 1996 – an average annual increase of only about 3%. While these data do not account for multiple computers in a single household, they are probably more representative of future trends than some of the projections cited above. However, to reflect the growing influence of the Internet, we assumed a 6% annual growth in saturation through 2010 (double the historical rate). Starting with 21% saturation in 1997, this would result in 45% saturation by 2010.

Exhibit 7-20: U.S. Penetrations for Computers



The 1997 saturation used in Exhibit 6-9 is significantly lower than suggested by this source.

Source: [Appliance2, 1997; p. 87]

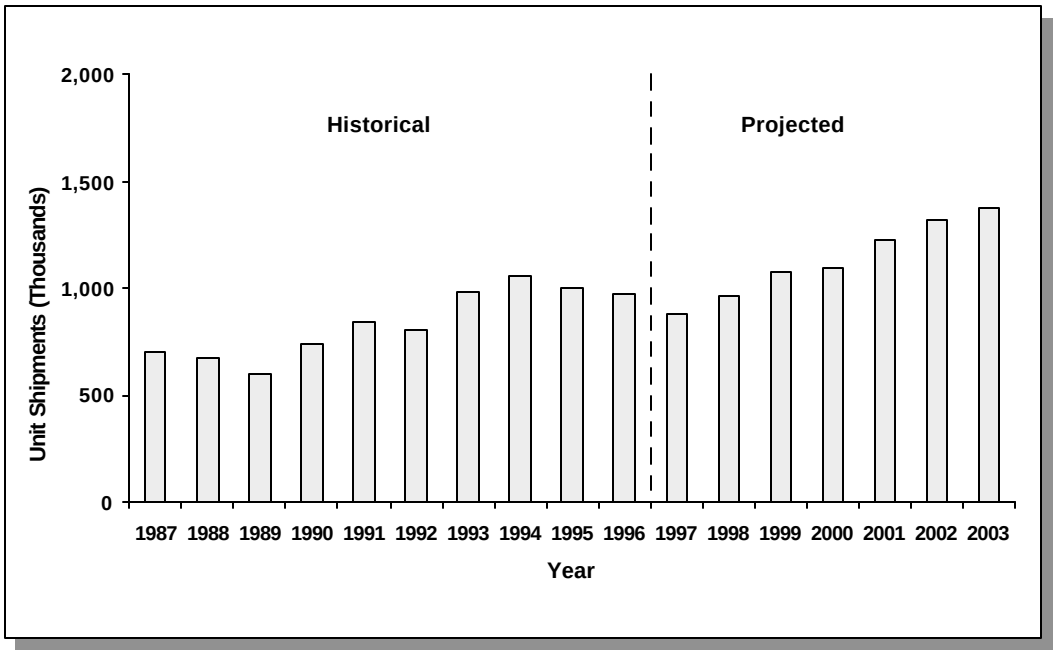
Computer power draw has been decreasing in recent years as a result of technology innovation and voluntary programs such as EPA ENERGY STAR. The motivation, however, for power-draw reductions often has little to do with national energy savings. More often, the drivers are size/cost reduction, reducing cooling requirements, and extending operating periods on portable power supplies. Further power-draw reductions are likely as well. One source estimates that Liquid Crystal Display (LCD) monitors will be much more prevalent in five years [WSJ, 1998]. Another source estimates LCD monitors will draw about 30 W [Fanara, 1998]. We assumed a 5% annual reduction in power draw for the installed based between 1997 and 2010, which would cut in half typical power draws by 2010.

Operating hours are expected to increase as well, as the Internet and video games increase in popularity. One source estimates that per-person time spent playing video games will increase by 7.3% annually between 1996 and 2001, while per-person consumer on-line time will increase by 19.5% annually over the same period [Veronis, Suhler, 1997, p. 37]. However, a significant part of this growth will be due to increased saturation of computers, rather than increased per-person usage. Our projections assume a 5% annual increase in operating hours between 1997 and 2005, but no further increase through 2010.

Dehumidifier (Space Cooling)

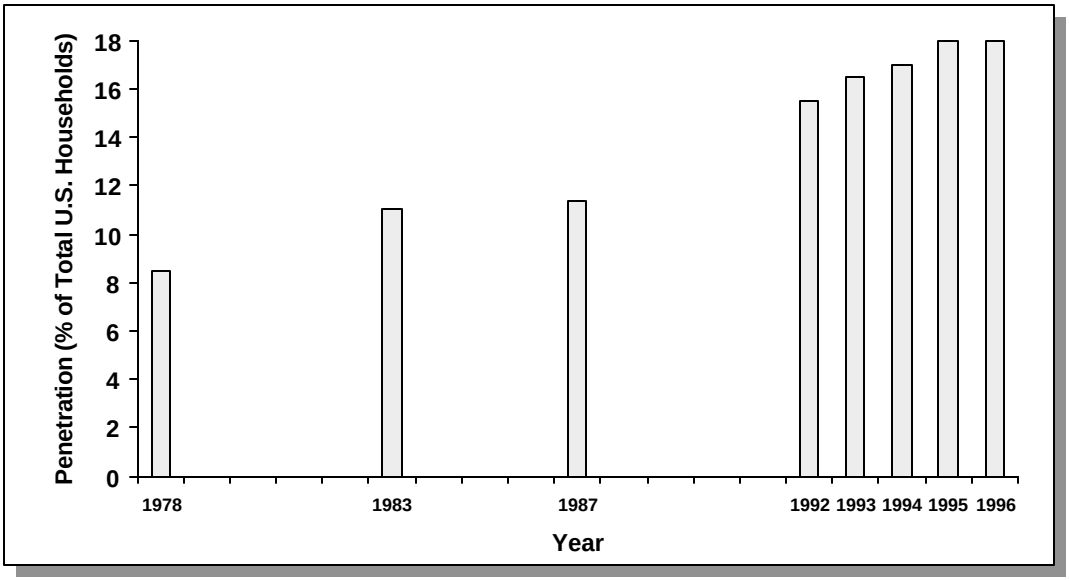
Exhibits 7-21 and 7-22 indicate shipment trends and historical penetrations, respectively. Historically, penetrations have increased at about 2.5% annually (see Appendix B). (For dehumidifiers, penetrations and saturations are probably about the same, assuming few households have multiple dehumidifiers.) Our projections assume a 2.5% annual increase in saturation between 1997 and 2010 – an overall increase in saturation from 11% to 15%.

Exhibit 7-21: U.S. Shipments for Dehumidifiers



Sources: [Appliance, 1997; p.38 and Appliance3, 1998; pp. 47, 54]

Exhibit 7-22: U.S. Penetrations for Dehumidifiers



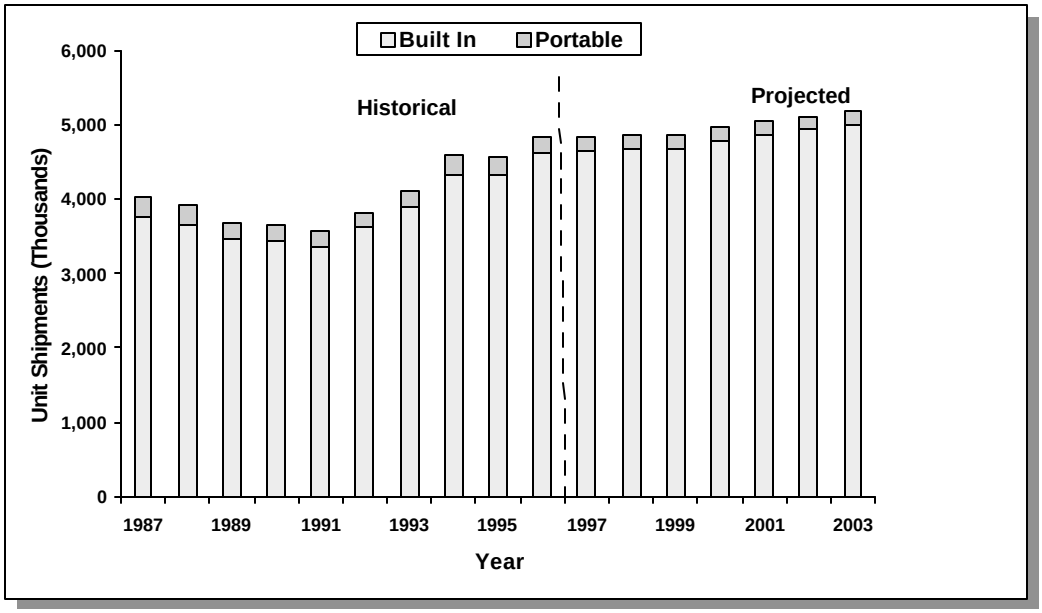
The 1997 saturation used in Exhibit 6-9 is lower than suggested by this source.
Data not provided by this source for years not shown
Source: [Appliance2, 1997; p. 87]

Currently, there is a performance standard in Canada, but none in the U.S. However, many U.S. products meet the Canadian standard, since manufacturers sell products in both countries. We have not attempted to predict possible future standards, and have assumed no change in efficiency in our projections. We have also assumed no change in operating hours.

Dishwasher (White Goods)

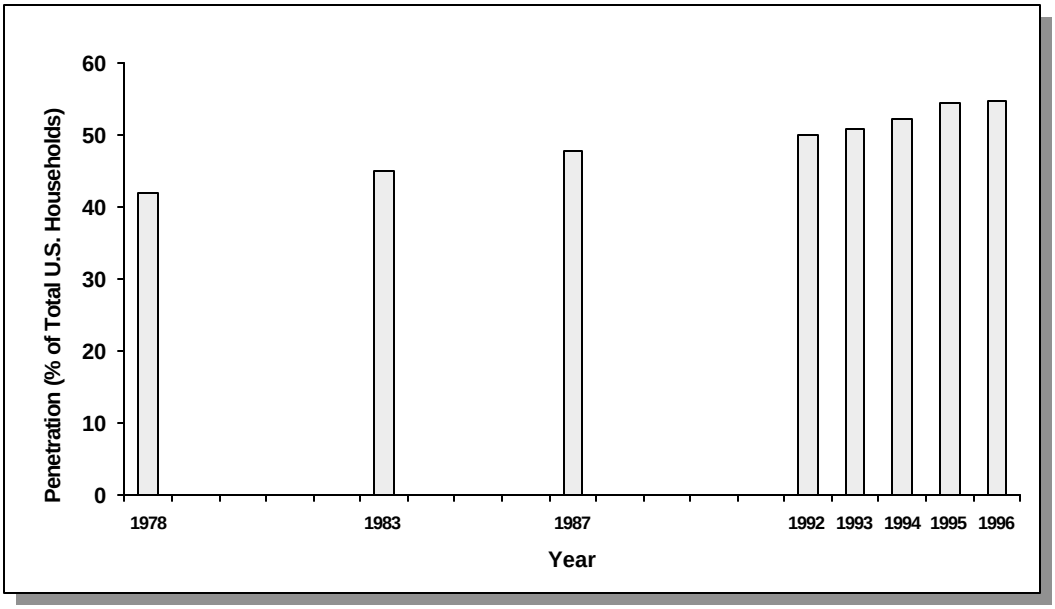
Exhibits 7-23 and 7-24 indicate shipment trends and historical penetrations, respectively. Penetrations have increased by about 1.5% annually (on average) between 1978 and 1996. We assumed that saturations will increase by 1.5% annually from 1997 to 2010, resulting in a saturation increase from about 57% to about 69%. We have assumed that operating hours and energy consumption per cycle will remain the same. While some recently introduced products have stand-by losses, we assumed they will not achieve large market penetration by 2010.

Exhibit 7-23: U.S. Shipments for Dishwashers



Sources: [Appliance, 1997; p. 86 and Appliance3, 1998; pp. 46, 54]

Exhibit 7-24: U.S. Penetrations for Dishwashers

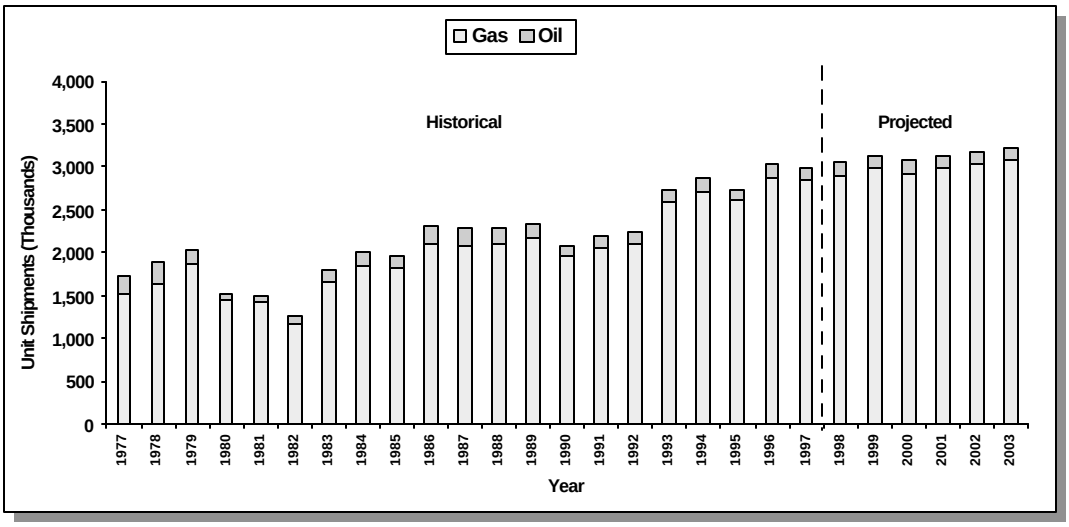


Data not provided by source for years not shown
Source: [Appliance2, 1997; p. 86]

Furnace Fan (Space Heating)

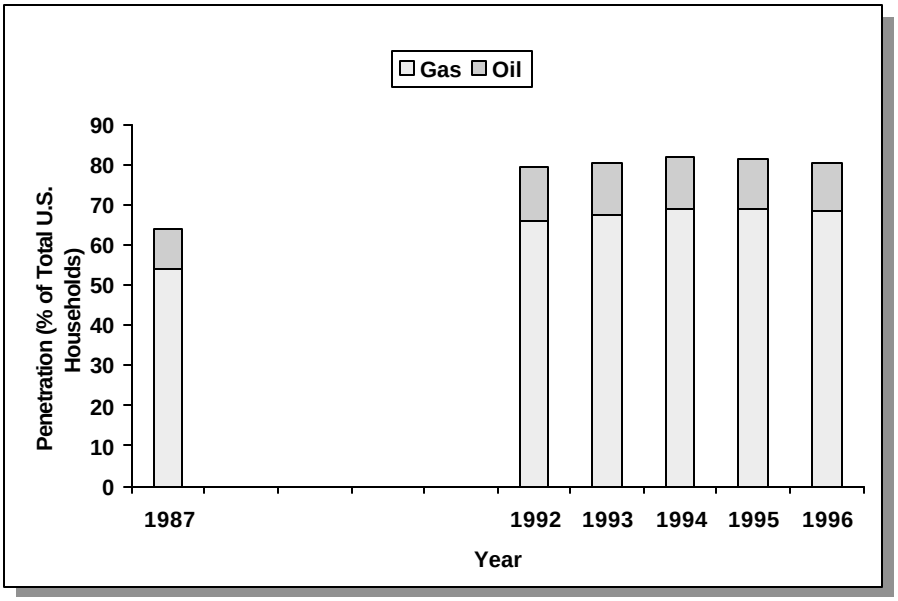
Exhibits 7-25 and 7-26 indicate shipment trends and historical penetrations, respectively, for warm-air central furnaces. Furnace penetrations have increased by an average of 2.6% annually between 1987 and 1996. However, the growth in penetration was very small between 1993 and 1996. Shipments are projected to increase by 1.2% annually between 1997 and 2003 – a trend consistent with the growth in U.S. households. We assumed no increase in furnace fan saturation between 1997 and 2010. We also assumed no change in power draw or operating hours in this time period.

Exhibit 7-25: U.S. Shipments for Central, Warm-Air Furnaces



Gas furnaces include natural gas and LPG.
Electric furnace shipments have been excluded.
Sources: [GAMA, 1986; GAMA, 1994; and GAMA; 1997]

Exhibit 7-26: U.S. Penetrations for Central, Warm-Air Furnaces

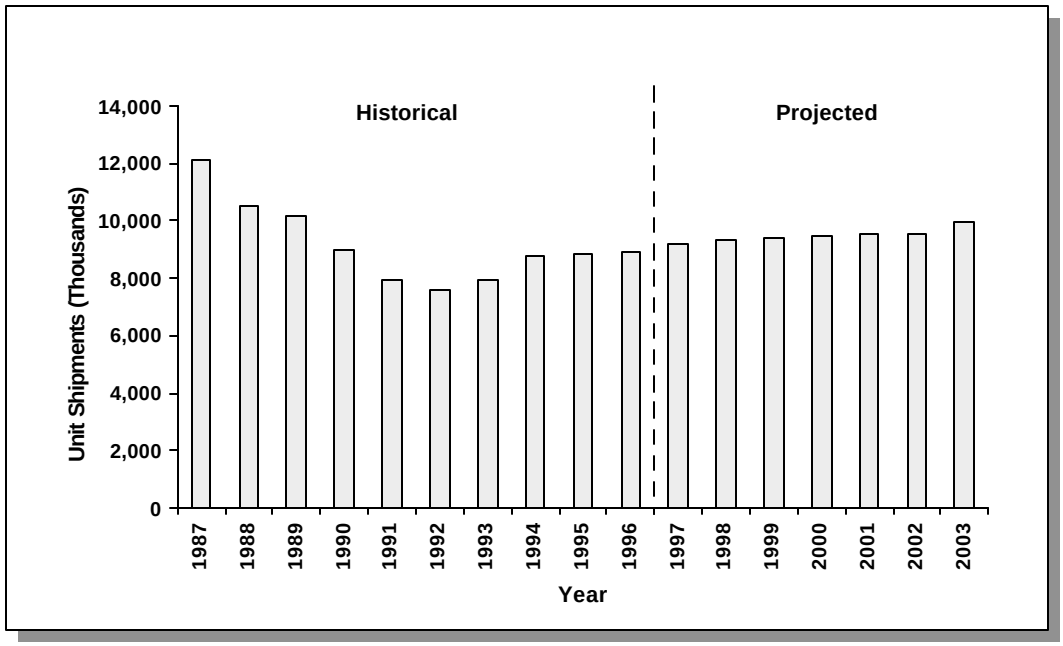


Electric furnaces have been excluded.
Gas furnaces include natural gas and LPG.
The 1997 saturation used in Exhibit 6-9 is lower than suggested by this source.
Data not provided by this source for years not shown
Source: [Appliance2, 1997; p. 86]

Microwave Oven (Cooking)

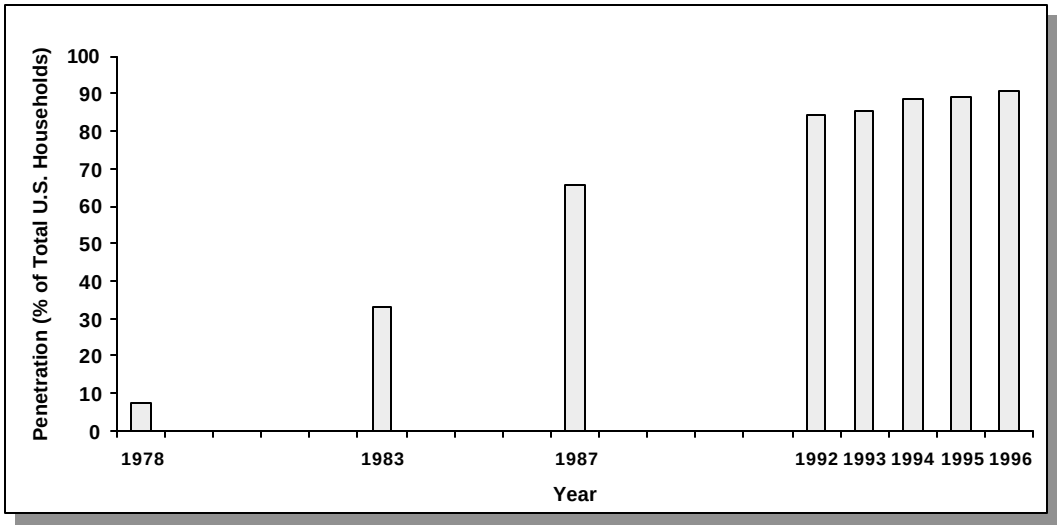
Exhibits 7-27 and 7-28 indicate the shipment trends and penetration histories for microwave ovens. Exhibit 7-28 indicates the microwave ovens have penetrated over 90% of U.S. households. It's clear that saturation levels are very nearly stabilized and, therefore, we assumed only a modest increase in saturation between 1997 and 2000 (0.5% annually), which would result in a saturation of about 91% in 2000. We assumed no additional increase through 2010.

Exhibit 7-27: U.S. Shipments for Microwave Ovens



Excludes combination ranges and microwave/convection
Sources: [Appliance, 1998; p. 37 and Appliance3, 1998; pp. 46, 53]

Exhibit 7-28: U.S. Penetrations for Microwave Ovens



Data not provided by this source for years not shown
Source: [Appliance2, 1997; p. 86]

Power draws for microwave ovens have remained relatively constant for many years – higher-end models typically draw as much power as a 15-amp household circuit will allow. Magnetron

efficiency has steadily improved, however, which effects shorter cooking times (and, hence, lower operating hours) for newer models. We assumed power draws will remain constant through 2010. We assumed operating hours, however, will decrease as the more efficient models saturate the inventory. We used a forward-stepping vintaging analysis to predict how operating hours will change (see Appendix B). The results of the vintaging analysis indicate that operating hours will decrease from 72 hours/year in 1997 to about 56 hours/year in 2010.

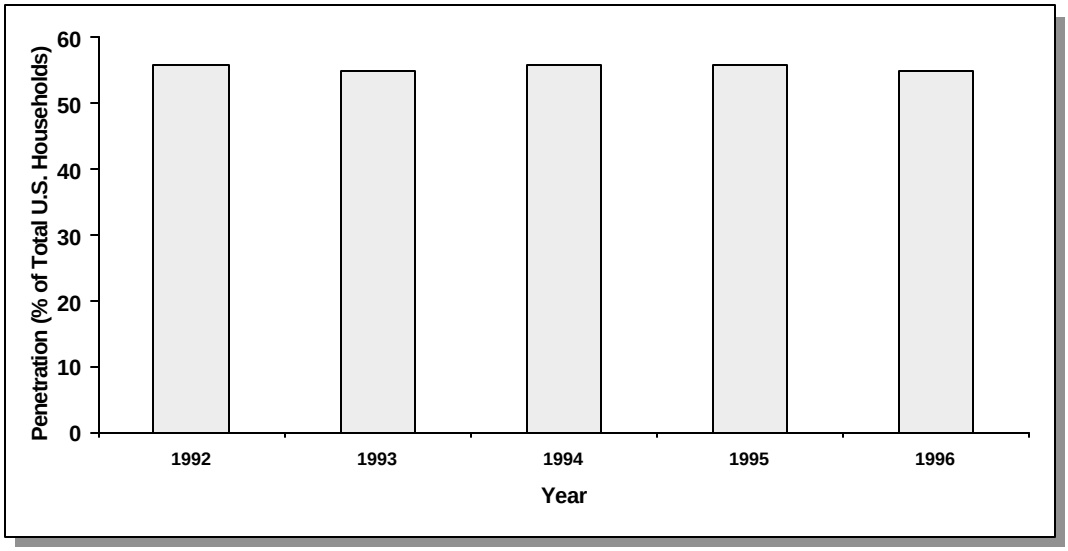
Pool Pump (Motor)

We assumed swimming pool saturation will remain at 5% through 2010. We also assumed that pool-pump power draw and operating hours will not change significantly through 2010.

RACK Audio System (Electronics)

Exhibit 7-29 shows the penetration history. (Shipment data are not available, as RACK audio systems are sold by individual components.) These data indicate that penetration has been stable for several years. We assumed saturation levels will remain at 55% through 2010. For the reasons similar to those discussed previously for compact audio systems, we assumed no change in listening time and power draw for RACK audio systems.

Exhibit 7-29: U.S. Penetrations for RACK Audio Systems



Source: [Appliance2, 1997; p. 87]

Torchiere Lamp – Halogen

As indicated in Exhibit 6-9, current saturation is estimated at 35%. The future of torchiere lamps is, however, very uncertain. Due to their very low cost, the market has grown rapidly (especially in college dormitory rooms). However, the halogen bulbs operate at a sufficiently high temperature to present a fire hazard. Currently, at least 189 fires have been blamed on these lamps [Calwell, 1998]. Some colleges and universities have banned the lamps in dormitories and

many others are considering a ban [ECOS, 1998]. The Consumer Product Safety Commission (CPSC) has done little to date towards a product ban. CPSC did, however, issue a voluntary manufacturer recall for repair in September 1997. Manufacturers provided a metal guard to keep flammable materials from contacting the bulb. However, one source estimates that fewer than 20% of torchiere lamps have such a guard [Calwell, 1998]. Litigation concerns may drive manufacturers to discontinue production, but to date there is no evidence to suggest this is happening. Manufacturers are developing torchiere lamps having compact fluorescent bulbs, which will greatly increase energy efficiency (and safety). Even with federal and state government promotional efforts, it is difficult to predict whether such a product can overcome the appeal of low first cost associated with the halogen-lamp products.

There are large uncertainties associated with the future of this product. The saturation levels could continue to grow, or they could drop. We assumed that saturation levels will remain at about 35% through 2010. Also, we assumed no changes in operating time and power draw.

Video Cassette Recorder (Electronics)

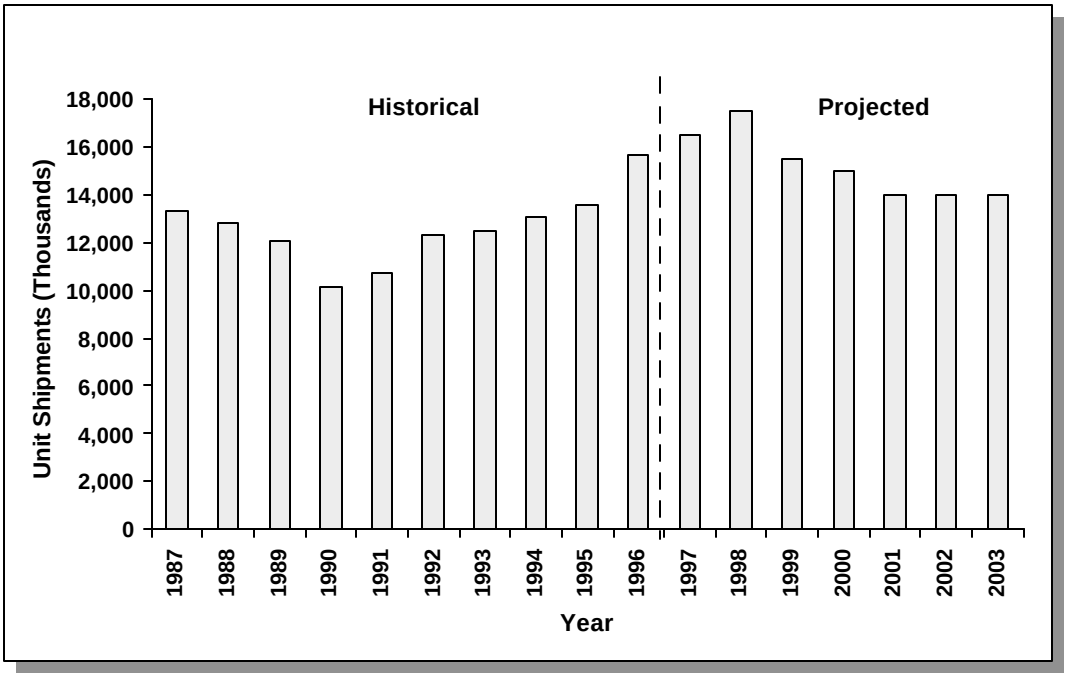
Exhibit 7-30 indicates shipment trends. Exhibits 7-31 and 7-32 show penetration trends, from two different sources. Penetration estimates from the two sources are generally in good agreement. Both indicate a penetration growth of about 2.5% annually for recent years. Shipment forecasts suggest that VCR sales have peaked, but this may be due to the market introduction of digital video disk (DVD) players. For the purposes of our investigation, however, we consider DVD players to be in the same product category as VCRs. In 1997 (the first year of introduction), 360,000 DVD players were sold [NIKKEI, 1998]. This represents only about 2% of the market (with about 98% being VCRs), but the market should grow as the price inevitably drops and the product becomes more popular. Therefore, we suggest that the combined VCR/DVD market will continue to grow. In the short term, we assumed that growth in saturation will be 2.5% annually, but will taper off in future years. Our saturation assumptions are:

- 1997: 121% (per Exhibit 6-2);
- 2000: 130% (2.5% annual saturation increase from 1997 to 2000);
- 2005: 140% (1.5% annual saturation increase from 2000 to 2005); and
- 2010: 148% (1.0% annual saturation increase from 2005 to 2010).

Veronis, Suhler & Associates report that VCR viewing time per person increased 4.1% annually (on average) from 1990 to 1996, and they forecast the same rate of increase through 2001 [Veronis, 1997; p. 37]. (These data are also shown in Exhibit 7-12). These forecasts apply only to viewing of pre-recorded tapes, but we assumed similar increases in viewing of taped television broadcasts and user-produced video tapes. However, these growth trends won't continue indefinitely, so we assumed a realistic flattening with time:

- 1997: 1248/182/78 (on/play/record time in hours/year; from Exhibit 6-8);
- 2000: 1248/195/78[2] (4.1% annual increase in pre recorded "play" time [3] between 1997 and 2000);
- 2005: 1248/207/78 (2% annual increase in pre recorded "play" time between 2000 and 2005; and
- 2010: 1248/207/78 (no increase between 2005 and 2010).

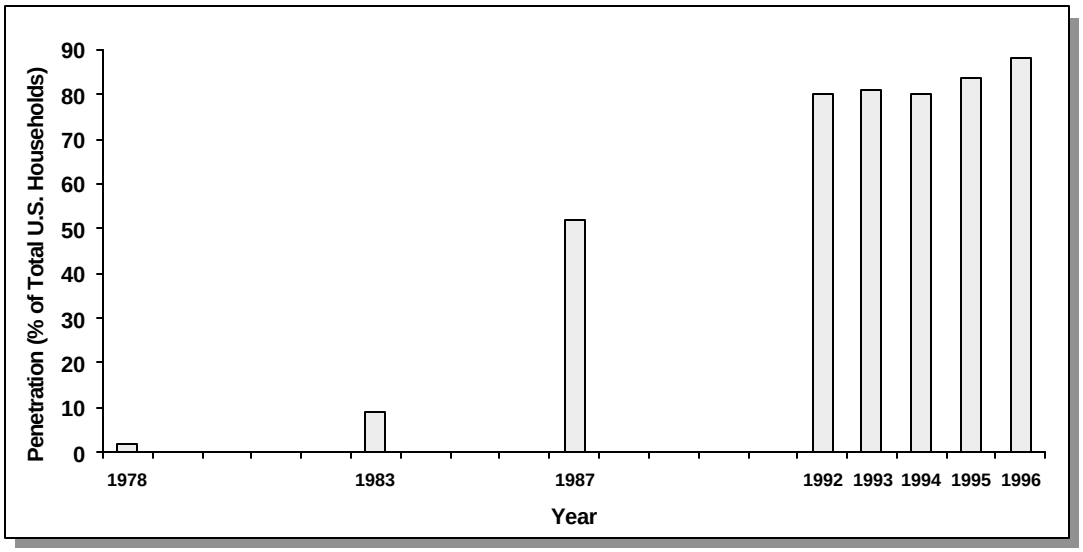
Exhibit 7-30: U.S. Shipments for Video Cassette Recorders



Does not include television/VCR combinations.
Sources: [Appliance, 1997; p. 38 and Appliance3, 1998; pp. 52, 58]

[2] Assumes no increase in VCR "on" and "record" times, since these are normally associated with television viewing.
[3] Assumes that the 182 hours of "play" time includes 78 hours of non-pre-recorded viewing, which is assumed not to increase.

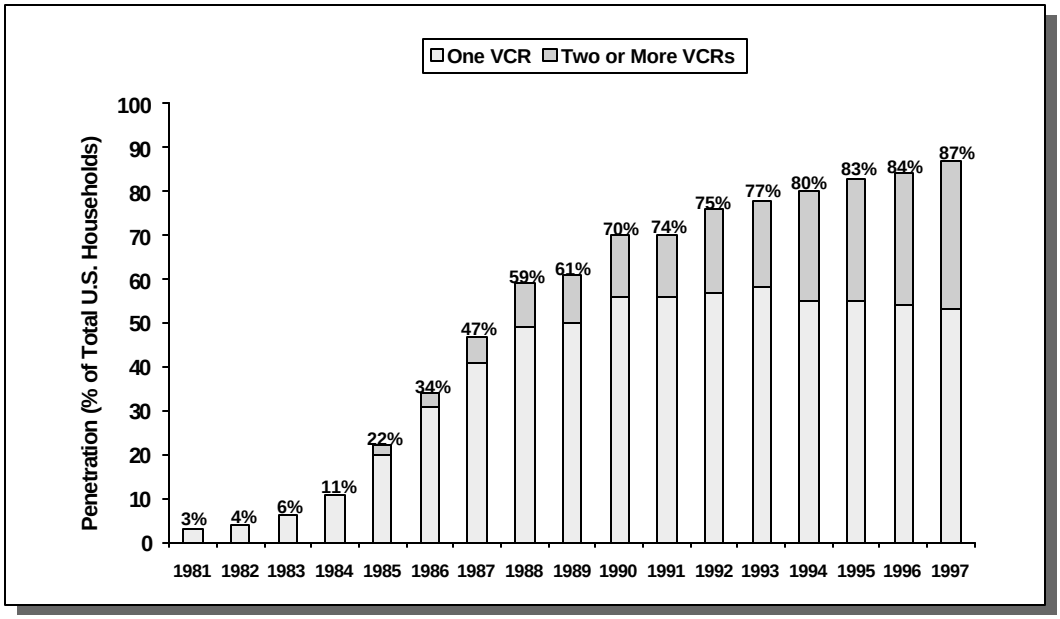
Exhibit 7-31: U.S. Penetrations for Video Cassette Recorders



There is a significant difference between VCR "penetration" and "saturation", since many households have multiple VCRs.
Data not provided by source for years not shown

Source: [Appliance2, 1997; p. 87]

Exhibit 7-32: U.S. VCR Penetration Trends



See Appendix C for tabular data
Source: [MD-TVD, 1998]

We assumed no change in operating power draw through 2010. Manufacturers are working to reduce stand-by losses to between one and two watts [Sylvania, 1998]. Some major manufacturers already offer products having stand-by losses between two and four watts. We assumed that stand-by power draw will drop with time in a manner similar to color television (see previous discussion), resulting in projected VCR stand-by draws of:

- 1997: 5.6 W (from Exhibit 6-8);
- 2000: 5.6 W;
- 2005: 2.8 W; and
- 2010: 1.4W.

Waterbed Heater

The Waterbed Council, Inc. was unwilling to disclose shipment data, but two historical data points were found [HE-2 1994; p. 1]:

- 1988 domestic sales (year of peak sales): 3.8 million wholesale units; and
- 1992 domestic sales: 2.5 million wholesale units.

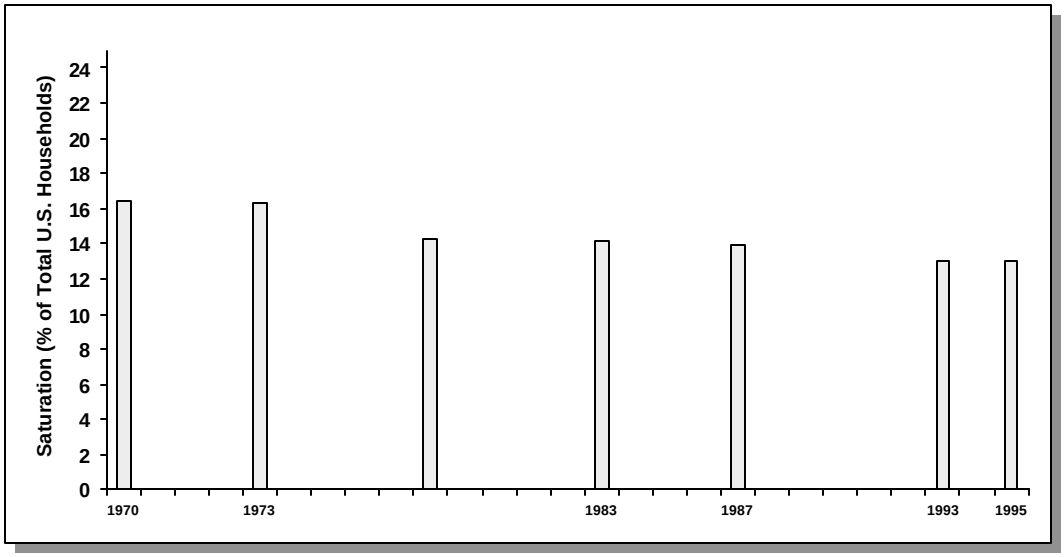
These data indicate almost a 10% average annual decrease in sales between 1988 and 1992. Unfortunately, no published forecasts of shipments or saturations were available. We assumed that saturations of waterbeds would decline by 2% annually through 2005 (resulting in a saturation of about 14% in 2000 and about 13% in 2005), and then stabilize at that level through 2010. There is evidence that waterbeds are becoming more efficient (through improved insulation), but we to quantify this. The impact of improved efficiency would be shorter operating hours.

We assumed no change in power draw and operating hours through 2010. There is, however, evidence that waterbeds are becoming more efficient (through improved insulation), but we did not find data quantifying the improvements. The impact of improved efficiency would be shorter operating hours.

Well Pump (Motor)

Exhibit 7-33 shows the historical stock of well pumps used by U.S. households. These data suggest that the number of well pumps was fairly steady between 1987 and 1995 (the latest year for which data are available). We assumed that the number of installed well pumps will remain the same through 2010. This implies, however, a reduction in the saturation level with time, to offset the growth in number of households. Also, we assumed no changes in power draw and operating time through 2010.

Exhibit 7-33: U.S. Saturations for Well Pumps



Sources: [AHS, 1978; AHS, 1981; AHS, 1987; and AHS, 1993]

8. Comparisons to Other Estimates

Comparisons were made of our energy-consumption estimates to other selected estimates.

We compared our energy-consumption estimates to those from four selected sources:

- LBNL's draft report, Miscellaneous Electricity Use in the U.S. Residential Sector[1] [LBL-40295, 1998];
- EIA Annual Energy Outlook 1997 [EIA/AEO, 1997];
- EIA Annual Energy Outlook 1998 [EIA/AEO, 1998]; and
- EIA Household Energy Consumption and Expenditures [RECS-HECE, 1993].

We did not include comparisons to LBNL's Energy Data Sourcebook for the U.S. Residential Sector [EDSB, 1997] since LBNL's draft report (listed above) supersedes this document.

In many cases, the four sources listed above are not independent – in fact, none of the sources is completely independent of the other sources. However, enough of the estimates for individual end uses are independent so that comparisons are meaningful.

There are some differences in the approaches taken by LBNL and ADL. First, LBNL neglected changes in UECs in future years (relative to 1995), while ADL varied future projections of UECs based on anticipated changes in efficiencies and usage patterns. The resulting differences are most significant for consumer electronics. Second, LBNL utilized a mathematically rigorous approach to forecasting saturations. In most cases, they utilized vintaging analyses based on historical shipment data. While ADL used this approach for a couple end uses, we tended to rely more on applying subjective judgment to observed (and anticipated) qualitative trends when forecasting saturations (as discussed in Section 7). As noted in Section 4, the AEO utilizes a conditional demand analysis to estimate and project national energy consumption. This approach is substantially different relative to either LBNL's and ADL's approach.

Exhibit 8-1 compares power-draw estimates (for the operating mode) from LBNL and ADL. There are significant differences (over 25% relative to ADL) for four of the eleven end uses (for which power-draw estimates were available from LBNL):

- **Automatic Coffeemaker:** LBNL's estimate is 36% higher relative to ADL's. As discussed in Section 6.2, power-draw estimates range from 860 W to 1500 W. ADL selected 1100 W, and LBNL used 1500 W;

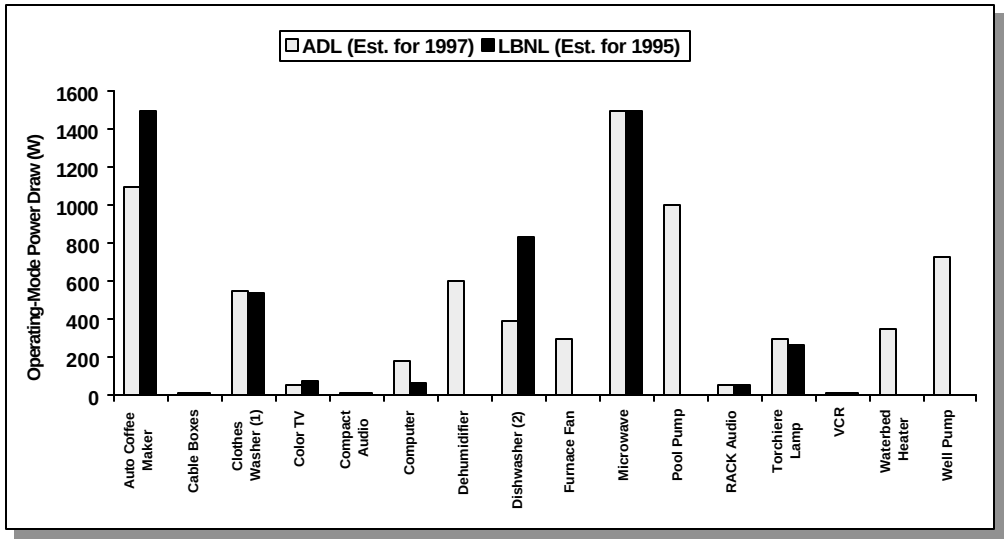
[1] LNBL's draft report projects energy consumption for three scenarios: 1) Predicted Scenario; 2) Low-Growth Scenario; 3) High-Growth scenario. We based comparisons on LBNL's Predicted Scenario.

- **Color Television:** LBNL's estimate is 28% higher relative to ADL's. As noted in Section 6.2, television power draws vary significantly, making typical values difficult to estimate;

- **Computer:** LBNL's estimate is 64% lower relative to ADL's. Power-draw estimates ADL obtained from manufacturers are higher relative to LBNL's estimate; and

- **Dishwasher:** LBNL's estimate is 109% higher relative to ADL's. However, this comparison is not particularly insightful since ADL based estimates on UEC measurements and operating-hour estimates, and then backed out power draw. See discussion below on UEC comparisons.

Exhibit 8-1: Comparison of Power-Draw Estimates by End Use – Operating Mode – Current Data

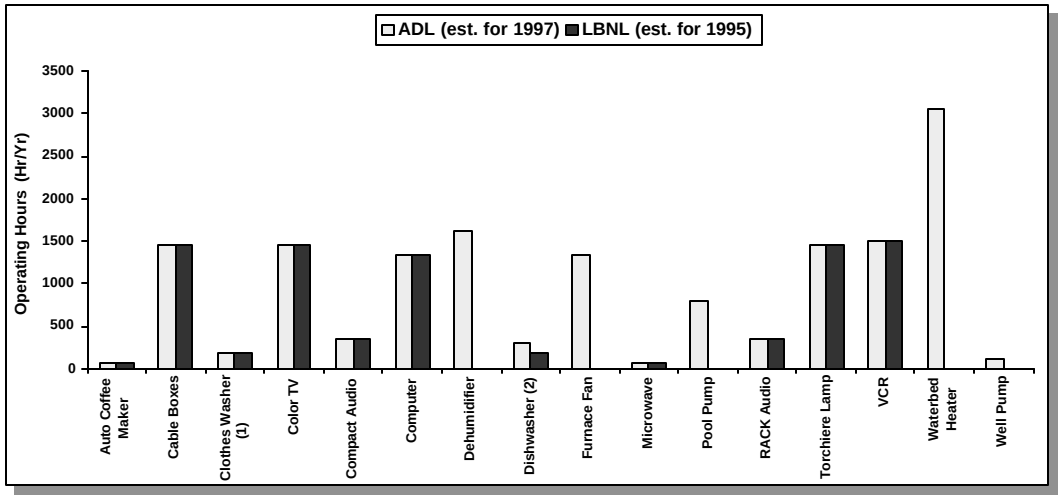


(1) ADL conversion to wattage from 0.267 kWh/cycle by assuming a cycle length of 30 min.
(2) ADL conversion to wattage from 0.322 kWh/cycle by assuming a cycle length of 50 min.

Sources: LBNL (est. for 1995) [LBL-40295, 1998; Appendix B, pp. 1-7],
ADL (est. for 1997) Exhibit 6-8

Exhibit 8-2 compares operating-hour estimates from LBNL and ADL. There are significant differences (over 25% relative to ADL) for one of the eleven end uses (for which operating-hour estimates were available from LBNL). LBNL's estimate for dishwashers is 37% lower relative to ADL's.

Exhibit 8-2: Comparison of Operating-Hour Estimates by End Use – Current Data



(1) ADL data conversion into hr/yr based on 392 cycles/yr and 30 min/cycle.
(2) ADL data conversion into hr/yr based on 365 cycles/yr and 50 min/cycle.

Sources: ADL (est. for 1997) Exhibit 6-8
LBNL (est. for 1995) [LBL-40295, 1998; Appendix B; pp. 1-7]

Exhibit 8-3 compares UEC estimates from LBNL and the RECS to ADL estimates. There are significant differences (over 25% relative to ADL) for nine of the 16 end uses:

- **Automatic Coffeemaker:** LBNL's estimate is 26% higher relative to ADL's, which is traceable to LBNL's higher power-draw estimate (discussed above);

- **Color Television:** The RECS estimate [RECS-HECE, 1993] is 209% higher relative to ADL's, while LBNL's estimate is only 21% higher relative to ADL's;

- **Computer:** LBNL's estimate is 41% lower relative to ADL's, and the RECS estimate is 71% lower relative to ADL's. The difference between LBNL's estimate and ADL's is traceable to the difference in power-draw estimates discussed above;

- **Dehumidifier:** LBNL's estimate is 59% lower relative to ADL's, and the RECS estimate is 62% lower relative to ADL's. The RECS and LBNL did not provide power-draw or operating-hour estimates, making it difficult to trace the sources of the differences;

- **Dishwasher:** LBNL's estimate is 31% higher relative to ADL's, and the RECS estimate is 147% higher relative to ADL's. As discussed in Sect 6.2, ADL used metered data from the ELCAP study [BPA, 1992]. LBNL based their estimate on the baseline

"Standard Water Heating Dishwasher" unit used in the U.S. DOE Appliance Standards Analysis (U.S. DOE 1990);

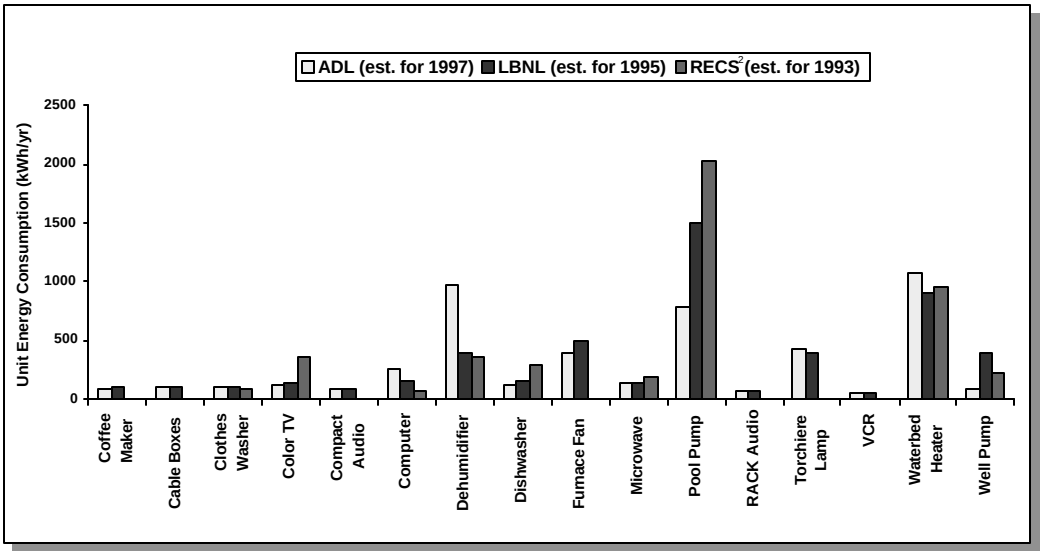
- **Furnace Fan:** LBNL's estimate is 26% higher relative to ADL's. LBNL did not provide power-draw or operating-hour estimates, making it difficult to trace the source of the differences;

- **Microwave Oven:** The RECS estimate is 42% higher relative to ADL's, however, LBNL's estimate is in good agreement with ADL's;

- **Pool Pump:** LBNL's estimate is 90% higher relative to ADL's, and the RECS estimate is 155% higher relative to ADL's. LBNL and the RECS did not provide power-draw or operating-hour estimates, making it difficult to trace the sources of the differences; and

- **Well Pump:** LBNL's estimate is 380% higher relative to ADL's, and the RECS estimate is 173% higher relative to ADL's. As noted in Section 6.2, ADL choose to base its estimates on an engineering analysis, since data are sparse. LBNL and the RECS did not provide power-draw or operating-hour estimates, making it difficult to trace the sources of the differences.

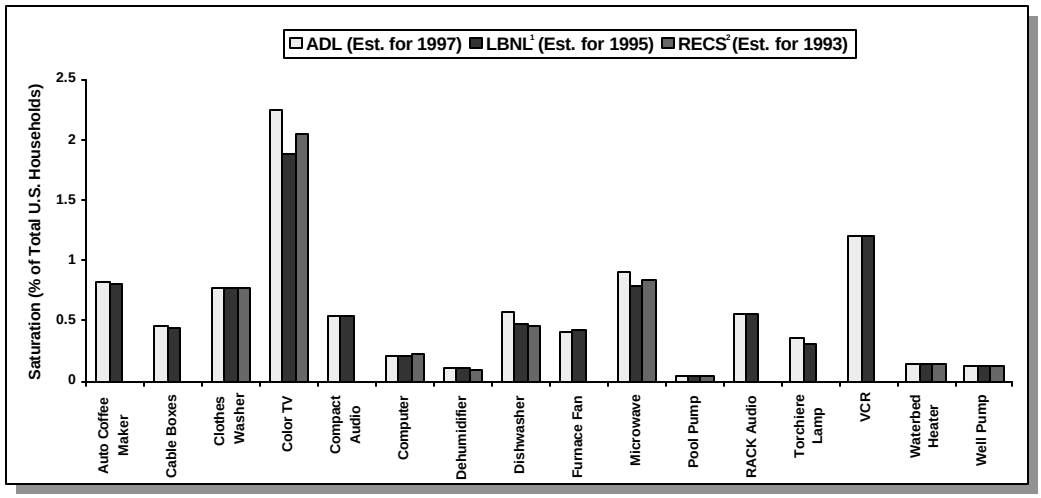
Exhibit 8-3: Comparison of Unit-Energy-Consumption Estimates by End Use – Current Consumption



Sources: ADL (est. for 1997) Exhibit 6-8
LBNL (est. for 1995) [LBL-40295, 1998; Appendix B; pp. 1-7]
RECS (est. for 1993) [RECS-HECE 1993, p. 10]

Exhibit 8-4 compares saturation estimates from LBNL and the RECS to ADL's estimates. All saturation estimates are within 25% of ADL's.

Exhibit 8-4: Comparison of Saturation Estimates by End Use – Current Data



1) 1995 estimate [LBNL-40295, 1998] converted to saturation based on 99.06 million households in 1995. [EIA/AEO, 1998]
2) 1993 estimate [RECS-HECE, 1993] converted to saturation based on 96.6 million households in 1993 [EIA/AEO, 1998]

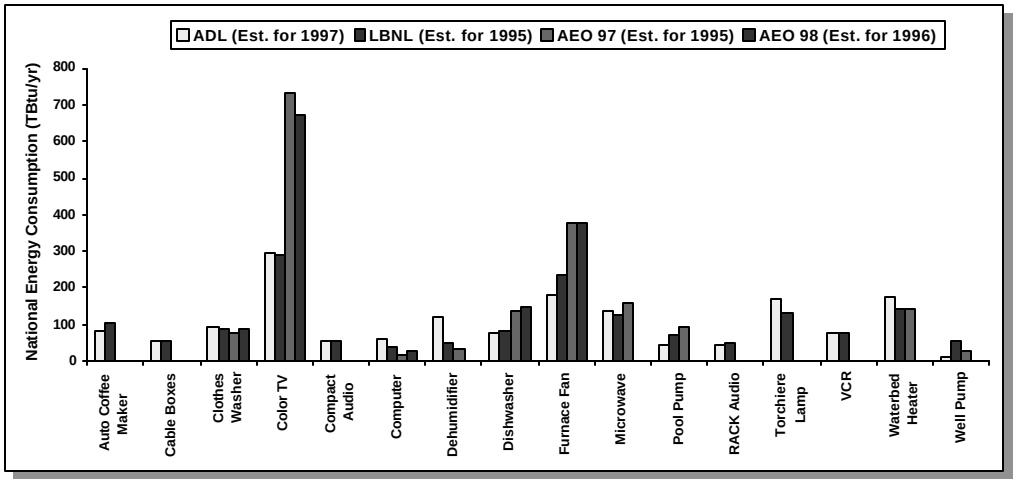
Sources: ADL (est. for 1997) Exhibit 6-8
LBNL (est. for 1995) [LBL-40295, 1998; Appendix B; pp. 1-7]
RECS (est for 1993) [RECS-HECE, 1993]

There are some significant differences in national energy consumption estimates among the sources compared.

There are significant discrepancies (over 25% relative to ADL) in national energy consumption estimates for seven of the 16 end uses (see Exhibit 8-5):

- **Color Television**: The AEO 1997 and AEO 1998 estimates are 150% and 128% higher, respectively, relative to ADL's;
- **Computer**: Other estimates are 41% to 71% lower relative to ADL's;
- **Dehumidifier**: Other estimates are 60% to 71% lower relative to ADL's;
- **Dishwasher**: The AEO 1997 and AEO 1998 estimates are 75% and 94% higher, respectively, relative to ADL's;
- **Furnace Fan**: The AEO 1997 and AEO 1998 estimates are 108% higher relative to ADL's and LBNL's is 29% higher relative to ADL's;
- **Pool Pump**: Other estimates are 60% to 117% higher relative to ADL's; and
- **Well Pump**: Other estimates are 140% to 319% higher relative to ADL's.

Exhibit 8-5: Comparison of National Energy Consumption Estimates by End Use – Current Consumption



Sources: ADL (est. for 1997) Exhibit 6-8
LBNL (est. for 1995) [LBL-40295, 1998; Appendix B; pp. 1-7]
AEO 97 (est. for 1995) [EIA/AEO, 1997 Table A4]
AEO 98 (est. for 1996) [EIA/AEO, 1998 Table A4]

The most significant discrepancies based on absolute energy consumption (more than 100 TBtu/yr difference) are for color televisions and furnace fans. The discrepancies for televisions are traceable to discrepancies in the unit energy consumption estimates. As discussed in Section 6.2, many of the operating-hour estimates available exceeded the plausible range. Also noted in Section 6.2, there is a wide range of estimates for typical television power draw. These factors may contribute to the discrepancies.

EIA estimated the UEC for furnace fans at 404 kWh/year [RECS-HECE 1993, p. 10], which agrees very well with ADL's estimate of 400 kWh/year. The AEO, however, does not provide sufficient detail to explain the discrepancy in national energy consumption for furnace fans.

Exhibit 8-6 summarizes energy-consumption projections from LBNL, AEO 1997, AEO 1998, and ADL. Observations from Exhibit 8-6 include:

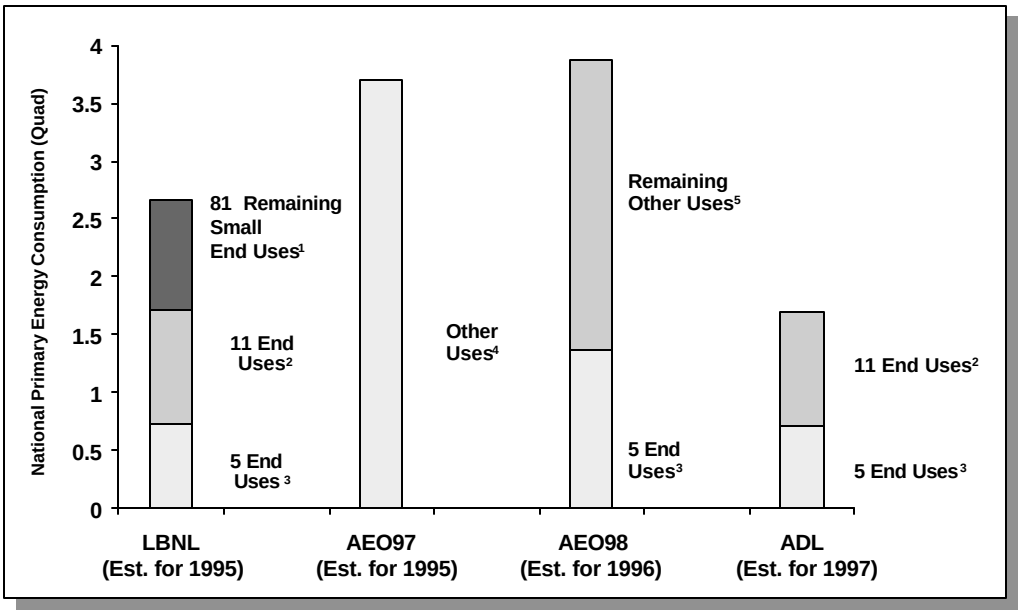
- The LBNL data (first bar in Exhibit 8-6) show that about 65% of the energy consumption is associated with 16 end uses (about 1.7 quad) and only about 35% is in the remaining 81 end uses (about 1.0 quad). Thus, the energy consumption of small residential end uses is represented reasonably well by the group of 16 end uses;

- For the total of 16 end uses evaluated, LBNL's and ADL's consumption estimates are in very good agreement (within 2%); and

- For the total of five end uses (clothes washer, color television, dishwasher, computer, and furnace fan), LBNL's and ADL's consumption estimates are in very good agreement (within 3%), while the AEO 1998 estimate is 86% higher relative to ADL's; and

- The AEO estimates are significantly higher relative to both LBNL and ADL estimates.

Exhibit 8-6: Comparison of National Energy Consumption Estimates for Small Electric End Uses – Current Consumption



1) Remaining of the 97 small end uses investigated by LBNL
2) Includes: Automatic Coffee Maker, Cable Box, Compact Audio, Dehumidifier, Microwave Oven, Pool Pump, RACK Audio, Torchiere Lamp–Halogen, VCR, Waterbed Heater, Well Pump
3) Includes: Clothes Washer, Color TV, Dishwasher, Personal Computer, Furnace Fan
4) As defined in the EIA AEO 1997
5) As defined in the EIA AEO 1998

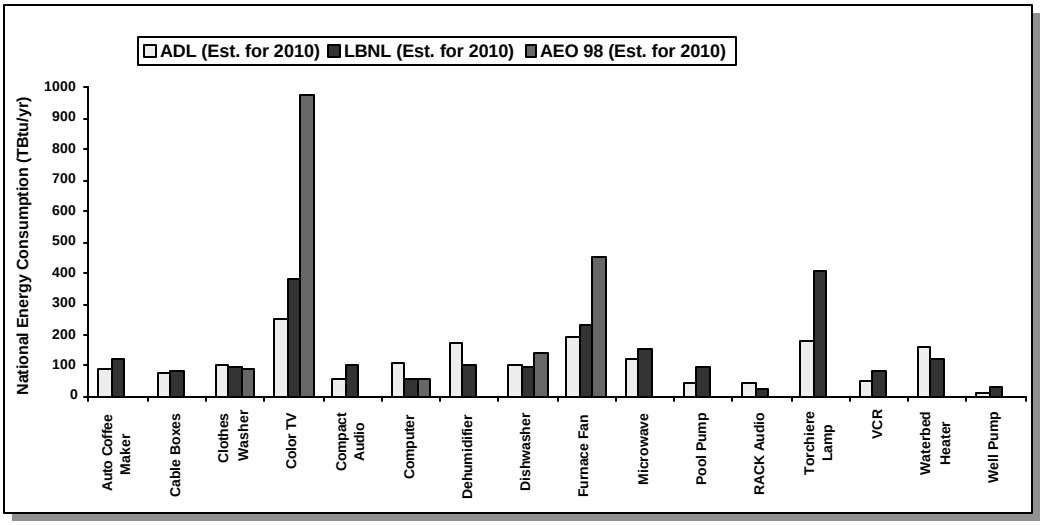
Sources: LBNL (est. for 1995) [LBL-40295, 1998],
AEO 97 (est. for 1995) [EIA/AEO, 1997],
AEO 98 (est. for 1996) [EIA/AEO, 1998],
ADL (est. for 1997) Exhibit 6-9

There are significant discrepancies in energy consumption projections for 2010 as well.

There are also significant discrepancies (over 25% relative to ADL) in the year-2010 national energy consumption projections for 13 of the 16 end uses (see Exhibit 8-7):

- **Automatic Coffeemaker:** LBNL's estimate is 33% higher relative to ADL's;
- **Color Television**: LBNL's projection is 52% higher and the AEO 1998 projection is 289% higher relative to ADL;
- **Compact Audio System**: LBNL's projections is 65% higher relative to ADL's;
- **Computer**: LBNL's and the AEO 1998 projections are 44 to 45% lower relative to ADL's;
- **Dehumidifier**: LBNL's projection is 41% lower relative to ADL's;
- **Dishwasher**: The AEO 1998 projection is 40% higher relative to ADL, but LBNL's projection is in good agreement with ADL;
- **Furnace Fan**: The AEO 1998 projection is 130% higher relative to ADL's, but LBNL's projection is only 18% higher relative to ADL's;
- **Microwave**: LBNL's projection is 26% higher relative to ADL's;
- **Pool Pump**: LBNL's projection is 107% higher relative to ADL's;
- **RACK Audio System**: LBNL's projection is 40% lower relative to ADL's;
- **Torchiere Lamp**: LBNL's projection is 120% higher relative to ADL's;
- **VCR**: LBNL's projection is 71% higher relative to ADL's; and
- **Well Pump**: LBNL's projection is 194% higher relative to ADL's.

Exhibit 8-7: Comparison of National Energy Consumption Projections by End Use for 2010



Sources: ADL (est. for 2010) Exhibit 6-8
LBNL (est. for 2010) [LBL-40295, 1998; Appendix B; pp. 1-7]
AEO 98 (est. for 2010) [EIA/AEO, 1998 Table A4]

The most significant discrepancies based on absolute energy consumption (more than 100 TBtu/yr difference) are for color televisions, furnace fans, and torchiere lamps. For color television, the differences between ADL and LBNL are due to two factors:

- LBNL projects an increase in stock of 43% between 1995 and 2010, while ADL projects only a 14% increase between 1997 and 2010; and
- LBNL neglects changes in UEC, while ADL projects a 31% reduction in UEC.

For color television, the AEO 1998 national consumption estimate for 1996 (670 TBtu/year) was already much higher relative to ADL (294 TBtu/year) or LBNL (290 TBtu/year). AEO projects a 46% increase in national consumption for color television between 1996 and 2010 (to 980 TBtu/year).

For furnace fans, ADL and LBNL estimates are in reasonably good agreement. The difference between AEO 1998 and ADL is consistent with the differences seen for current consumption (see earlier discussion for Exhibit 8-5).

For torchiere lamps, the difference between ADL and LBNL is largely due to the 260% stock growth projected by LBNL between 1995 and 2010 versus the 15% stock growth projected by ADL between 1997 and 2010. Both LBNL and ADL acknowledge the uncertainties in their projections. (See discussion in Section 7 regarding future trends for torchiere lamps.)

Exhibit 8-8 summarizes energy-consumption projections for 2010 from LBNL, AEO 1998, and ADL. Observations from Exhibit 8-8 include:

- The 16 end uses selected for evaluation represent about 65% of the projected energy use for the 97 small end uses investigated by LBNL (based on LBNL's projections for the 16 end uses);

- For the total of the 16 end uses evaluated, LBNL's consumption projection is 23% higher relative to ADL's; and

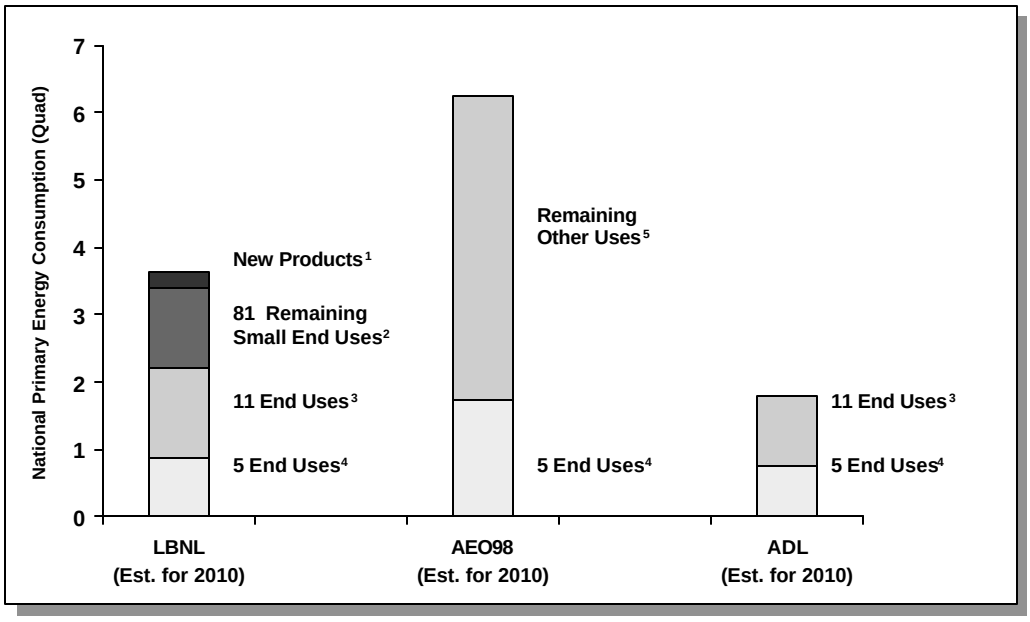
- For the total of five end uses (clothes washer, color television, dishwasher, computer, and furnace fan), LBNL's projections are 15% higher relative to ADL's, and the AEO 1998 projections are 128% higher relative to ADL's; and

- The AEO projections are significantly higher relative to both LBNL and ADL projections.

Comparisons to LBNL's projections suggest that, of the 16 end uses we selected for evaluation, 12 are among the largest of the 97 small end uses evaluated by LBNL.

As discussed in Section 5, we selected the 16 end uses for evaluation from the top-15 energy-consuming small end uses projected by LBNL for 2010 [LBNL-40245, 1998], and then removed crankcase heaters (which ranked fifteenth among LBNL's projections), then added well pumps and RACK audio systems. LBNL's sixteenth-ranked end use (ceiling fans) is projected by LBNL to consume 5.2 TWh/year (54 TBtu/year) in 2010. Based on the projections shown in Exhibit 7-3, 12 of the 16 end uses evaluated by ADL will have year-2010 energy consumptions greater than 54 TBtu/year. This would suggest that we were successful in including the top-12 small end uses among the 16 end uses evaluated (per our goal, as stated in Section 5). We are assuming, of course, that none of LBNL's projected consumptions for end uses they ranked sixteenth or greater would increase significantly upon a more detailed evaluation.

Exhibit 8-8: Comparison of National Energy Consumption Projections for Small Electric End Uses – 2010 Consumption



1) LBL forecast accounts for the introduction of new products that are not currently on the market
2) Remaining of the 97 small end uses investigated by LBNL
3) Includes: Automatic Coffee Makers, Cable Box, Compact Audio, Dehumidifier, Microwave Oven, Pool Pump, RACK Audio, Torchiere Lamp-Halogen, VCR, Waterbed Heater, Well Pump
4) Includes: Clothes Washer, Color TV, Dishwasher, Personal Computer, Furnace Fan
5) As defined in the EIA AEO 1998

Sources: LBNL (est. for 2010) [LBL-40295, 1998],
AEO 98 (est for 2010) [EIA/AEO, 1997],
ADL (est. for 2010), Exhibit 7-3

9. Additional Data Collection Needs

While many data points are available from a range of sources, almost all available data are poorly documented and are difficult to trace to the original source.

Our investigation produced 90 sources citing power-draw, operating-hour, saturation, UEC, and/or national energy consumption estimates for the 16 end uses evaluated. Almost without exception[1], the available sources do not provide documentation sufficient to trace each value to its original source and determine how the value was estimated or measured. Often, the same (or similar) values are cited by two or more sources, leaving one to speculate whether the values are truly independent. Many sources provide a collection of data from various other sources, without rigorous documentation of the original sources.

Several sources (most notably for consumer electronics) are suspect, given the conflict of interest between accurate estimating/projecting and promotion of self interests.

Saturation estimates and projections by some manufacturers and trade associations, especially for consumer electronics, tend to be significantly higher relative to other sources – by a factor of two or more in cases. We speculate that these manufacturers and trade associations may be subconsciously indulging in wishful thinking. It's also possible that some deliberately inflate estimates/projections in hopes that the optimistic estimates/projections will help stimulate the markets for their products.

The above observations point to the need for rigorously documented primary data.

It is important that new primary data collected be rigorously documented so that it is understandable and credible. This documentation should include:

- Detailed descriptions of the end uses evaluated, including manufacturers, models, capacities, etc.;
- Types of installations covered (locations, seasons, sample sizes, household types and sizes, and other descriptive information);
- Precisely how data were obtained. Field-test documentation should include descriptions of test and data-collection equipment, how measurements were made, duration of monitoring, sampling rate, and other pertinent information. Field-survey documentation should include a copy of the questionnaire, duration of monitoring, etc.; and
- Thorough documentation of all calculations, estimates, etc.

[1] Sources having good, traceable documentation include [BPA, 1992] and [Dieckmann, 1997].

Several priority areas have been identified for additional data collection.

Saturation Estimates

While Exhibit 8-4 suggests that there is good agreement among saturation estimates, many of these estimates are not independent. As noted in Section 6.3, saturation estimates can vary by a factor of two or more, depending on the source. Of the end uses investigated, the greatest uncertainties are associated with cable boxes, computers, and torchiere lamps. Field work to firm up saturation estimates would improve energy-consumption estimates.

Operating-Hour Estimates

Perhaps the greatest uncertainties in operating hours are associated with estimating how many products, while theoretically in the inventory, are not used or are used very little. It's very rare for large, expensive appliances to be purchased and installed if they aren't to be used regularly. However, many small end uses are sufficiently small and inexpensive that they are:

- Received as gifts (that may not be used);
- Purchased with little forethought and not used;
- Purchased for a one-time need;
- Duplicated when households merge; or
- Replaced (but not disposed of) when minor or cosmetic damage occurs.

Who doesn't have an assortment of electric gadgets in his/her closet, basement, and/or attic that rarely, if ever, is used? If these "closet appliances" are assumed to be in use regularly, the resulting national energy consumption estimates can be exaggerated. Fortunately, many of the 16 end uses evaluated are sufficiently large/expensive that they are unlikely to go unused. However, in our judgment, several could fall into this category: automatic coffee makers, cable boxes, color televisions[2], computers, dehumidifiers, and torchiere lamps.

Even for regularly used appliances, usage patterns can vary greatly from household to household, from season to season, or from geographic region to geographic region. In our judgment, the most important uncertainties in operating hours are associated with color televisions, computers, dehumidifiers, pool pumps, and torchiere lamps.

To understand usage patterns better will require an extensive and well-thought-out field survey.

[2] Our method of estimating color television energy consumption is somewhat insensitive to the number of unused, or rarely used, televisions. See discussions in Sections 6.2 and 6.3.

Power-Draw Estimates

For some end uses, power draws are easily determined with a good level of certainty. Also, fortuitously, the power draw of most small end uses is not largely influenced by factors such as climate or where it's installed in the home. (Obviously, these factors can impact operating hours significantly.) However, the power draws for some end uses can vary significantly, depending on factors such as capacity/size, manufacturer, date of manufacture, and stand-by features. Based on review of the data available, the end uses having the greatest variability in power draw (of the 16 end uses investigated) are: color televisions, computers, dehumidifiers, microwave ovens, waterbed heaters, and well pumps[3]. A program to measure power draws for these end uses (for a wide range of manufacturers, models, capacities/sizes, features, locations, and ages) would provide important and useful information.

[3] Variability in well-pump power draw is associated with variability in well depth.

10. Summary/Conclusions

A summary of, and conclusions from, this study are briefly described below.

A revised categorization has been proposed that places small end uses in more appropriate categories. The revised categorization:

- Provides better insight into residential electric use; and
- Reduces the size of the *Other Uses* category from about 2.5 quad (per the AEO 1998) to about 1.3 quad.

This re-categorization moves consumption to more descriptive and fitting categories, thus providing a more accurate representation of the energy consumption in the residential sector by which to judge RD&D priorities. The new *Other Uses* category (1.3 quad or about 11% of residential electric consumption) is smaller relative to the AEO 1998 estimate (2.5 quad, or about 21%) and is in better proportion to the major end uses in the residential sector.

We selected 16 residential end uses for detailed evaluation: automatic coffee maker, cable box, clothes washer, color television, compact audio system, computer, dehumidifier, dishwasher, furnace fan, microwave oven, pool pump, RACK audio system, torchiere lamp – halogen, video cassette recorder, waterbed heater, and well pump. Most of these 16 small end uses belong in the larger, traditional end-use categories (such as furnace fans in space heating and torchiere lamps in lighting); but they were evaluated to guide possible, future RD&D efforts on their own merits. The 16 selected end uses represent about 65% of the energy consumption associated with the 97 end uses investigated by LBNL.

For the total of 16 end uses evaluated, LBNL's and ADL's estimates were in very good agreement for current energy consumption (1.72 quad in 1995 and 1.69 quad in 1997, respectively). However, LBNL projects total consumption in 2010 for the 16 end uses of 2.20 quad (28% growth), while ADL projects 1.79 quad in 2010 (6% growth). This growth is slower than previous forecasts by either EIA (in the AEO) or LBNL, and is in reasonable perspective (at about 0.45% per year) to the growth rates of major end uses in the residential sector (range is 0.1 to 0.7% annually in the AEO98 [EIA/AEO, 1998]). The differences in future consumptions projected by LBNL and ADL are largely due to differences in approach. First, LBNL assumed that Unit Energy Consumptions (UECs) remain constant, while ADL varied UECs based on anticipated changes in efficiencies and usage patterns. Second, LBNL utilized a mathematically rigorous approach to forecasting saturations (based on historical shipment data), while ADL relied more on applying subjective judgment to observed (and anticipated) qualitative trends.

The 16 end uses were estimated to consume 1.69 quad, which is about 65% of the consumption estimated by LBNL for 97 small end uses. Given that the energy consumption is

concentrated in a few small end uses and the lesser amount of consumption is dispersed among 81 end uses, the strategic approach to RD&D planning should focus on these 16 end uses. Thus, potential, future RD&D actions are more tractable than previously thought.

For the total of five end uses (clothes washer, color television, dishwasher, computer, and furnace fan), the AEO 1998 estimates current energy consumption of 1.36 quad (in 1996), while ADL estimates 0.71 quad (in 1997) – a difference of 91%. The AEO 1998 projects total consumption in 2010 for the five end uses of 1.73 quad (27% growth), while ADL projects 0.76 quad (7% growth).

Overall the AEO current estimate and future projections are high relative to ADL's. Further, the AEO estimates and projections are high relative to LBNL's for the grouping of 97 end uses investigated by LBNL (which includes virtually all the small electric end uses in the residential sector). Despite differences in future projections, both LBNL and ADL estimate a smaller current consumption and slower growth in the future relative to the AEO.

Although numerous sources report primary data associated with the energy use of small residential end uses, good, traceable documentation describing how the data were obtained is often not provided. Further field work is needed to verify these data. Highest priority items are:

- **Cable Box** (saturation);
- **Color Television** (power draw and operating hours);
- **Computer** (power draw, saturation, and operating hours);
- **Dehumidifier** (power draw and operating hours); and
- **Halogen Torchiere Lamp**[1] (saturation and operating hours).

The end uses for which 1997 consumption estimates exceed 100 TBtu/year (of the 16 end uses evaluated) are:

- **Color Television** (294 TBtu/yr.);
- **Furnace Fan** (183 TBtu/yr.);
- **Waterbed Heater** (177 TBtu/yr.);
- **Halogen Torchiere Lamp** (172 TBtu/yr.);
- **Microwave Oven** (136 TBtu/yr.); and
- **Dehumidifier** (120 TBtu/yr.).

[1] Although it is included in the Lighting category, we evaluated halogen torchiere lamps because their historical growth rate has far exceeded that for the Lighting category in general.

The end uses for which 2010 consumption projections exceed 100 TBtu/year are:

- **Color Television** (250 TBtu/year – 14% reduction relative to 1997));
- **Furnace Fan** (200 TBtu/year – 7% increase);
- **Dehumidifier** (180 TBtu/year – 48% increase);
- **Halogen Torchiere Lamp** (180 TBtu/year – 7% increase);
- **Waterbed Heater** (160 TBtu/year – 9% reduction);
- **Microwave Oven** (120 TBtu/year – 11% reduction); and
- **Computer** (110 TBtu/year – 77% increase).

Our projections indicate that energy use will grow the fastest between 1997 and 2010 for:

- **Computer** (77% growth) – primarily due to increased saturation projected based on purchase-price reductions and increasing popularity of Internet-related services;
- **Dehumidifier** (48% growth) – primarily due to increased saturation projected based on historical saturation growth; and
- **Cable Box** (36% growth) – primarily due to increased saturation based on the increasing popularity of premium channels.

Our projections indicate that energy use will decrease between 1997 and 2010 for:

- **VCR** (37% reduction) – primarily due to reductions in stand-by power draw. The reductions in stand-by power assumed are consistent with manufacturers' projections.
- **Color Television** (14% reduction) – primarily due to reductions in stand-by power draw. The reductions in stand-by power assumed are consistent with manufacturers' projections;
- **Microwave Ovens** (11% reduction) – primarily due to improved efficiencies of newer products, which reduces operating hours;
- **Waterbed Heater** (9% reduction) – primarily due to declining sales and, hence, projected drop in saturation; and
- **Well Pump** (7% reduction) – primarily due to gradually dropping saturation (projected based on historical trends).

LBNL's estimates for 1995 consumptions [LBNL-40295, 1998], relative to ADL's (for 1997), are:

- **Computer:** 41% lower – due primarily to a lower operating-power-draw estimate;
- **Dehumidifier:** 60% lower – due primarily to lower UEC and lower saturation estimates[2];

[2] LBNL's report does not provide operating-hour or power-draw estimates for this end use.

- **Furnace Fan:** 29% higher – due primarily to a 26% higher UEC estimate[1];
- **Pool Pump:** 60% higher – due primarily to a higher UEC estimate[1];
- **Well Pump:** 319% higher – due primarily to a higher UEC estimate[1]; and
- **Other 11 End Uses**: Within +/- 25%.

AEO1998 estimates for 1996 consumptions [EIA/AEO, 1998], relative to ADL's for 1997, are (for the five end uses estimated by both sources):

- **Color Television:** 128% higher;
- **Computer:** 51% lower;
- **Dishwasher:** 94% higher;
- **Furnace Fan:** 108% higher; and
- **Clothes Washer:** 5% lower.

The AEO does not provide sufficient detail to examine the sources of the discrepancies.

LBNL's projections for year-2010 consumptions [LBNL-40295, 1998], relative to ADL's, are:

- **Automatic Coffee Maker:** 33% higher – due primarily to higher saturation growth projected by LBNL;
- **Color TV:** 52% higher – due primarily to higher saturation growth projected by LBNL, and ADL's projected reduction in stand-by power draw (LBNL assumed no change in UEC);
- **Compact Audio System:** 65% higher – due primarily to higher saturation growth projected by LBNL;
- **Computer:** 44% lower – consistent with discrepancy in current consumption estimates;
- **Dehumidifier:** 41% lower – consistent with discrepancy in current consumption estimates;
- **Microwave Oven:** 26% higher – due primarily to higher saturation growth projected by LBNL and ADL's projected reduction in operating power draw (LBNL assumed no change in UEC);
- **Pool Pump:** 107% higher – due primarily to the higher UEC estimate plus a higher saturation growth projected by LBNL;
- **RACK Audio System:** 40% lower – due primarily to a reduction in saturation projected by LBNL;
- **Torchiere Lamp – Halogen:** 120% higher – due primarily to higher saturation growth projected by LBNL;
- **VCR:** 71% higher – due primarily to the reduction in stand-by power draw projected by ADL;

- **Well Pump:** 194% higher – due primarily to the higher UEC estimate (noted above), which is partially offset by a greater reduction in saturation projected by LBNL; and
- **Other 5 End Uses:** Within +/- 25%.

AEO1998 projections for year-2010 consumptions [EIA/AEO, 1998], relative to ADL's, are (for the five end uses estimated by both sources):

- **Color Television:** 289% higher;
- **Computer:** 45% lower;
- **Dishwasher:** 40% higher;
- **Furnace Fan:** 130% higher; and
- **Clothes Washer:** 12% lower.

The AEO does not provide sufficient detail to examine the sources of the discrepancies.

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Appendix A

Space Heating*	Quads	Source
Space Heating **	1.520	[EIA/AEO, 1998]
Humidifier	0.014	[LBL-40295, 1998]
Furnace Fan	0.183	Exhibit 6-9
	1.72	
	14.4%	

Space Cooling*	Quads	Source
Space Cooling**	1.490	[EIA/AEO, 1998]
Ceiling Fan	0.077	[LBL-40295, 1998]
Dehumidifier	0.120	Exhibit 6-9
Evaporative Cooler	0.036	[LBL-40295, 1998]
Floor Fan	0.003	[LBL-40295, 1998]
Whole House Fan	0.004	[LBL-40295, 1998]
Window Fan	0.001	[LBL-40295, 1998]
Stand Fan	0.003	[LBL-40295, 1998]
Desk Fan	0.003	[LBL-40295, 1998]
	1.74	
	14.6%	

Household Water Heating*	Quads	Source
Water Heater	1.16	[EIA/AEO, 1998]
	1.16	
	9.7%	

subtotal	**10.69**
other uses	**1.22**
	10.3%
TOTAL	**11.91**

* Shaded entries are directly from AEO 1998

** Based on AEO 1998 definitions of categories

[1] Only heating is being considered. Further information on spa pumps is needed.

[2] Assume that 25% of halogen torchiere lamp offsets other lighting and 75% is new lighting load.

Space Heating*	Quads	Source	White Goods*	Quads	Source	Lighting*	Quads	Source
Space Heating **	1.520	[EIA/AEO, 1998]	Refrigerator	1.330	[EIA/AEO, 1998]	Lighting**	1.090	[EIA/AEO, 1998]
Humidifier	0.014	[LBL-40295, 1998]	Freezer	0.420	[EIA/AEO, 1998]	Torchiere Halogen Lamps[2]	0.172	Exhibit 6-9
Furnace Fan	0.183	Exhibit 6-10	Clothes Dryer	0.610	[EIA/AEO, 1998]	75% of Torchiere Halogen Lamps[2]	0.129	
	1.72		Clothes Washer	0.095	Exhibit 6-9	Grow Lamps	0.004	[LBL-40295, 1998]
	14.4%		Dishwasher	0.077	Exhibit 6-9	Lava Lamp		
				2.53		Aquarium	0.046	[LBL-40295, 1998]
				21%		Other Halogen Lamps		
							1.27	
							10.65%	

Cooking*	Quads	Source
Cooking**	0.420	[EIA/AEO, 1998]
Microwave	0.136	Exhibit 6-9
Air Corn Popper	0.001	[LBL-40295, 1998]
Automatic Griddles	0.002	[LBL-40295, 1998]
Broiler	negligible	[LBL-40295, 1998]
Deep Fryer	0.003	[LBL-40295, 1998]
Electric Grill	0.001	[LBL-40295, 1998]
Electric Kettle	0.001	[LBL-40295, 1998]
Espresso Maker	0.001	[LBL-40295, 1998]
Hot Oil Corn Popper	0.000	[LBL-40295, 1998]
Hot Plate	0.008	[LBL-40295, 1998]
Perc Coffee	0.012	[LBL-40295, 1998]
Slow Cooker	0.010	[LBL-40295, 1998]
Toaster Oven	0.022	[LBL-40295, 1998]
Coffee Maker	0.084	Exhibit 6-9
Toaster	0.036	[LBL-40295, 1998]
Waffle Iron/ Sandwich grill	0.000	[LBL-40295, 1998]
Bread Maker		
	0.737	
	6.2%	

Electronics	Quads	Source
Color TV	0.294	Exhibit 6-9
VCR	0.078	Exhibit 6-9
Compact Audio	0.057	Exhibit 6-9
RACK Audio	0.044	Exhibit 6-9
Security System	0.042	[LBL-40295, 1998]
Cable Box	0.057	Exhibit 6-9
Computer	0.062	Exhibit 6-9
Answering Machine	0.021	[LBL-40295, 1998]
B & W TV	0.005	[LBL-40295, 1998]
Boom Box	0.017	[LBL-40295, 1998]
Clock	0.019	[LBL-40295, 1998]
Copier	0.001	[LBL-40295, 1998]
Cordless Phone	0.016	[LBL-40295, 1998]
DoorBell	0.013	[LBL-40295, 1998]
Garage Door Opener	0.009	[LBL-40295, 1998]
Home Medical Equipment	0.002	[LBL-40295, 1998]
Hand Held Rechargable Vacuum	0.004	[LBL-40295, 1998]
Home radio/ small clock	0.021	[LBL-40295, 1998]
Ink Jet Fax	0.010	[LBL-40295, 1998]
Laser Printer	0.007	[LBL-40295, 1998]
Printer	0.003	[LBL-40295, 1998]
Projection Color TV	0.012	[LBL-40295, 1998]
Satellite Earth Station	0.008	[LBL-40295, 1998]
TV/VCR Combo	0.013	[LBL-40295, 1998]
Video Games	0.017	[LBL-40295, 1998]
Power Strip	0.003	[LBL-40295, 1998]
Multi-fcn Device	0.001	[LBL-40295, 1998]
Modem	0.002	[LBL-40295, 1998]
Battery Charger	0.023	[LBL-40295, 1998]
Walkmans		
Gameboys		
Discmans		
Timer	0.005	[LBL-40295, 1998]
	0.865	

7.3%

Motor	Quads	Source
Pool Pump	0.044	Exhibit 6-9
Well Pump	0.013	Exhibit 6-9
AIr Cleaner Electric, not mounted	0.013	[LBL-40295, 1998]
Blender	0.006	[LBL-40295, 1998]
Bottled Water Dispenser (Cold Only)	0.003	[LBL-40295, 1998]
Can Opener	0.002	[LBL-40295, 1998]
Central Vacuum	0.000	[LBL-40295, 1998]
Compactor	0.001	[LBL-40295, 1998]
Exhaust Fan	0.006	[LBL-40295, 1998]
Electric Knife	0.000	[LBL-40295, 1998]
Electric Lawn Mower	0.007	[LBL-40295, 1998]
Electric Toothbrush	0.003	[LBL-40295, 1998]
Food Slicer	0.000	[LBL-40295, 1998]
Foot Massager	negligible	[LBL-40295, 1998]
Garbage Disposal	0.005	[LBL-40295, 1998]
Hand Held Electric Vacuum	0.001	[LBL-40295, 1998]
Hand Held Massager	0.000	[LBL-40295, 1998]
Hand Mixer	0.001	[LBL-40295, 1998]
Juicer	0.000	[LBL-40295, 1998]
Men's Shaver	0.005	[LBL-40295, 1998]
Mounted AIr Cleaner	0.028	[LBL-40295, 1998]
Stand Mixer	0.000	[LBL-40295, 1998]
Sump/Sewage Pump	0.004	[LBL-40295, 1998]
Vacuum	0.033	[LBL-40295, 1998]
Women's Shaver	0.001	[LBL-40295, 1998]
Pasta Maker		
Food Processor		
Sewing Machine		
Power Tools		
	0.1758	
	1%	

Misc. Heating	Quads	Source
Electric Blanket	0.038	[LBL-40295, 1998]
Iron	0.050	[LBL-40295, 1998]
Instant Hot Water	0.001	[LBL-40295, 1998]
Waterbed Heater	0.177	Exhibit 6-9
Auto Engine Heaters	0.005	[LBL-40295, 1998]
Curling Iron	0.001	[LBL-40295, 1998]
Hair Dryer	0.033	[LBL-40295, 1998]
Hair Setter	0.003	[LBL-40295, 1998]
Heating Pads	0.003	[LBL-40295, 1998]
Heat Tape	0.003	[LBL-40295, 1998]
Snow Melting Coil		
Plug-In Air Freshener		
	0.31	
	2.6%	

Appendix B

Automatic Coffee Maker ****Bolded entries signifies information utilized within this report.**

Saturation Information	Information Received from Source	Information Modified by ADL	Source and Miscellaneous Information
CGHES	0.3-0.5	0.3-0.5	American Council for an Energy Efficient Economy (ACEEE) publication with table referencing LBNL [ACEEE, 1996]
AHAM Spreadsheet	89%	0.89	AHAM [AHAM SPDSHT, 1997]
Appliance Magazine	74.50%		Penetration [Appliance2, 1997]
Vintaging Model	**56.47 million units**	**0.56**	**See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.**
LBNL	80.72 million units	0.82	LBNL: (1995 data divided by 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
CGHES	20-300(kWh/yr)	20-300kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996]
AHAM Spreadsheet	104.5 kWh/yr	104.5kWh/yr	AHAM [AHAM SPDSHT, 1007]
Kennebunk Light & Power District	30 kWh (monthly)	360kWh/yr	National standard energy publication, over 8 yrs old. ADL assumed 12 months per year in use. [KLPD, 1997]
Narragansett Electric Company	10-13 kWh/mon	120-156kWh/yr	DOER, Mass Division of Energy Resources literature for Inclusion in ECS Residential Energy Audit, Information reported in Narragansett's Web Site. [NEES, 1997]
Central Maine Power Company	22 kWh/mon	264kWh/yr	Based on wattage & usage. Does not include warming plate, only drip cycle. ADL assumed 12 months per year usage [CMPCO, 1997]
Energy Cost for Household Appliances	5 kWh/mon	60kWh/yr	Based on wattage and usage estimations. ADL assumed 12 months usage.[HEI, 1997]
Southern Alabama Electric Cooperative	5 kWh/mon	60kWh/yr	National Energy Information Center. ADL assumed 12 months of usage [SAEC1, 1998]
Walton EMC	8.3kWh/mon	99.6kWh/yr	Information from an ACEEE brochure. ADL assumed 12 months of usage. [WaltonEMC, 1997]
LBNL	116kWh/yr	116kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Central Maine Power Company	20hr/mon	240hr/yr (brew)	40 min/day (of drip cycle, not of the warming plate). ADL assumed 12 months usage [CMPCO, 1997]
Energy Cost for Household Appliances	8min/day	48.66hr/yr (brew)	Hawiian Electric Estimation. ADL estimation of 365 days per year of usage [HEI, 1997]
Energy Cost for Household Appliances	2hr/day	730 hr/yr (warm)	Hawiian Electric Estimation. ADL estimation of 365 days per year of usage [HEI, 1997]
AHAM Spreadsheet	600	600	[AHAM SPDSHT, 1997]

Energy Specs: Appliances	2 brews/day	97.3hr/yr (brew)	California Energy Commission Estimation on number of 8 min brewing cycles. [CEC, 1997] ADL estimation of 365 day per year usage
Energy Specs: Appliances	1hr/day	365hr/yr (warm)	California Energy Commission Estimation on the warming plate time.[CEC, 1997] ADL estimation of 365 days per year of usage (Information cited below by LBNL)
LBNL	**61 hr/yr**	**61hr/yr (brew)**	**California Energy Commision: brewing once a day (10 min/brew), warming 1hr/day (360 day/yr) [LBL-40295, 1998]**
LBNL	**1hr/day**	**360hr/yr (warm)**	**California Energy Commision: brewing once a day (10 min/brew), warming 1hr/day (360 day/yr) [LBL-40295, 1998]**
Wattage Information			
AHAM Spreadsheet	**1100W**	**1100W (brew)**	**[AHAM SPDSHT, 1997]**
Central Maine Power Company	**1100W**	**1100W (brew)**	**Wattage of the drip cycle. [CMPCO, 1997]**
Central Maine Power Company	200W	200W (warm)	Wattage of the warm cycle. [CMPCO, 1997]
Energy Cost for Household Appliances	1500W	1500W (brew)	Hawiian Electric Company [HEI, 1997]
Energy Cost for Household Appliances	**70W**	**70W (warm)**	**Hawiian Electric Company [HEI, 1997]**
Manufacturer Spreadsheet	1100W	1100W (brew)	Manufacturer Customer Service (Proctor Silex/Hamilton Beach) [PS/HB, 1997]
Seattle City Light	900W	900W (brew)	Avg wattage taken off tag of unit found in the employ storage room. [SCL, 1997]
Energy Specs: Appliances	860W	860W (brew)	Brewing Cycle [CEC, 1997]
Energy Specs: Appliances	70W	70W (warm)	Warming Plate [CEC, 1997] (Information cited below by LBNL)
LBNL	1500W	1500W (brew)	Brewing Wattage: from the California Energy Commision [LBL-40295, 1998]
LBNL	70W	70W (warm)	Warming Plate wattage: from the California Energy Commission [LBL-40295, 1998]
Lifetime Comparison			
Appliance: [Appliance2, 1997]		[LBL-40295, 1998]	
Low 3 years		Avg 5 years	
Avg 4 years			
High 6 years			

Cable Box

**** Bold entries signify information utililzed within this report**

Saturation Information	Information Received from Source	Information Modified by ADL	Source and Miscellaneous Information
Leaking Electricity: Standby and Off Mode Power	**0.45**	**0.45**	**TV and Cable Factbook [Suozzo, 1997]**
Media Dynamics	65%		Penetration of cable TV [MD-TVD, 1998]
National Cable TV Association	49130000		Estimate of pay cable subscriptions in 1997 [NTCA, 1997]
Media Dynamics	27%		Penetration of pay cable TV estimate [MD-TVD, 1998]
Notebook	0.66		Penetration of Cable TV. Neilsen Study (% of HH that have cable TV, not cable boxes) [Nielsen, 1997]
LBNL	43.57 million units	0.44	LBNL: (1995 data divided by 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
LBNL	144kWh/yr	144kWh/yr	LBNL: Summary Tables [LBL-40295, 1998]
Usage Information			
Leaking Electricity: Standby and Off Mode Power	6844hr/yr (standby)	6844hr/yr (standby)	Assumed always plugged in. [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	1916hr/yr	1916hr/yr	Based on TV time usage [Suozzo, 1997]
LBNL	**1456hr/yr**	**1456hr/yr**	**Estimation by Webber; same time as TV [LBL-40295, 1998]**
Wattage Information			
Leaking Electricity: Standby and Off Mode Power	12.8W	12.8W	Published results and/or an educated guess. [Suozzo, 1997]
Leakage Summary Table	11.6W (standby)	11.6W (standby)	Metered by Huber [Huber, 1997] (cited below by LBNL)
LBNL	**20W**	**20W**	**Metered by Huber [LBL-40295, 1998]**
LBNL	**11.6W (standby)**	**11.6 W (standby)**	**Metered by Huber [LBL-40295, 1998]**

Clothes Washer

			****Bolded entries signifies information utilized within this report.**
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
1997 Major Appliance Industry Fact Book	95.30%	0.953	Home Appliance Saturation and Length of First Ownership Study, 1991, NFO Research Inc. [AHAM, 1997]
Appliance Magazine	**78.40%**		**Penetration Appliance Magazine, Sept. 1997 [Appliance2, 1997]**
Housing Characteristics	77.10%	0.771	[RECS-HC, 1993]
Vintaging Model	87.19 million units	0.86	See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.
LBNL	76.71 million unit	0.77	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
1997 Major Appliance Industry Fact Book	1.7% of those who have 1 clothes washer have access to multiple units		Home Appliance Saturation and Length of First Ownership Study, 1991, NFO Research Inc.[AHAM, 1997]
KWH Information			
Central Maine Power Company	11 kWh/mon	132 kWh/yr	Average metering, along with the wattage x usage information. ADL assumes 12 months per year usage [CMPCO, 1997]
Description of Electrical Energy Use in Single...	107 kWh/yr	107kWh/yr	Metered data; does not include water heating [BPA, 1992]
Energy Cost for Household Appliances	11 kWh/mon	132 kWh/yr	Based on usage estimation and wattage. Does not include water heating. ADL assumes 12 months per year usage [HEI, 1997]
Kennebunk Light & Power District	8 kWh/mon	96 kWh/yr	National Energy Information Center, data is over 8 yrs old. ADL assumes 12 months per year of usage [KLPD, 1997]
Manufacturer Spreadsheet	898 kWh/yr	898 kWh/yr	Maytag Customer Service: based on 8 loads/week and gas water heating [Maytag, 1997]
Narragansett Electric Company	12-16 kWh/mon	144-192 kWh/yr	DOER, Mass Division of Energy Resources literature for inclusion in ECS Residential Energy Audit, Information reported in Narragansett's Web Site.

			[NEES, 1997]
Walton EMC	12 kWh/mon	144 kWh/yr	Operation only; not water heating: Info. from ACEEE. ADL estimate for 12 months per year of usage [WaltonEMC, 1997]
Washing Machine Laboratory Testing	**0.25-0.3kWh/cycle**	**98-118kWh/yr**	**ADL Labs, Testing based on Appendix J,. machine energy use. [Dieckmann,1997]**
DOE	0.22kWh/cycle	86kWh/yr	US DOE, Oct. 1996 Workshop. Based on 392 cycles/yr
LBNL	102 kWh/yr	102kWh/yr	US DOE 1990; calculated by the number of cycles/yr [LBL-40295, 1998]
Usage Information			
Central Maine Power Company	20 hr/mon	240 hr/yr	~1 load/day (30min/load). Derived from average metering [CMPCO, 1997]
Energy Cost for Household Appliances	8 loads/wk	416 loads/yr	Estimation: about the average number of loads. ADL estimate for 12 months per year usage [HEI,1997]
Manufacturer Spreadsheet	8 loads/wk	416 loads/yr	Maytag based it on the National Average. ADL assumes 52 weeks per year usage [Maytag, 1997]
Energy Specs: Appliances	20 loads/mon	240 loads/yr (180hr/yr)	Based on 45 min/load. ADL assumes 12 months per year usage [CEC, 1997]
ADL Testing Laboratory	**392cycles/yr**	**392cycles/yr**	**[Dieckmann, 1997]**
LBNL	380hr/yr	380 hr/yr	US DOE 1990 (wattage and usage) [LBL-40295, 1998]
Wattage Information			
AHAM Spreadsheet	500W	500W	[AHAM SPDSHT, 1997]
Central Maine Power Company	550W	550W	Just mechanical wattage. Manufacturer information as well as metering averages. [CMPCO, 1997]
Manufacturer Spreadsheet	max (6 A)(120V)	720W	Maytag Customer Service [Maytag, 1997]
Manufacturer Spreadsheet	(10A)(120V)	1200W	GE Customer Service [GE, 1997]
Seattle City Light	600W	600W	Avg wattage taken off tag of unit found in the employ storage room. [SCL, 1997]
Energy Cost for Household Appliances	333W	333W	motor wattage only [HEI, 1997]
Energy Specs: Appliances	500W	500W	does not include water heating [CEC, 1997]
LBNL	269W	269W	US DOE 1990: includes motor energy/cycle only [LBL-40295, 1998]
Lifetime Comparison			
	Appliance: [Appliance2, 1997]		
	Low 11 years		

	Avg. 13 years High 14 years		

Color TV

			**Bolded entries signifies information utilized within this report.
Saturation Information	**Information Recieved from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
CGHES pg 234-235	.96-.99		Penetration. ACEEE publication with table referencing LBNL [ACEEE, 1996]
Leaking Electricity: Standby and Off Mode Power	1.91	1.91	An LBNL Number, [Suozzo, 1997]
Neilsen Media	2.36 sets/HH		Based on Households that have television sets. [Neilsen, 1997]
Housing Characteristics	0.977		Penetration. [RECS-HC, 1993]
Media Dynamics	**2.3 sets/HH**	**2.25**	**Based on 2.3 sets/TV household and 98% TV Penetration [MD-TVD, 1998]**
Appliance Magazine	98.0%		Penetration [Appliance2, 1997]
Vintaging Model	237.49 million units	2.34	See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.
LBNL	186.32 million units	1.881	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
Central Maine Power Company	18kWh/mon	216 kWh/yr	Based on the wattage x usage. ADL assumed 12 months per year usage [CMPCO, 1997]
CGHES pg 234-235	75-1000kWh/yr	75-1000kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Energy Cost for Household Appliances	18-36kWh/mon	216-432kWh/yr	Based on a 19"-21" screen size and 6 hr/day. ADL assumed 12 months per year usage [HEI, 1997]
Kennebunk Light & Power District	48kWh/mon	576kWh/yr	National Energy Information Center, Information is over 8 yrs old. ADL assumed 12 months per year usage [KLPD, 1997]
Narragansett Electric Company	25-33 kWH/mon	300-396 kWh/yr	Conditional Demand Survey, 1995 Information reported in Narragansett's Web Site [NEES, 1997]
Southern Alabama Electric Cooperative	13kWh/mon	156kWh/yr	Info. from National Energy Information Center. ADL assumed 12 months per year usage [SAEC2, 1998]
Walton EMC	40kWh/mon	480 kWh/yr	Info. from ACEEE brocheur. ADL assumed 12 months per year usage [WaltonEMC, 1997]
LBNL	141 kWh/yr	141 kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Central Maine Power Company	180 hr/mon	2160hr/yr/HH	Estimation of 6 hr/day/HH. ADL assumed 12 months per year usage [CMPCO, 1997]
Energy Cost for Household Appliances	6hr/day	2190hr/yr	Estimation: Hawiian Electric Company. ADL assumed 365 days per year of use [HEI, 1997]
Leaking Electricity: Standby and Off Mode Power	6844hy/yr (standby)	6844hr/yr (standby)	Assumed always plugged in. Estimation based on EPA, LBNL and people. [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	1916 hr/yr	1916 hr/yr	Estimation based on EPA, LBNL and people [Suozzo, 1997]

Neilsen Media (Canadian)	23hr12min/pers/wk		[Nielsen, 1996]
TV & VCR Calculation Spreadsheet	28hr/wk	1456hr/yr	Estimated by Webber [Webber, 1997] (Information cited below by LBNL)
Veronis, Schuler & Associates Communications Industry Forcast	1567hr/person/yr TV		TV usage. 1996 Data [Veronis, 1997]
Veronis, Schuler & Associates Communications Industry Forcast	49hr/per/yr Home Video		1997 Data [Veronis, 1997]
Energy Specs: Appliances	6hr/day	2190hr/yr	California Energy Commission Estimation. ADL assumed 365 days per year of usage [CEC, 1997]
LBNL	**1456 hr/yr**	**1456 hr/yr**	**Estimation by Webber [LBL-40295, 1998]**
Wattage Information			
Cental Maine Power Company	100W	100W	19" screen, (the standard size). Manufacturer information [CMPCO, 1997]
Leakage Summary Table	4W (standby)	4W (standby)	Metered by Huber [Huber, 1997] (Information cited below by Webber)
Leaking Electricity: Standby and Off Mode Power	5.9W (standby)	5.9W (standby)	Sales Weighted Average from CEMA (current items) [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	75W	75W	Sales Weighted Average from CEMA (current items) [Suozzo, 1997]
Manufacturer Spreadsheet	**45-75W**	**60W**	**Dependent on Screen Size. Manufacturer Customer Service (Thomson Consumer Electronics) [Thomson, 1997] We used an average of this range**
Manufacturer Spreadsheet	160W	160W	27" screen; Manufacturer Customer Service (Sony) [Sony, 1997]
Manufacturer Spreadsheet	185W	185W	32" screen; Manufacturer Customer Service (Sony) [Sony, 1997]
Manufacturer Spreadsheet	200W;120W	200W;120W	36"-31"screen size. Manufacturer Customer Service (Matushita) [Matsushiita, 1997]
Seattle City Light	250W	250W	Avg wattage taken off tag of unit found in the employ storage room. [SCL,1997]
Southpower	150W	150W	A New Zealand Utiliy [So.Power, 1997]
TV & VCR Calculation Spreadsheet	76.8W	76.8W	Metered by Webber [Webber, 1997]
TV & VCR Calculation Spreadsheet	**4W (standby)**	**4W(standby)**	**Metered by Webber [Webber, 1997] (Information from Huber cited below by LBNL)**
Sylvan	3W (standby)	3W (standby)	Energy Star standby criteria [Sylvan, 1998]
Energy Specs	200W	200W	[CEC, 1997]
LBNL	77W	77W	Estimated by Webber [LBL-40295, 1998]
LBNL	4W(standby)	4W (standby)	Estimated by Webber [LBL-40295, 1998]
Lifetime Comparison			
Appliance [Appliance2, 1997]			[LBL-40295, 1998]

Low 10 years		Avg 11 years	
Avg 11 years			
High 12 years			
US DOE 1993c (19” and 20”)			
Avg 11.5 years			

Compact Audio System

			**Bolded entries signifies information utilized within this report.
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
Leaking Electricity: Standby and Off Mode Power	0.5375	0.5375	An LBNL Number [Suozzo, 1997]
Appliance Magazine	70.0%	0.7	[Appliance2, 1997]
Vintaging Model	30.37 million units	0.3	See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.
LBNL	**53.21 million units**	**0.537**	**LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]**
KWH Information			
LBNL	94 kWh/yr	94 kWh/yr	Metered by LBNL [LBL-40295, 1998]
Usage Information			
Leaking Electricity: Standby and Off Mode Power	8395 hr/yr (standby)	8395 hr/yr (standby)	Assumed always plugged in. [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	**365 hr/yr**	**365hr/yr**	**Estimation by ACEEE [Suozzo, 1997]**
LBNL	365hr/yr	365hr/yr	Estimation by Sanchez; 1 hr/day [LBL-40295, 1998]
Wattage Information			
Leaking Electricity: Standby and Off Mode Power	10.9W (standby)	10.9W (standby)	Metered by LBNL [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	22.2W	22.2W	Metered by LBNL [Suozzo, 1997]
Leakage Summary Table	**10.6W (standby)**	**10.6W (standby)**	**Metered Data collected by Huber [Huber, 1997] (Information cited below by LBNL)**
LBNL	**15W**	**15W**	**Metered Data collected by Huber [LBL-40295, 1998]**
	10.6W (standby)	10.6W(standby)	Metered Data collected by Huber [LBL-40295, 1998]
Lifetime Comparison			
Appliance: [Appliance2, 1997]		[LBL-40295, 1998]	
Low 4 years		Avg 15 years	
Avg 7 years			
High 10 years			

Computer

			****Bolded entries signifies information utilized within this report.**
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
CGHES p 234-235	.1-.2	.1-.2	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Housing Characteristics	0.233	0.233	[RECS-HC, 1993]
NPR	42%		Penetration. Cited by Scott Miller, Industry Analyst from Dataquest. [NPR, 1998]
Appliance Magazine	40.10%	0.401	[Appliance2, 1997]
Vintaging Model	56.47 million units	0.56	See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.
LBNL	**21.25 million units**	**0.2145**	**LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]**
KWH Information			
Central Maine Power Company	72kWh/mon	864kWh/yr	'ADL assumed12 months per year of usage. Based wattage & usage [CMPCO, 1997]
CGHES pg 234-235	25-400kWh/yr	25-400kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Energy Cost for Household Appliances	48kWh/day	12480kWh/yr	Based on 5 day/wk per year usage Hawaiian Estimation: Disk drive and Monitor based on 200W for 2hr/day [HEI, 1997]
Narragansett Electric Company	13-17kWh/mon	156-204kWh/yr	DOER, Mass Division of Energy Resources literature for Inclusion in ECS Residential Energy Audit, Information reported in Narragansett's Web Site. [NEES, 1997]
Miscellaneous Electric Use (ACEEE)	130 kWh/yr	130kWh/yr	ACEEE [Nore, 1994]
LBNL	156 kWh/yr	156kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Central Maine Power Company	120hr/mon	1440hr/yr	'ADL assumed12 months per year of usage. Customer Survey of 4 hrs/day avg usage [CMPCO, 1997]
Miscellaneous Electric Use (ACEEE)	8hr/day	2080hr/yr	Based on 5 day/wk by ACEEE [Nore, 1994]
Energy Cost for Household Appliances	8hr/dy	2080hr/yr	Based on 5 day/wk & Hawaiian Electric Estimation [HEI, 1997]
Leaking Electricity: Standby and Off Mode Power	4555hr/yr (standby)	4555hr/yr(standby)	When they are off.. they are off (no power consumption) [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	4205hr/yr	4205hr/yr	Koomey "Efficiency Improvements in US Office Equipment", LBNL Report [Suozzo, 1997]
LBNL	**1337hr/yr**	**1337hr/yr**	**1/5 HH operated like an office (9% active:26% stdby) all others active 2hr/day, stdby 15min turn off computer complete when not in use (Sanchez, Huber, Koomey) [LBL-40295, 1998]**

Wattage Information			
Central Maine Power Company	600W	600W (monitor and diskdrive)	Monitor and Disk Drive based on manufacturer information. [CMPCO, 1997}
Miscellaneous Electric Use (ACEEE)	200W	200W	Large PC [Nore, 1994]
Manufacturer Spreadsheet	**(120V)(1.1A)-monitor**	**132W- monitor (active)**	**Manufacturer Customer Service (IBM) [IBM, 1997]**
Manufacturer Spreadsheet	**30W (idle)**	**30W Drive (idle)**	**Manufacturer Customer Service (IBM) [IBM, 1997]**
Manufacturer Spreadsheet	**50W (active)**	**50W Drive (active)**	**Manufacturer Customer Service (IBM) [IBM, 1997]**
Seattle City Light	300W	300W	Avg wattage taken off tag of unit found in the employ storage room. [SCL, 1997]
Southpower	120W max	120W max	A New Zealand Utility [So.Power, 1997]
LBNL	65W	65W (harddrive & monitor)	Assume pre-EnergyStar- from Koomey et al 1996. Office equipment report [LBL-40295, 1998]
LBNL	65W (standby)	65W (idle)	Assume pre-EnergyStar- from Koomey et al 1996, No sleep mode. Office equipment report [LBL-40295, 1998]
Lifetime Comparison			
Appliance: [Appliance2, 1997]			
Low	4 years		
Avg	6 years		
High	8 years		

Dehumidifier

			**Bolded entries signifies information utilized within this report.
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
1997 Major Appliance Industry Fact Book	0.149	0.149	source: Home Appliance Saturation & Length of First Ownership Study; 1991, NFO Research Inc. [AHAM, 1997]
CGHES pg 234-235	.1-.13	.1-.13	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Housing Characteristics	0.094	0.094	[RECS-HC, 1993]
Appliance Magazine	18.0%	0.18	[Appliance2, 1997]
Vintaging Model	7.01 million units	0.07	See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.
LBNL	10.92 million units	0.11	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
AHAM Spreadsheet	140 kWh/yr	140 kWh/yr	[AHAM SPDSHT, 1997]
Central Maine Power Company	**324 kWh/mon**	**1620 kWh/yr**	**Average metering, along with the wattage x usage information. 'ADL assumed 5 months per year of usage [CMPCO, 1997]**
CGHES pg 234-235	200-1000 kWh/yr	200-1000 kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Kennebunk Light & Power District	175 kWh/mon	875 kWh/yr	National Energy Information Center. Information is up to 8 yrs old.[KLPD, 1997] ADL assumed 5 months per year of usage.
Narragansett Electric Company	45-59 kWh/mon	540-708 kWh/yr	Conditional Demand Survey, 1995 reported in Narragansett's WebSite [NEES, 1997]
Walton EMC	576kWh/mon	2880 kWh/yr	Info. from ACEEE Brochure.[WaltonEMC, 1997] ADL assumed 5 months per year of usage
LBNL	400 kWh/yr	400 kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Central Maine Power Company	360 hr/mon	1620 hr/yr	[CMPCO, 1997] ADL assumed 3 months at 369 hr/mon and 3 months at 180 hr/mon.
LBNL	--	--	Usage not Available; Meier et al 1992, Table 2 [LBL-40295, 1998]
Wattage Information			
AHAM Spreadsheet	1200W	1200W	[AHAM SPDST,1997]
Central Maine Power Company	900W	900W	Average metered value. [CMPCO, 1997]
Manufacturer Spreadsheet	(115V)(15A)	1725W	Whirlpool Customer Service [Whirlpool, 1997]
Manufacturer Spreadsheet	(115V)(8.8A)	1012W	GE Customer Service [GE, 1997]
Southpower	200-400W	200-400W	A New Zealand Utility [So.Power, 1997]
Ebac, Inc.	(115V)(4A)	460W	Model CD-35, 17 pint [Ebac, 1998]
Ebac, Inc.	(115V)(5A)	575W	Largest model, up to12 gallon capacity [Ebac, 1998]
Whirlpool	**582W/577W/635W**	**600W**	**25 pint system/ 40 pint system/ 50 pint system. ADL assumed the avg wattage. [Whirlpool, 1998]**
LBNL	--	--	Wattage not Available. Meier et al 1992 [LBL-40295, 1998]
Lifetime Comparison	Appliance: [Appliance2, 1997]		[LBL-40295,1998]

	Low 6 years Avg. 8 years High 10 years	Avg. 15 years

Dishwasher

			****Bolded entries signifies information utilized within this report.**
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
1997 Major Appliance Industry Fact Book	**0.596**	**0.569**	**Source: Home Appliance Saturation & Length of First Ownership Study; 1991, NFO Research Inc. [AHAM, 1997]**
CGHES pp 234-235	.38-.5	.38-.5	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Housing Characteristics	0.452	.452+	[RECS-HC, 1993]
Appliance Magazine	54.90%		Penetration [Appliance2, 1997]
Vintaging Model	36.68 million units	0.36	See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.
LBNL	46.59 million units	0.47	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
AHAM Spreadsheet	165 kWh/yr	165 kWh/yr	[AHAM SPDSHT, 1997]
Central Maine Power Company	30 kWh/mon	360 kWh/yr	Average metering, along with the wattage x usage information. ADL assumed 12 months per year of usage [CMPCO, 1997]
CGHES pp 234-235	75-500kWh/yr	75-500 kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Description of Electrical Energy Use in Single	**121 kWh/yr**	**121 kWh/yr**	**Metered data; no water heating [BPA, 1992]**
Energy Cost for Household Appliances	25 kWh/mon	300 kWh/yr	Takes into consideration a heating element (1200W). ADL assumed 12 months per year of usage [HEI, 1997]
Kennebunk Light & Power District	3kWh/mon	36 kWh/yr	National Energy Information Center. Information is over 8 yrs old. ADL assumed 12 months per year of usage [KLPD, 1997]
Manufacturer Spreadsheet	avg 695 kWh/yr	avg 695 kWh/yr	Whirlpool Customer Service; [Whirlpool, 1997]
Manufacturer Spreadsheet	186 kWh/yr	186 kWh/yr	Maytag Customer Service; Gas water heating, based on 322 cycles/yr [Maytag, 1997]
Narragansett Electric Company	30-39 kWh/mon	360-468 kWh/yr	NEES - Tips for Saving Energy 1992, Information reported in Narragansett's Web Site [NEES 1997]
Southern Alabama Electric Cooperative	35 kWh/mon	420 kWh/yr	Info. from National Energy Information Center. ADL assumed 12 months per year of usage [SAEC2. 1998]
Walton EMC	1kWh/load	322 kWh/yr	Operation only; not water heating: Info based on ACEEE brochure. [WaltonEMC, 1997]

LBNL	159 kWh/yr	159 kWh/yr	LBNL:[LBL-40295, 1998]
Usage Information			
Central Maine Power Company	**25hr/mon**	**300hr/yr**	**Based on 1 cycle/day, 50 min/cycle and the average metering information [CMPCO, 1997]**
Energy Cost for Household Appliances	1 load/day	365 cycles/yr	Estimation - Hawaiian Electric Company 365 day/yr [HEI, 1997]
Energy Specs: Appliances	1load/day	365 cycles/yr	California Energy Commission Estimation. 365 day/yr [CEC, 1997]
DOE	392cycles/hr	392cycles/yr	[DOE, 1997]
LBNL	229 hr/yr	229 hr/yr	US DOE 1990; Based on the number of cycles/yr [LBL-40295, 1998]
Wattage Information			
AHAM Spreadsheet	1201W	1201W	[AHAM SPDSHT, 1997]
Central Maine Power Company	1200W	1200W	Manufacturer mechanical & booster heater info along with the avg metered information [CMPCO, 1997]
Manufacturer Spreadsheet	max (11A)(120V)	max (11A)(120V)	Maytag Customer Service [Maytag, 1997]
Manufacturer Spreadsheet	(8.6A)(120V)	(8.6A)(120V)	GE Customer Service [GE, 1997]
Seattle City Light	1400W	1400W	Avg wattage taken off tag of unit found in the employ storage room. [SCL, 1997]
Energy Specs: Appliances	1300W	1300W	With a booster heater [CEC, 1997]
LBNL	694W	694W	US DOE 1990; Based on the motor energy/cycle [LBL-40295, 1998]
Lifetime Comparison			
Appliance [Appliance2, 1997]			
Low	7 years		
Avg	9 years		
High	12 years		

Furnace Fan

			****Bolded entries signifies information utilized within this report.**
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
CGHES	.45-.6	.45-.6	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
Housing Characteristics	**0.362 (natural gas)**	**0.362 (natural gas)**	**Saturation of natural gas central warm air furnaces [RECS-HC, 1993]**
Housing Characteristics	**0.047 (fuel oil)**	**0.047 (fuel oil)**	**Saturation of fuel oil central warm air furnaces [RECS-HC, 1993]**
Appliance Magazine	0.683 (natural gas)	0.683 (natural gas)	Saturation of natural gas furnaces [Appliance2, Sept. 1997]
Appliance Magazine	0.12 (fuel oil)	0.12 (fuel oil)	Saturation of fuel oil furnaces [Appliance2, Sept. 1997]
LBNL	42.89million units	0.433	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
CGHES	300-1500kWh/yr	300-1500kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
Central Maine Power Company	80kWh/mon	400kWh/yr	ADL assumed 5 months per year of usage. Average metering, along with the wattage x usage information [CMPCO, 1997]
Kennebunk Light & Power District	400kWh/mon	2000kWh/yr	ADL assumed 5 months per year of usage. National Energy Information Center, Information is over 8 yrs old KLPD, 1997]
Narragansett Electric Company	80-104kWh/mon	1248kWh/yr	DOER, Mass Division of Energy Resources literature for Inclusion in ECS Residential Energy Audit, Information reported in Narragansett's Web Site. [NEES 1997]
LBNL	500kWh/yr	500kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Central Maine Power Company	**270hr/mon**	**1350hr/yr**	**ADL assumed 5 months per year of usage. Avg metered information. Cycles longer than burner motor. [CMPCO, 1997]**
LBNL	--	--	Usage not provided [LBL-40295, 1998]
Wattage Information			
Central Maine Power Company	**295W**	**295W**	**Avg metering information. [CMPCO, 1997]**
Seattle City Light	200W	200W	Avg wattage taken off tag of unit found in the employ storage room. [SCL, 1997]
LBNL	--	--	Wattage not provided. [LBL-40295, 1998]

Microwave Oven

			**Bolded entries signifies information utilized within this report.
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
1997 Major Appliance Industry Fact Book	**0.9**	**0.9**	**source: Home Appliance Saturation & Length of First Appliance Ownership Study; 1991, NFO Research Inc. [AHAM, 1997]**
CGHES	.7-.9	.7-.9	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
Leaking Electricity: Standby and Off Mode Power	0.7917	0.7917	An LBNL Number [Suozzo, 1997]
Housing Characteristics	0.841	0.841	[RECS-HC, 1993]
Appliance Magazine	90.60%	0.906	[Appliance2, 1997]
Vintaging Model	91.7 million units	0.9	See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.
LBNL	78.37 million unit	0.791	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
AHAM Spreadsheet	100kWh/yr	100kWh/yr	[AHAM SPDSHT, 1997]
Central Maine Power Company	6 kWh/mon	72 kWh/yr	Based on the usage and the wattage. ADL assumed 12 months per year of usage [CMPCO, 1997]
CGHES	50-300kWh/yr	50-300kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
CGHES	.36kWh/day	131.4kWh/yr	ACEEE publication with table referencing LBNL. ADL assumed 365 days per year of usage [ACEEE, 1996, p 188-189]
Energy Cost for Household Appliances	15 kWh/day	5475 kWh/yr	Based on High Power at 1500W. ADL assumed 365 days per year of usage [HEI, 1997]
Kennebunk Light & Power District	40 kWh/mon	480 kWh/yr	National Energy Information Center. Information is over 8 yrs old. ADL assumed 12 months per year of usage. [KLPD, 1997]
Narragansett Electric Company	21-27 kWh/mon	252-324 kWh/yr	Conditional Demand Survey, 1995 reported in Narragansett's WebSite [NEES, 1997]
Southern Alabama Electric Cooperative	16kWh/mon	192kWh/yr	Info. from National Energy Information Center. ADL assumed 12 months per year of usage [SAEC2, 1998]
Walton EMC	1.2kWh/ one hr use	109.5 kWh/yr	ADL estimate based on 15min/day for 365 days per year of usage [WaltonEMC, 1997]
Molinder	15.98 kWh/yr	15.98 kWh/yr	EU average (not weighted) [Molinder, 1997]
LBNL	144kWh/yr	144kWh/yr	LBNL: [Sanchez Summary Tables]
Usage Information			
Central Maine Power Company	**6 hr/mon**	**72hr/yr**	**Estimation from a customer survey. [CMPCO, 1997] ADL assumed 12 months per year of usage.**

CGHES	15 min/day	91.25 hr/yr	ACEEE. [ACEEE, 1996, p 188-189] ADL assumed 365 day of usage.
Energy Cost for Household Appliances	20min/day	121.67hr/yr	Estimation. ADL assumed 365 days per year of usage [HEI, 1997]
Leaking Electricity: Standby and Off Mode Power	8682 hr/yr (standby)	8682hr/yr (standby)	Assumed always plugged in. Estimation by ACEEE [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	78hr/yr	78hr/yr	Estimation by ACEEE. ~13 min/day [Suozzo, 1997]
Energy Specs: Appliances	30min/day	182.5hr/yr	California Energy Commission Estimation. [CEC, 1997] ADL assumed 365 days per year of usage
Vintaging Model	62hr/yr	62hr/yr	Estimated for 2000. See Vintaging Analysis for Microwave Oven Usage Times. Appendix B.
Vintaging Model	56.2hr/yr	56.2hr/yr	Estimated for 2005. See Vintaging Analysis for Microwave Oven Usage Times. Appendix B.
Vintaging Model	55.6hr/yr	55.6hr/yr	Estimated for 2010. See Vintaging Analysis for Microwave Oven Usage Times. Appendix B.
LBNL	78hr/yr	78hr/yr	15min/day - 6day/wk: estimated by Sanchez [LBL-40295, 1998]
Wattage Information			
AHAM Spreadsheet	1450W	1450W	[AHAM SPDSHT, 1997]
Energy Cost for Household Appliances	1500W	1500W	Based on High Power [HEI, 1997]
Leakage Summary Table	**3.1W (standby)**	**3.1W (standby)**	**Metered by Huber [Huber, 1997] (Information cited below by LBNL)**
Leaking Electricity: Standby and Off Mode Power	3.7W (standby)	3.7W (standby)	LBNL metered data that was verified by other sources [Suozzo, 1997]
Seattle City Light	1600W	1600W	Avg wattage taken off tag of unit found in the employ storage room. [SCL, 1997]
Southpower	1400W	1400W	A New Zealand Utility [So.Power, 1997]
Energy Specs: Appliances	**1500W**	**1500W**	**[CEC, 1997]**
Sharp Electronics	1100-1650W	1500W	70% of microwaves sold have the highest wattage. [Daniel, 1998]
LBNL	3.1W (standby)	3.1W (standby)	Standby metered by Huber [LBL-40295, 1998]
LBNL	1500W	1500W	Active power from Davis Energy Group [LBL-40295, 1998]
Lifetime Comparison			
Appliance [Appliance2, 1997]			
Low 8 years			
Avg 10 years			
High 12 years			

Pool Pump

			**Bolded entries signifies information utilized within this report.
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
CGHES pg 234-235	.04-.06	.04-.06	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Housing Characteristics	**0.048**	**0.048**	**[RECS-HC, 1993]**
NSPI	3362000 pools		Inground pools [NPSI, 1994]
NSPI	3211000 pools		Above ground pools [NPSI, 1994]
LBNL	4.29 million units	0.0433	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
CGHES pg 234-235	500-4000kWh/yr	500-4000kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Central Maine Power Company	268kWh/mon	1070kWh/yr	ADL assumed 4 months per year of usage. Average metering, along with the wattage x usage information [CMPCO, 1997]
Energy Cost for Household Appliances	240kWh/mon	960kWh/yr	ADL assumed 4 months per year of usage. Hawaiian Electric Company: 1000W at 8 hr/day [HEI, 1997]
Kennebunk Light & Power District	410kWh/mon	1640kWh/yr	ADL assumed 4 months per year of usage. National Energy Information Center, Information is 8+yrs old) [KLPD, 1997]
Narragansett Electric Company	630-820kWh/mon	3150-4100kWh/yr	DOER, Mass Division of Energy Resources literature for Inclusion in ECS Residential Energy Audit, Information reported in Narragansett's Web Site. [NEES, 1997]
Southern Alabama Electric Cooperative	25kWh/mon	100kWh/yr	ADL assumed 4 months per year of usage. Info. from National Energy Information Center. [SAEC2, 1997]
Walton EMC	354kWh/mon	1416kWh/yr	ADL estimate from 4 month of usage. Info. from ACEEE brochure. [WaltonEMC, 1997]
LBNL	1500kWh/yr	1500kWh/yr	LBNL: Summary Tables [LBL-40295, 1998]
Usage Information			
Central Maine Power Company	360hr/mon	1080hr/yr	Is based on 3 mon per year for 12 hr/day [CMPCO, 1997]
Energy Cost for Household Appliances	8hr/day	976 hr/yr	ADL assumed 4 months per year of usage: Hawaiian Electric. [HEI, 1997]
Solar Living Sourcebook	4 hr/day (Summer)		Metered data by the FSEC [RGTC, 1994]
Solar Living Sourcebook	2hr/day (Winter)		Metered data by the FSEC [RGTC, 1994]
Walton EMC	1/2 day operation	1836hr/yr	ADL assumed 153 day/yr of usage. Info based on ACEEE brochure. [WaltonEMC, 1997]
ADL	**792 hr/yr**	**792 hr/yr**	**ADL estimate based on 1 month at 8 hr/day for 30 days, 2 months at 6 hr/day for 31 days and 1 month at 6 hr/day for 30 days**
LBNL	--	--	Usage not Available. Meier et al 1992 [Sanchez Summary Tables}
Wattage Information			
Central Maine Power Company	746W	746W	Avg wattage (1HP) and avg metering [CMPCO, 1997] Appears not to account for motor information.
Seattle City Light	1100W	1100W	Avg wattage taken off tag of unit found in the employ storage room. [SCL, 1997]
Southpower	**1000W**	**1000W**	**A New Zealand Utiliy [So.Power, 1997]**

ADL	913W	913W	ADL engineering estimate based on 70 gal/min, 15 psi pressure and 50% efficiency.
LBNL	--	--	Wattage not Available. Meier et al 1992 [LBL-40295, 1998]

RACK Audio System

			****Bolded entries signifies information utilized within this report.**
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
Appliance Magazine	**55%**		**Penetration. [Appliance2, 1997]**
LBNL	54.58 million units	0.551	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
LBNL	81kWh/yr	81kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Leaking Electricity: Standby and Off Mode Power	8395hr/yr (standby)	8395hr/yr (standby)	Assumed always plugged in. Estimation by ACEEE [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	**365hr/yr**	**365hr/yr**	**Estimation based on various "How people spend there free time" surveys [Suozzo, 1997]**
LBNL	365hr/yr	365hr/yr	Estimation by Sanchez: assume 1 hr/day, 365 day/yr [LBL-40295, 1998]
Wattage Information			
Leakage Summary Table	**5.8W (standby)**	**5.8W (standby)**	**Metered data collected by Huber [Huber,1997]**
Leaking Electricity: Standby and Off Mode Power	4.2W (standby)	4.2W (standby)	Metered LBNL data [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	44.6W	44.6W	Metered LBNL data [Suozzo, 1997]
LBNL	***60W***	***60W***	***Metered data collected by Huber [LBL-40295, 1998]***
LBNL	7W (standby)	7W (standby)	Metered data collected by Huber [LBL-40295, 1998]

Torchiere Lamp - Halogen

			****Bolded entries signifies information utilized within this report.**
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
Bright Prospects for CFL Torchieres	40 million	0.399	Chris Calwell: ADL based this on 100.37 million HH [HE, 1997]
ECOS	81%		Penetration of dorm rooms with torchiere lamps [ECOS, 1998]
Consumer Prodect Saftey Commission	**30 -40 million units**	**35-40%**	**[CPSC, 1996]**
LBNL	30.22million units	0.305	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
LBNL	394 kWh/yr	394kWh/yr	LBNL: Summary Tables [LBL-40295, 1998]
Usage Information			
Solar Living Sourcebook	**at least 4+ hr/day**	**1460hr/yr+**	**FSEC estimation. ADL estimate for 365 days of usage [RGTC, 1994]**
ECOS	39 hr/wk	2028hr/yr	ECOS: in dorm rooms. ADL estimate for 12 months of usage [ECOS, 1998]
LBNL	4hr/day	1460hr/yr	Chris Calwell. ADL estimate of 365 days of usage [LBL-40295, 1998]
Wattage Information			
Bright Prospects for CFL Torchieres	300-600W	300-600W	Chris Calwell [HE, 1997]
Telephone Communication	**300W**	**300W**	**Chris Calwell [Calwell, 1998]**
Solar Living Sourcebook	300-400+W	300-400+W	Metered by FSEC [RGTC,1994]
Underwriters Laboratory	300W max	300W max	Bruce Bohren at UL [UL, 1997]
LBNL	270W	270W	Chris Calwell- 270 watts/lamp [LBL-40295, 1998]

VCR

			**Bolded entries signifies information utilized within this report.
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
CGHES pg 234-235	.6-.7		Penetration. ACEEE publication with table referencing LBNL [ACEEE, 1996]
Leaking Electricity: Standby and Off Mode Power	1.36	1.36	*LBNL. Based on 98.9 million households [Suozzo, 1997]*
Notebook	0.82		Penetration. Neilsen Media Research Center [Nielsen, 1997]
Media Facts	0.85		Penetration. AAA Executive Summary of Television Production Cost Survey [CM, 1997]
Media Dynamics	**see notes**	**1.21**	**89% of Households that have TVs have a VCR (54% of households that have TVs have one VCR. 35% of households that have TVs have 2 or more VCRs) See footnote on p. 6-13 for calculations. [MD-TVD, 1998]**
Appliance Magazine	88.30%	0.883	Penetration. [Appliance2, 1997]
Vintaging Model	139.38 million units	1.37	See Vintaging Analysis for Saturation of Miscellaneous End Uses. Appendix B.
LBNL	119.52 million unit	1.207	LBNL: (1995 data divided by 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
CGHES pg 234-235	10-70kWh/yr	10-70kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996]
Energy Cost for Household Appliances	1.5kWh/mon	18kWh/yr	ADL assumed 12 months per year of usage. Hawaiian Electric Company: based on 25 W at 2 hr/day [HEI, 1997]
Walton EMC	10kWh/mon	120kWh/yr	ADL assumed 12 months per year of usage. Info. from ACEEE Brochure. [WaltonEMC, 1997]
LBNL	58kWh/yr	58kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Energy Cost for Household Appliances	2hr/day	730hr/yr	[HEI, 1997]
Leaking Electricity: Standby and Off Mode Power	6785 hr/yr (standby)	6785hr/yr (standby)	Assumed always plugged in. [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	1975 hr/yr	1975hr/yr	Estimation: ON time 1721 hr/yr; play/rec time 253.7 hr/yr : Assumed always plugged in. [Suozzo, 1997]
Media Dynamics	1.9 hr/wk (record)	98.9 hr/yr	ADL assumed 52 weeks of usage per year. [MD-TVD, 1998]
Media Dynamics	4 hr/wk (play)	208 hr/yr	ADL assumed 52 weeks of usage per year. [MD-TVD, 1998]
Media Facts	**1.5 Rec/3.5 Play**	**78hr/yr Rec/182hr/yr**	**AAA Executive Summary of Television Production Cost Survey [CM, 1997]**

		Play	(Information cited below by Webber)
TV & VCR Calculation Spreadsheet	24 hr/wk ON	1248hr/yr ON	Webber, Assume that the VCR is on whenever the TV is on. Playing and recording is separate.[Webber,1997]
TV & VCR Calculation Spreadsheet	1.5hr/wk Record	78 hr/yr Record	AAA Executive Summary of Television Production Cost Survey; Media Facts [Webber, 1997] (Information cited below by LBNL)
TV & VCR Calculation Spreadsheet	3.5hr/wk Play	182hr/yr Play	AAA Executive Summary of Television Production Cost Survey; Media Facts [Webber, 1997] (Information cited below by LBNL)
TV & VCR Calculation Spreadsheet	144 hr/wk OFF	7488hr/yr	Assumed plugged in at all times. Off the same amount of time the TV is Off. [Webber, 1997]
LBNL	7246hr/yr (standby)	7246hr/yr (standby)	Carrie Webber [LBL-40295, 1998]
LBNL	78hr/yr (record)	78hr/yr (record)	Carrie Webber [LBL-40295, 1998]
LBNL	182hr/yr (play)	182hr/yr (play)	Carrie Webber [LBL-40295, 1998]
LBNL	1255hr/yr(on)	1255hr/yr(on)	Carrie Webber [LBL-40295, 1998]
LBNL	1515 hr/yr	1515 hr/yr	Carrie Webber, 1255hr ON, 78hr Record, 182 hr Play, 7246 Off [LBL-40295, 1998]
Wattage Information			
Energy Cost for Household Appliances	25W	25W	Personal Communication with Hawaiian Electric Company [HEI, 1997]
Leakage Summary Table	5.6W (standby)	5.6W (standby)	Averaged from FSEC and LBNL metered data [Huber, 1997] (Information cited below by LBNL)
Leaking Electricity: Standby and Off Mode Power	5.1W (standby)	5.1W (standby)	Sales weighted average from CEMA (current Items) [Suozzo, 1997]
Leaking Electricity: Standby and Off Mode Power	17/12.5W (play or record/on)	17/12.5W (play or record/on)	Sales weighted average from CEMA (current items) [Suozzo, 1997]
Media Facts	5.4W (standby)	5.4W (standby)	[CM, 1997, p 2]
Manufacturer Spreadsheet	23W	23W	Manufacturer Customer Service (Thomson Consumer Electronics) [Thomson, 1997]
LBNL	**5.4W (standby)**	**5.4W (standby)**	**Carrie Webber [LBL-40295, 1998]**
LBNL	**15.7W (record)**	**15.7W (record)**	**Carrie Webber [LBL-40295, 1998]**
LBNL	**15.7W (play)**	**15.7W (play)**	**Carrie Webber [LBL-40295, 1998]**
LBNL	**10.7W (on)**	**10.7W (on)**	**Carrie Webber [LBL-40295, 1998]**
LBNL	12W (avg)	12W (avg)	Carrie Webber [LBL-40295, 1998]
LBNL	5.6W	5.6W (standby)	Metered by Huber [LBL-40295, 1998]
Lifetime Comparison			
Low	10 years	Avg	11 years
Avg	11 years		
High	12 years		

Waterbed Heater

			****Bolded entries signifies information utilized within this report.**
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
CGHES	12 - 20%	0.12-0.2	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
Home Energy	**15-20%**	**0.15-0.2**	**[HE-2, 1994; p 1]**
LBNL	14.62 million units	0.148	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
Central Maine Power Company	114kWh/mon (K) : 89kWh/mon (Q)	1368kWh/yr(K):1068kWh /yr(Q)	Average metering, along with the wattage x usage information. ADL assumed 12 months per year of usage [CMPCO, 1997]
CGHES	500-2000 kWh/yr	500-2000kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
Narragansett Electric Company	83-108 kWh/mon (low-high use)	996-1296kWh/yr (low-high use)	DOER, Mass Division of Energy Resources literature for Inclusion in ECS Residential Energy Audit, Information reported in Narragansett's Web Site. [NEES, 1997]
Walton EMC	150-225 kWh/mon	1800-2700kWh/yr	Info based on ACEEE brochure. ADL assumed 12 months per year of usage [WaltonEMC, 1997]
Home Energy	1044kWh and 1404kWh	1044kWh and 1404kWh	Not Seasonal. Metered data of an Aqua Queen and Thermafoil heater, respectively, during March and April. [HE-2, 1994]
Home Energy	1500kWh/yr	1500kWh/yr	Calculated avg for baseline case- king size bed (with a quilted mattress pad, two sheets and a comforter) heated to 90 F in a 70 F room. [HE-3, 1988]
Home Energy	3.5kWh/day	1277.5kWh/yr	Metering done by Midwest Power in Des Moines, Iowa during a winter month. ADL assumed 365 days per year.[HE-2, 1994]
Home Energy	1636kWh/yr	1636kWh/yr	Metered by Columbus Southern Power. [HE-2, 1994]
LBNL	900kWh/yr	900kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Central Maine Power Company	**326 hr/mon (K) : 254 hr/mon (Q)**	**3912(K)-3051(Q) hr/yr**	**Metered and customer survey. ADL assumed 12 months per year of usage [CMPCO, 1997]**
LBNL	--	--	Usage not Available. Meier et al 1992 [Sanchez Summary Tables}
11.1.1.1.1.1 Wattage Information			
Central Maine Power Company	**350W (K&Q)**	**350W (K&Q)**	**Manufacturer information and avg metered information [CMPCO, 1997]**
Seattle City Light	300W	300W	Avg wattage taken off tag of unit found in the employ storage room.[SCL, 1997]
Home Energy	150, 330 and 380W	150, 330 and 380W	[HE-2, 1994]
LBNL	--	--	Wattage not Available. Meier et al 1992 [LBL-40295, 1998]

Well Pump

			****Bolded entries signifies information utilized within this report.**
Saturation Information	**Information Received from Source**	**Information Modified by ADL**	**Source and Miscellaneous Information**
CGHES p 234-235	.05-.2	.05-.2	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
Misc. Electric Energy Use (ACEEE)	.1-.15	.1-.15	ACEEE [ACEEE-2, 1997]
Housing Characteristics	**0.134**	**0.134**	**[RECS-HC, 1993]**
LBNL	11.89 million units	0.12	LBNL: (1995 data dividedby 99.06 million households in 1995) [LBL-40295, 1998]
KWH Information			
CGHES p 234-235	200-800kWh/yr	200-800 kWh/yr	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
Narragansett Electric Company	42-55kWh/mon	504-660kWh/yr	Conditional Demand Survey, 1995 reported in Narragansett's WebSite [NEES, 1997]
Walton EMC	10-20kWh/mon	120-240kWh/yr	ADL assumed 12 months per year of usage. Info. from ACEEE Brochure. [WaltonEMC, 1997]
ADL	83 kWh/yr	83 kWh/yr	ADL engineering estimate. See section 6-2
LBNL	400kWh/yr	400kWh/yr	LBNL: [LBL-40295, 1998]
Usage Information			
Misc Electric Energy Use (ACEEE)	few hours a day, at most	1095 hr/yr	[ACEEE-2,1997] 'ADL assumed 365 day usage. Based on 3 hr/day estimation ACEEE
ADL	**115hr/yr**	**115hr/yr**	**ADL Engineering Estimate (see Section 6.2)**
LBNL	--	--	Usage not Available. Meier et al 1992 [LBL-40295, 1998]
Wattage Information			
CGHES	.5-2kW	500-2000 W	ACEEE publication with table referencing LBNL [ACEEE, 1996, p 234-235]
LBNL	--	--	Wattage not Available. Meier et al 1992 [LBL-40295, 1998]
Other Information			
U.S. Census Bureau	27.6%	27.6%	Rural Households. American Housing Survey, 1995 [AHS, 1995]
	72.4%	72.4%	Urban Households, American Housing Survey, 1995 [AHS, 1995]

Vintaging Analysis for Microwave Oven Usage Times

Historical unit shipment data [Appliance, 1997] and unit shipment projections [Appliance3, Jan. 1998] were used to stock of microwaves in each year from 1997-2010. The vintaging model assumed that every microwave lasted *exactly* ten years, the average microwave lifetime [Appliance2, Sept. 1997].

The power input of microwave ovens, approximately 1500 watts, has remained consistent over the past decade, but their efficiencies have improved. In 1987, the output power of a typical microwave was 600 watts (40% efficient) [Daniel, April 1998]. In 1997, the typical output was 980 watts (65% efficient). Hence, even though the unitary power draw of microwaves has remained constant, the amount of use, or cooking time, has decreased due to improved efficiencies. Between the years 1987 and 1997 a straight-line efficiency gain was assumed. Industry sources suggest that microwave efficiency has "peaked" and hence we assumed it remained constant at 65% in the vintaging model for all the units introduced after 1997 [Daniel, April 1998].

A Central Maine Power survey [CMPCO, 1997] estimated an average annual usage of 72 hours for the existing stock of microwaves. The source did not specify the reference year, but we assumed it to be 1997. Using this estimate as a baseline, the ADL vintaging model projected the average annual microwave use by calculating the weighted unit output of the existing stock. As seen in Figure 1 and Table 1, average annual microwave use decreases from 72 hours in 1997 to roughly 56 hours in 2010, due to the replacement of older, less efficient units.

Vintaging Analysis for 1997 Saturations of Miscellaneous End Uses

Table 1 lists appliance saturation levels based on the 1997 existing stock, calculated from historical shipment data [Appliance, 1997]. This simplified analysis assumed that all equipment is used for its *exact* average lifetime, as reported in Appliance Magazine [Appliance2, 1997]. For example, the 1997 saturation of coffee makers (4 year average lifetime) is the sum of the unit shipments from 1993 to 1996, inclusive, divided by the number of 1997 households, 101.66 million.

Table 1: Small End Use Saturations in the Year 1997

End Use	Average Life (years)	Stock in the Year 1997 (thousands of units)	1997 Saturation	
			Vintage Model	Exhibit 6-9 Value
Coffee maker	4	56,470	56%	82%
Clothes Washer	13	87,191	86%	78%
Color TV	11	237,492	234%	225%
Compact Audio System	7	30,369	30%	54%
Computer	4-6	-	-	22%
Dehumidifier	8	7,008	7%	15%
Built In (Dishwasher)	9	36,677	36%	57%

The existing stock is calculated from *actual* historical shipment data (1987-1996) except for the those appliances having an average lifetime greater than 10 years, including VCRs, color televisions, and the clothes washers. For these appliances, unknown unit shipments prior to 1987 were set equal to 1987 unit shipments.

The only remaining exception is computers. Computer shipment data prior to 1996 were not available, therefore a historical vintaging analysis could not be performed. Computer shipment *projections* [Appliance3, 1998] are available, however, these projections are suspect. To illustrate, these forecasts were used to estimate the saturation of computers in the year 2000, shown in Table 2 below. The projected saturations for the year 2000 (172%) is far greater than the most optimistic saturation projections from other sources and it would appear to be unrealistic.

Table 2: Computer Saturation in the year 2000

End Use	Average Life (years)	Stock in the Year 2000 (thousands of units)	Saturation in the Year 2000[1]
computers	5	181,095	172%

1. Based on 105.34 million households in 2000.

Projected dehumidifier saturations were calculated between the years 1995 and 2003 using historical [Appliance, 1997] and projected [Appliance3, 1998] shipment data. The results of dehumidifier vintaging are shown in Table 3. The average annual saturation growth between 1995 and 2003 is 2.5%.

Appendix C

Backup Data for Exhibit 7-7													
Cable Penetration													
(% of US Households)													
		Basic Networks											
	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	1996	1997	1998
% of tv penetration	9%	67%	86%	95%	96%	97%	98%	98%	98%	98%	98%	98%	98%
% of TV Homes with Cable		1%	2%	2%	7%	12%	18%	43%	56%	63%	64%	65%	66%
% of TV Homes with Pay Cable							7%	26%	29%	28%	28%	28%	28%
% of TV Homes with Basic Cable		1%	2%	2%	7%	12%	11%	17%	27%	35%	36%	37%	38%
% of TV Homes without Cable		99%	98%	98%	93%	88%	82%	57%	44%	37%	36%	35%	34%
% of Total U.S. Households with Cable[1]			2%	2%	7%	12%	18%	42%	55%	62%	63%	64%	65%
% of Total U.S. Households with Pay Cable[1]							7%	26%	28%	27%	27%	27%	27%
% of Total U.S. Households with Basic Cable[1]			2%	2%	7%	12%	11%	17%	27%	34%	35%	36%	37%
[1] Percent of total households in each category represents percent of TV households in that category multiplied by percent of TV penetration													
[MD-TVD, 1998]													

Backup Data for Exhibit 7-12					
Television and Cable Usage					
(Hours per person per year)					
	Total Broadcast Television	**Basic Networks**	**Premium Channels**	**Home Video**	**Total**
1990	1120	260	90	38	1508
1991	1065	340	90	40	1535
1992	1073	359	78	42	1552
1993	1082	375	78	43	1578
1994	1091	388	81	45	1605
1995	1019	468	88	45	1620
1996	980	498	89	49	1616
1997	942	528	94	52	1616
1998	907	547	98	54	1606
1999	873	571	104	56	1604
2000	854	592	109	58	1613
2001	830	612	109	60	1611
[Veronis, 1997, p. 34-5]					

Backup Data for Exhibit 7-13													
Growth of TV Penetration													
		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	1996	1997
% of tv penetration		9%	67%	86%	95%	96%	97%	98%	98%	98%	98%	98%	98%
% of tv households with one set		99%	97%	88%	78%	65%	57%	50%	44%	36%	32%	29%	28%
% of tv households with two or more sets		1%	3%	12%	22%	35%	43%	50%	56%	64%	68%	71%	72%
% of Total Households with One Set[1]	1 Set	9%	65%	76%	74%	62%	55%	49%	43%	35%	31%	28%	27%
% of Total Households with Two or More Sets[1]	2+ Sets	0%	2%	10%	21%	34%	42%	49%	55%	63%	67%	70%	71%
[1] Percent of total households in each category represents percent of TV households in that category multiplied by percent of TV penetration													
[MD-TVD, 1998]													

Back-Up Data for Exhibit 7-16												
Radio and Recorded Music Usage												
(Hours per person per year)												
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Radio	1135	1115	1150	1082	1102	1091	1091	1089	1085	1076	1074	1072
Recorded Music	235	219	233	248	294	289	289	296	303	313	325	336
Total	1370	1334	1383	1330	1396	1380	1380	1385	1388	1389	1399	1408
[Veronis, 1997, p. 34-35]												

Back-Up Data for Exhibit 7-30																	
VCR Penetration																	
(% of Total U.S. Households)																	
Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
% of tv penetration	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
% of TV Homes with one VCR	0.03	0.04	0.06	0.11	20%	32%	42%	50%	51%	57%	57%	58%	59%	0.56	56%	55%	54%
% of TV Homes with two or more VCRs					2%	3%	6%	10%	11%	14%	18%	19%	20%	0.26	29%	31%	35%
% of total homes with one VCR	3%	4%	6%	11%	20%	31%	41%	49%	50%	56%	56%	57%	58%	55%	55%	54%	53%
% of total homes with two or more VCRs	0%	0%	0%	0%	2%	3%	6%	10%	11%	14%	18%	19%	20%	25%	28%	30%	34%
% of total homes with one or more VCRs	3%	4%	6%	11%	22%	34%	47%	59%	61%	70%	74%	75%	77%	80%	83%	84%	87%
Note: Percent of total households in each category represents percent of TV households in that category multiplied by percent of TV penetration																	
[MD-TVD, 1998]																	