Pacific Gas and Electric Company

Emerging Technologies Program

Application Assessment Report #0513

Consumer Electronics: Market Trends, Energy Consumption, and Program Recommendations 2005-2010

Issued:	December 2006
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Executive Summary

Stimulated by new technologies and lower selling prices, consumer electronics have become a prominent and growing source of home energy consumption. This report describes the market trends and energy characteristics for several consumer electronic devices that are rising in popularity among Pacific Gas and Electric Company (PG&E) Mass Market customers.[1] In 2005, the product categories studied in this report represented a stock of 60 million units in PG&E's Mass Market, or roughly 12.7 units per household. The resulting energy consumption was an estimated 4,550 million kilowatt-hours – 18% of the total Mass Market consumption. By 2010, this consumption could increase by 57% under "business-as-usual" conditions.

There are opportunities to dampen the growth in the energy consumption of consumer electronics through energy efficiency and conservation measures. This study is an initial step to highlight those opportunities and to help inform PG&E's Customer Energy Efficiency (CEE) programs.

The product categories covered are:

- Home and Small Commercial Office Equipment
- Televisions
- Set-Top Boxes
- Home Entertainment Systems
- Smart White Goods
- Personal Electronic Chargers

For each category, the market trends and energy consumption are presented for 2005 and are forecasted through 2010. We rely on two scenarios that characterize possible future outcomes:

- **Baseline Scenario** – A "business-as-usual" scenario that aims to reflect the average power draw and usage pattern for *all* the different devices being used within a certain equipment category.

- **Improved Case Scenario –** A scenario that reflects an increased amount of energy efficiency or conservation compared to the Baseline. In most cases, the Improved Case scenario reflects power levels for devices that are readily available on the market today.

Table 1-1 shows an overview of the major product categories analyzed for this report and the 33 unique electronic devices studied across all categories.[2]

[1] The PG&E Mass Market segment primarily includes single and multifamily residential customers in addition to small businesses that are not included in the other targeted market segments. See the Introduction Section for a more in depth description.

[2] Laptop PCs are discussed in both the Home and Small Office Equipment category and the Personal Electronic Chargers category. The Laptop PC values presented in the Home and Small Office Equipment category are for the *overall* unit energy consumption, whereas, the values presented in Personal Electronic Chargers section are specific to the battery charging system. To avoid double-counting, the values in the Personal Electronic Chargers section are not included in the grand totals.

Table 1 - 1 Current Study – Market Sector and Energy Consumption Overview

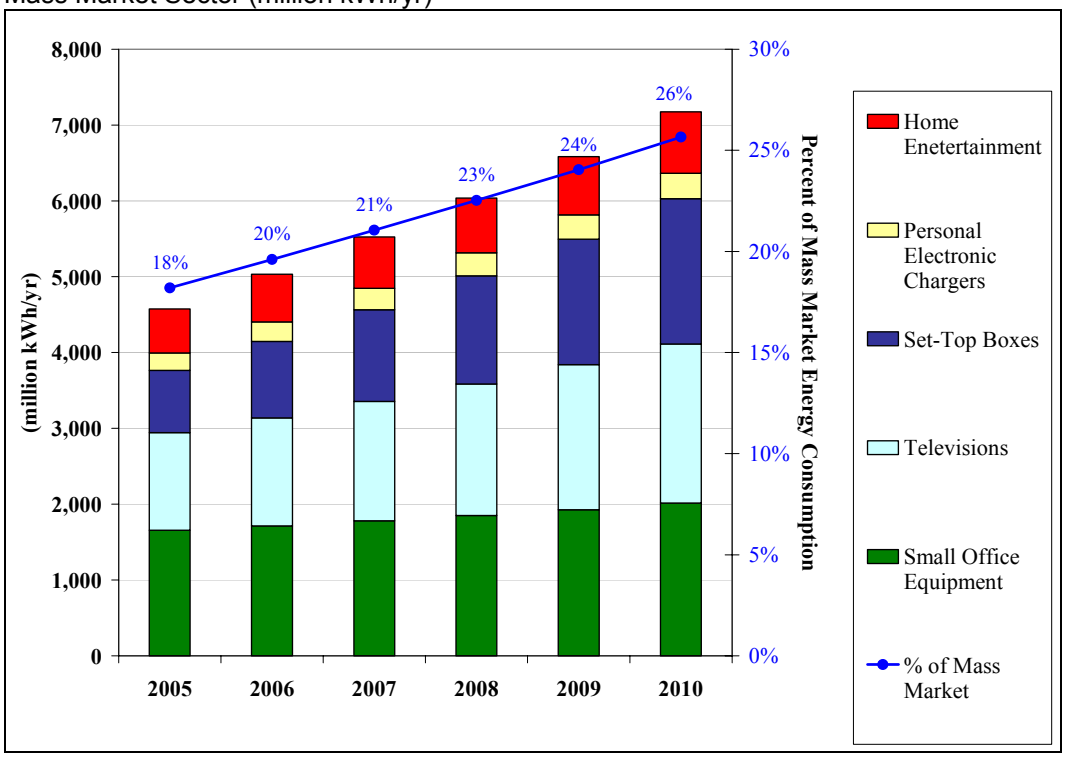
Product Category Technology / Device	2005 PG&E Mass Market Stock (000)	Units per PG&E household	Baseline Annual Energy Consumption (million kWh/yr)		
			2005	2010	% Change
Home & Small Office Equipment					
Desktop PCs	3,060	0.7	809	885	9%
Laptop PCs	1,930	0.4	143	220	54%
Monitors	3,060	0.7	209	229	9%
Inkjet Printers	1,980	0.4	42	27	-35%
Laser Printers	170	0.0	17	13	-24%
Scanners	870	0.2	39	25	-34%
Copiers	470	0.1	24	16	-34%
Fax machines	630	0.1	91	59	-35%
Multi-Function Devices	1,530	0.3	104	155	48%
Broadband Devices	1,940	0.4	153	310	103%
Home Router	390	0.1	20	36	77%
VoIP	140	0.0	5	39	686%
subtotal	*16,170*	*3.7*	*1,660*	*2,020*	*22%*
Televisions					
CRT	8,820	2.0	1,115	1,237	11%
LCD	520	0.1	56	348	517%
Plasma	190	0.0	53	287	437%
Projection	270	0.1	64	227	256%
subtotal	*9,800*	*2.2*	*1,290*	*2,100*	*63%*
Set-Top Boxes					
Digital cable box	2,100	0.5	334	616	84%
Digital satellite reciever	1,890	0.4	235	481	104%
Digital video recorders	930	0.2	246	736	199%
IPTV	40	0.0	5	81	1653%
subtotal	*4,960*	*1.1*	*820*	*1,910*	*133%*
Home Entertainment Systems					
DVD players	4,150	0.9	140	215	54%
Home theaters	900	0.2	104	167	61%
Component Stereo	1,600	0.4	212	243	14%
Compact Stereo	1,250	0.3	94	149	57%
Portable Stereo	1,600	0.4	30	38	28%
subtotal	*9,500*	*2.2*	*580*	*810*	*40%*
Personal Electronic Chargers					
Cell phones	5,740	1.3	75	101	34%
Cordless phones	5,230	1.2	69	68	-2%
Laptop PCs	1,930	0.4	25	39	54%
Digital camera	950	0.2	12	38	204%
Portable audio	1,700	0.4	22	51	126%
PDA's	340	0.1	4	12	168%
Rechargeable batteries	450	0.1	6	7	16%
Personal hygine	680	0.2	9	10	15%
Other / Misc.	510	0.1	7	10	45%
subtotal	*17,530*	*4.0*	*230*	*330*	*43%*
Current Study Total	**56,030**	**12.7**	**4,550**	**7,130**	**57%**
PG&E Mass Market			**25,000**	**27,800**	**11%**
Percent of PG&E Mass Market Energy Consumption			***18%***	***26%***	

The Smart White Goods category is not included in the Table because it has not gained significant traction within PG&E territory. A qualitative discussion of this category is presented in Section 4.5.

Figure 1-1 displays the forecasted Baseline annual energy consumption for the product categories and shows the cumulative total increasing 57% from 2005 to 2010 – from 4,550 million kilowatt-hours to 7,130 million kWh. Small office equipment represented the largest share of consumption in 2005 (1,660 million kWh), followed in order by televisions (1,290), set-top boxes (820), home entertainment systems (580), and personal electronic chargers (230). The distribution will shift over the next five years, primarily from increased penetration of set-top boxes and an evolving television segment. By 2010, set-top boxes will join televisions and small office equipment as the major energy consumers (roughly 1,900 to 2,100 million kWh), followed by home entertainment systems (810) and personal electronic chargers (330).

Figure 1-1 also highlights the impact of the energy consumption within PG&E's Mass Market segment. In 2005, the equipment studied in this report accounted for approximately 18% of the total Mass Market energy consumption.[3] In our Baseline scenario, this percentage increases significantly to 26% by 2010.

Figure 1 - 1 Forecasted Baseline Annual Energy Consumption – Consumer Electronics in PG&E Mass Market Sector (million kWh/yr)



[3] The energy consumption within PG&E's Mass Market was approximately 25,000 GWh in 2005, and is estimated to increase to 27,800 GWh by 2010. A detailed explanation of the Mass Market and these values is provided in this report's Introduction, Section 2.

The 18% value is comparable to results presented in the California Energy Commission's (2004) *California Statewide Residential Appliance Saturation Study*. The CEC study estimates that a "TV, PC, and Office Equipment" category accounts for 15% of household energy and a "Miscellaneous" category accounts for 11%.

A PG&E Customer Energy Efficiency program will aim to influence future customer purchases, and therefore, the projected energy consumption from those purchases is a key metric to analyze. Figure 1-2 shows the first-year annual energy consumption for new shipments—of all products covered in this report—to PG&E's Mass Market, based on our two scenarios. The *first-year* energy savings would exceed 400 million kWh per year if 100% of all new shipments met the Improved Case scenario. The cumulative *lifetime* savings would be much greater as most of the products studied have lifespans ranging from 4 to 9 years. While it is improbable that a program influences 100% of sales (with the exception of a mandatory standard), the savings showcase a technical potential that should serve to inform future policy and program decisions.

Figure 1 - 2 First-Year Annual Energy Consumption for New PG&E Shipments – Baseline and Improved Case Scenarios (million kWh/yr)

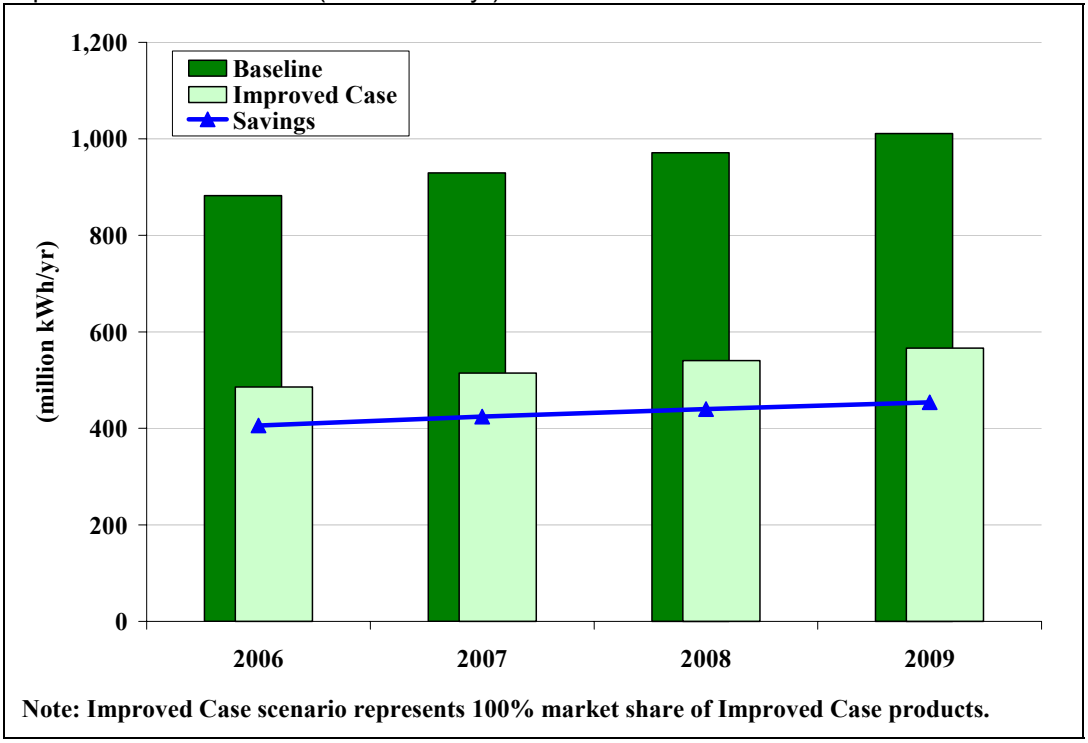
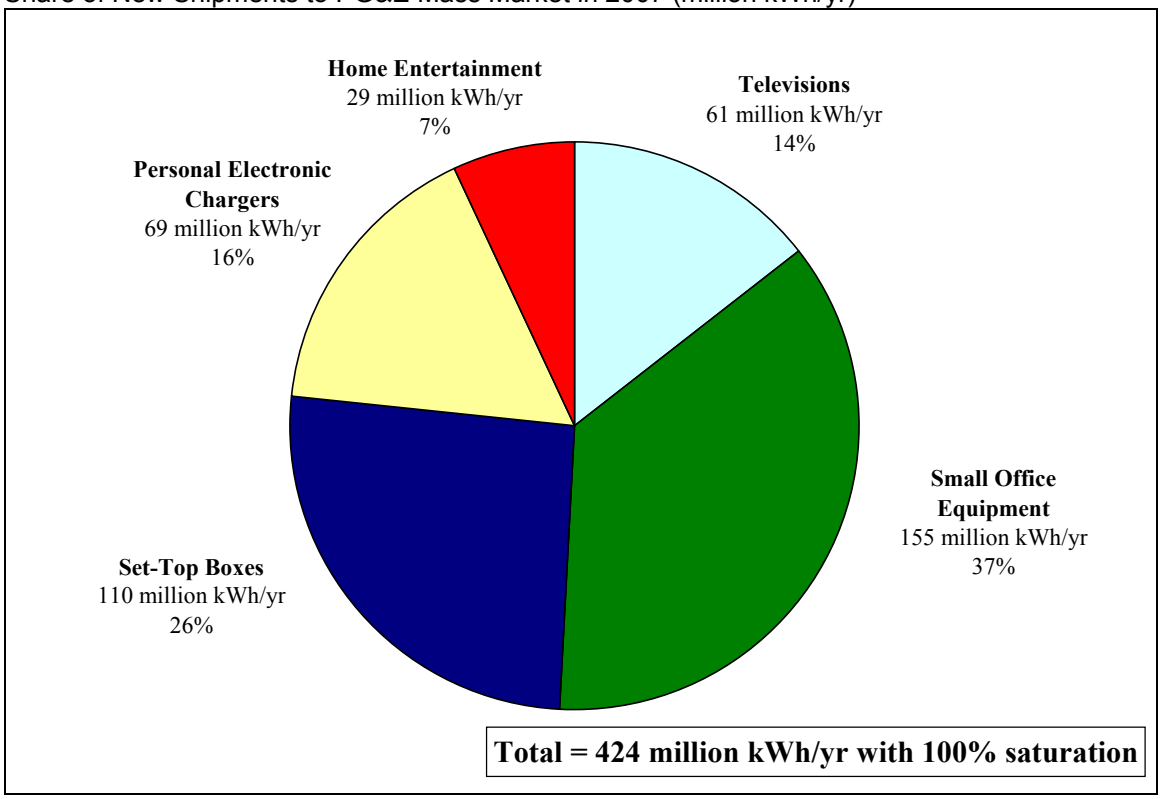


Figure 1-3 takes a closer look at the savings potential, by product category, for new shipments in 2007. Assuming a 100% market share of Improved Case products, the combined first-year energy savings is 452 million kWh. The small office equipment category represents the greatest savings amount at 155 million kWh, or 37% of the total. Set-top boxes represent over a quarter of the savings, followed by personal electronic chargers (16%), televisions (14%), and home entertainment systems (7%).

Figure 1 - 3 First-Year Annual Energy Savings with Improved Case Scenario – 100% Market Share of New Shipments to PG&E Mass Market in 2007 (million kWh/yr)



Recommendations

Section 5 provides program recommendations for each product category.

Our highest recommendation is for a near-term PG&E Customer Energy Efficiency program focus on computers and televisions because of their potential for energy savings and the feasibility of related programs. First, there are a wide range of efficiency levels for the current computers and televisions on the market—indicating that a program could promote the most efficient models on the market without imposing incremental costs or sacrificing functionality. Second, both of these products have forthcoming ENERGY STAR® specifications that will lay the groundwork to identify and promote the most efficient models on the market. Based on the ENERGY STAR specification schedules, it is conceivable that PG&E could address computers in its program offerings in the third quarter of 2007 and then televisions in the first quarter of 2008.

2 Introduction

Pacific Gas and Electric Company (PG&E) contracted Energy Solutions to evaluate the technical and market information for several electronic devices that are sold to PG&E Mass Market customers and to help inform future decisions regarding Customer Energy Efficiency (CEE) programs. This report fulfills Task 1, 2 and 3 of Contract Work Authorization (CWA) 05CEE-T-3309, *Market and Technical Research Study for Small Offices and Home Electronics*. The subsequent Task 4 activities will support the development of economic and Total Resource Cost (TRC) models for potential programs.

The product categories covered within this report are:

- **Home and Small Commercial Office Equipment –** office equipment that is used by residential households and small businesses within the Mass Market segment. A key aspect within this category is that the office users primarily purchase their equipment through retail channels. Twelve key equipment types are analyzed.

- **Televisions –** analog and digital televisions, categorized by the following display types: cathode ray tube (CRT), liquid crystal displays (LCD), plasma, and projection.

- **Set-Top Boxes –** cable boxes, satellite boxes, digital video recorders (e.g., TiVo™), digital television adaptors, and Internet Protocol television (IPTV).

- **Home Entertainment Systems –** recording, playback, and amplifying devices that are used primarily in conjunction with televisions and audio speakers. This includes DVD players, home theater systems (which are comprised of receiver/DVD player and speakers, also known as home theater in a box), component stereos (separate receivers and tuners), and compact stereos (integrated tuner, CD player, and speakers). Portable stereos (boom boxes) are also included in this category.

- **Smart White Goods –** "smart" appliances that combine the traditional functionality of kitchen and laundry appliances with entertainment, communication, networking, and computer functions.

- **Personal Electronic Chargers –** the battery charging systems used to charge a hand held, portable, or other electronic device that can be disconnected from the charger. Nine key equipment types are analyzed.

The PG&E Mass Market segment primarily includes single and multifamily residential customers in addition to small businesses that are not included in the other targeted market segments.[4]

[4] PG&E's full Mass Market definition includes residential single and multifamily as well as small commercial type businesses (primarily with A1/A6 rate structures) that are not included in the other targeted market segments.

Table 2-1 provides an overview of Mass Market customer accounts and energy consumption for 2005. The Mass Market represents 93% of PG&E's total customer base and roughly 44% of its electricity usage. In 2005, there were 4.48 million Mass Market electric accounts, and 98.4% (4.41 million) of those were residential.

The estimated Mass Market energy consumption in 2005 was 25,000 GWh (million kWh), with residential accounts responsible for 96% of the total. Assuming a 2.15% compound annual growth rate (CAGR), the 2010 Mass Market energy consumption is forecasted to increase to 27,800 GWh/yr.[5] These values are used throughout the report to benchmark each market segment's annual energy consumption.

Table 2- 1 PG&E Mass Market Segment Overview

Total customer electric accounts (1)	4.48	million
Residential accounts	*4.41*	*million*
Non-residential accounts	*0.07*	*million*
2005 electricity usage thru 9/22/05 (1)	17,950	GWh
Residential	*17,231*	*96%*
Non-residential	*720*	*4%*
Estimated 2005 electricity usage (2)	25,000	GWh
Estimated 2010 electricity usage (3)	27,800	GWh
Mass market segment as a percentage of PG&E total service area		
Customers	93%	
Electricity usage	44%	
Revenues	48%	

Sources: 1) PG&E (2005); 2) Projected based on actual Jan 1 - Sept. 22, 2005 data; 3) Projected based on 2.15% CAGR of 2005 to 2010 California electricity scenario presented in CEC (2002, Table II-1-2).

This report is organized with the following structure:

- Section 3 describes the methodology used to collect and analyze the market trends and energy consumption data. A discussion of key terms and calculation techniques is included.

Small commercial businesses in this segment include: construction, land subdivision, support activities for transportation, administrative offices, architectural, engineering and related services, technical and consulting services, business support services, travel and reservation services, investigation and security services, building and dwelling services, child day care services, recreation services, automotive repair and services, household goods repair and maintenance, personal care services, laundry services, funeral homes, religious, business, professional, labor and political organizations, and some technical and trade schools (e.g. language, sports, fine arts, exam preparation, auto driving, tutoring schools, etc) (PG&E 2005).

[5] The CAGR is based on a California Energy Commission electricity growth scenario from 2005 through 2010 (CEC 2002).

- Section 4 discusses the following topics for each product category: market trends, applicable standards and efficiency programs, usage characteristics, PG&E shipments and stock, PG&E energy consumption, lifecycle costs, opportunities for energy savings, and next steps.

- Section 5 provides program recommendations for each product category and summarizes our conclusions.

- A detailed appendix provides supporting data tables and documentation for each product category.

3 Methodology

Energy Solutions collected and analyzed an extensive data set to provide market and energy trends for consumer electronics sold to PG&E Mass Market customers. The research focused on collecting the most accurate and up-to-date information from market studies, industry reports, Web research, and personal communication with experts. Shipment trends, equipment stock, and energy consumption are presented for 2005 and are forecasted through 2010.

The energy consumption forecasts rely on two future scenarios: *Baseline* and *Improved Case*. The scenarios are defined as follows:

- **Baseline Scenario** – A "business-as-usual" scenario that estimates the average power draw and usage pattern for *all* the different devices being used within a certain equipment category.

- **Improved Case Scenario –** A scenario that reflects an increased amount of energy efficiency or conservation compared to the Baseline. For each equipment category, this could mean a lower average power draw and/or a shift in usage patterns (e.g., a power-managed desktop PC spending more time in sleep mode). Note, the Improved Case scenario reflects power levels for devices that are readily available on the market today.

Baseline and Improved Case scenarios are developed independently for each product category and are discussed throughout the report.

The scenario approach provides possible outcomes given certain market conditions, yet these outcomes should not be viewed as exact predictions. Over the next five years, many conditions will shape actual energy consumption – such as macroeconomic conditions, consumer confidence, new product introductions, and usage behavior –therefore, the scenarios should be used as a tool to inform policymakers about the potential magnitude of energy savings for each product category or technology.

Figures 3-1, 3-2, and 3-3 outline the general methodology used to develop annual energy consumption estimates and savings.[6] Key terms presented in the figures and used throughout the report are explained below:

- **Usage Modes –** Usage modes vary by device and refer to the different operating levels of a device, such as active, standby, sleep, or off mode.

- **Power Draw –** The average power draw representing all devices within the Baseline or Improved Case scenario. The power draw values are presented for each operating mode (i.e., active mode power, standby mode power, etc.), and are based on *actual* power draw

[6] Figure 3-1 based on ADL 2002.

measurements rather than *manufacturer-rated* values.[7] An effort was made to reflect "real-world" conditions by gathering a large sample set of power measurements from multiple studies. However, it is important to note that the power consumption values are not *shipment-weighted* or *stock-weighted* values. Generating statistically valid *shipment-* and *stock-weighted* values is the most exact way to evaluate energy use, but, in practice, the data collection required to do so is extensive and beyond the scope of this report.

It is also important to mention that the Baseline and Improved Case power assumptions remain constant for each scenario throughout the forecast period. Clearly, the actual averages will fluctuate as new products are introduced to the market. However, the error introduced by this simplification is likely to be narrowed by two competing trends: 1) increased product efficiency (lowers the average) and 2) increased product size and/or functionality (raises the average).

- **Duty Cycle –** The average amount of time that a device spends in its different operating modes (either presented in hours per day or hours per year).

- **Unit Electricity Consumption (UEC) –** For each operating mode, the UEC is calculated by multiplying power draw and the duty cycle together (for example, the active mode UEC is calculated by multiplying the active mode power by the annual hours that the device spends in active mode). The device UEC is the sum of the individual UECs, by mode. The UEC is expressed as kWh per year throughout this report (see Figure 3-1).

- **Stock –** The installed base of equipment in use during a certain time period.

- **Shipments –** Estimated customer-purchased products within a certain time period.

- **Annual Energy Consumption (AEC) –** This report present the AEC for new shipments and for the installed stock. For a given device, the AEC is calculated by multiplying the device UEC by the shipments or stock, respectively. The AEC is expressed as million kWh per year throughout this report (see Figure 3-2).

To highlight the potential *First-Year Annual Energy Savings* for future shipments to the Mass Market, the Improved Case scenario AEC is subtracted from the Baseline scenario AEC (see Figure 3-3).

Another key term used throughout the report is **Compound Annual Growth Rate (CAGR)**. The CAGR is the average percentage of growth per year experienced across the forecast time period.[8]

[7] An Arthur D. Little study highlights the caution of using rated power instead of actual measured power draw. Rated power typically represents the maximum power that the device's power supply can handle and does not reflect actual power draw. In fact, based on several studies analyzing IT equipment, the rated power was, on average, three times greater than actual power draw (ADL 2002).

[8] Throughout this report, the CAGR is typically expressed from 2005 to 2010. The CAGR is calculated with the following formula: CAGR = {(ending value / beginning value)^(1 / # of years) – 1}

Figure 3 - 1 Methodology – Unit Electricity Consumption

Mode	Power		Duty Cycle		Unit Electricity Consumption	
Active:	P_{active}	**x**	T_{active}	=	UEC_{active}	
Standby:	$P_{standby}$	**x**	$T_{standby}$	=	$UEC_{standby}$	$\sum = \mathbf{UEC_{device}}$
Off:	P_{off}	**x**	T_{off}	=	UEC_{off}	

Figure 3 - 2 Methodology – Annual Energy Consumption

Scenario		PGE Mass Market Shipments or Stock		Annual Energy Consumption
$UEC_{scenario}$	**x**	$PGE_{shipments}$	=	$AEC_{shipments - scenario}$
$UEC_{scenario}$	**x**	PGE_{stock}	=	$AEC_{stock - scenario}$

Figure 3 - 3 Methodology – First-Year Annual Energy Savings

Baseline AEC		Improved Case AEC		Savings
$AEC_{shipments - baseline}$	-	$AEC_{shipments - improved case}$	=	First-Year Annual Energy Savings with Improved Case Scenario

4 MARKET TRENDS AND ENERGY CONSUMPTION

4.1 Home and Small Commercial Offices (Small Offices)

4.1.1 Overview

Home and small commercial offices represent a significant and growing portion of PG&E's Mass Market energy consumption. Small office equipment consumed approximately 6.3% of all Mass Market electricity in 2005 – 1,660 million kWh – and is estimated to consume 8.1% by 2010, or 2,020 million kWh. Most small offices use several pieces of electronic equipment and thus present a major opportunity for energy savings. In 2007 alone, the Improved Case scenario highlights 138 million kWh of first-year savings potential for new shipments to the market.

In the context of this report, the home and small commercial office segment (herein referred to as *Small Offices*) consists primarily of areas within households that use office equipment, but also includes small businesses within the Mass Market segment.[9] A key characteristic of these small office users is that they purchase their office equipment through retail channels.

During the last decade, the increased use of information technology (IT) equipment by the general public, coupled with declining equipment costs, has led to considerable increases in market penetration. Computers and monitors already have high penetration rates within PG&E households, and peripheral devices, such as multi-function products and broadband equipment, will experience strong growth over the next five years.

This study assesses the market trends and energy consumption characteristics for twelve key devices used within small offices:

- Desktop PCs,
- Laptop PCs,
- Monitors,
- Inkjet Printers,
- Laser Printers,
- Scanners,
- Fax Machines,
- Multi-Function Devices (MFD),
- Broadband Devices,
- Home Routers, and
- Voice of Internet Protocol (VoIP).

As shown previously in Table 1-1, there are over 16 million of these devices being used by PG&E's Mass Market customers, and, by 2010, the total stock is forecasted to increase to over 20 million devices.

[9] As discussed in the Introduction (Section 2), non-residential Mass Market accounts represented 1.6% of the total electric accounts (0.07 out of 4.48 million) and 4% of electricity consumption (720 out of 17,950 GWh) from January 1, 2005 to September 22, 2005 (PG&E 2005).

4.1.2 Market Trends

After a decline in previous years – due to a downturn economy – the number of net new home offices is increasing and has returned to traditional levels. In the U.S. alone, there are roughly 25 million more home offices than there are small businesses (i.e., firms with fewer than 100 employees) (IDC 2005b). A significant development in recent years has been the increased integration of broadband high-speed Internet and local networking equipment within home offices.

Table 4.1-1 shows the current and forecasted PG&E service territory home office households from 2005 through 2010. Key trends come from IDC's *U.S. Home Office 2005-2009 Forecast* (2005b). IDC, a leading market research firm that bases its forecasts on both quantitative, survey-based data and on an assessment of current and expected market conditions.

There are two major home office segments that distinguish how the home office is used: ***self-employed*** and ***telecommuters / after hours***.[10] The two segments are defined, as follows:

- **Self-employed –** This segment includes households in which a home office is used to run a business, and that business is the full-time or part-time activity of at least one household member.

- **Telecommuters / after hours –** This segment includes households in which a home office is utilized by employees who work at home during the normal business hours (at least three days a month) or by workers that take work home from traditional jobs after the normal business hours.

It is important to note that some dual-income households may have a worker in each category and therefore the cumulative total of the two segments is greater than the total home office households. Since both segments utilize the same types of electronic equipment, the total number of home office households is the most important factor within the context of this report's scope. However, an understanding of the breakdown between each segment could be useful for developing a detailed usage pattern. For example, users in the self-employed segment are more likely to use office equipment during peak periods and for longer amounts of time.

Roughly 1 out of every 3 PG&E households has a home office – approximately 1.4 million in 2005. This is expected to grow by 2.6% per year, reaching 1.6 million by 2010. About 70% of the home offices are used by telecommuters or after hour employees, whereas, 40% are used by self-employed workers.

[10] The definitions presented in this report are different from IDC's to avoid terminology that could be confused with non-Mass Market businesses. IDC uses the term *Income-Generating Home-Based Businesses* instead of *Self-employed* and *Corporate Home Offices* instead of *Telecommuters / after hours*.

Table 4.1-1 PG&E Home Office Households, 2005-2010 (000)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
PG&E Households (1)	4,407	4,482	4,556	4,631	4,706	4,780	1.6%
PG&E home office households (2)	1,414	1,438	1,471	1,533	1,562	1,610	2.6%
Self-employed	*595*	*615*	*606*	*655*	*667*	*694*	*3.1%*
Telecommuters / after hours	*984*	*1,019*	*1,049*	*1,079*	*1,110*	*1,150*	*3.2%*

Note: The "Self-employed" and "Telecommuters / after hours" cumulative total is greater than "PG&E home office households" total because some dual-income households can have workers in both categories.
Sources:
1) Calculated based on PG&E growth trend from 2002 to 2005. [CEC (2004) and PG&E (2005).]
2) Based on comparative U.S. trends in IDC (2005b).

4.1.3 Applicable Standards and Efficiency Programs

The majority of the equipment within the small office segment is covered by the voluntary ENERGY STAR program. Table 4.1-2 summarizes the key criteria for each product and the 2004 market saturation. Broadband devices, home routers, and VoIP converters are the only products not covered. Most products have a sleep mode criteria and a default time at which the device must enter sleep mode. Monitors are the only product with a current active mode specification. The 2004 market saturation for home office equipment was very high, ranging from a low of 75% for scanners to 100% for printers.

An important program development for future PG&E programs is the forthcoming revised ENERGY STAR computer specification. On September 22, 2006, the EPA released the Final Draft Version 4.0 specification for comment.[11] The final Version 4.0 computer specification will be distributed on October 20, 2006, and will take effect on July 20, 2007. The specification will set power supply and operational mode efficiency requirements for desktop computers, game consoles, notebook and tablet computers, and workstations. A new key component will be the establishment of power level requirements for the “Idle State” operating mode. For the purposes of the specification, ENERGY STAR defines Idle as the state in which the operating system and other software have completed loading, the machine is not asleep, and activity is limited to those basic applications that the system starts by default. This is an encouraging step towards addressing total unit electricity usage and represents the evolution of ENERGY STAR in targeting higher energy usage operating modes.

The inclusion of Game Consoles—considered to be standalone computers whose primary use is to play video games— is another important addition to the new computer specification. However, game consoles were beyond the scope of this study. We highly recommend research on this product category based on their rising prevalence within homes and because their peak usage patterns tend to coincide with PG&E’s peak period. (See Figure 4.2-5 in the subsequent Television section for a typical game console usage pattern throughout the day).

[11] See the ENERGY STAR Computer Specification page for ongoing updated documents: http://www.energystar.gov/index.cfm?c=revisions.computer_spec

Another relevant voluntary program is “80 PLUS”, which promotes the sale of desktop computers and desktop servers that contain highly efficient power supplies. PG&E is a program sponsor and is involved in the buy-down of computers and servers with power supplies that are 80% or greater energy efficient at 20%, 50% and 100% of rated load with a true power factor of 0.9 or greater.[12]

PG&E has also supported in-depth computer monitor research (Energy Solutions 2005) and has now launched the **PG&E Monitor Rebate program**, a rebate program promoting the most energy-efficient computer monitors on the market. The program is designed to encourage the sale of computer monitors that are currently at least 25% more efficient than the current ENERGY STAR specification. PG&E is now exploring partnership agreements with selected monitor retailers and will initially offer a $10 midstream rebate for qualified monitors sold to PG&E customers. The Program will encourage midstream companies to participate in cooperative marketing strategies promoting these energy-efficient and environmentally preferable monitors. PG&E is expected to rebate 60,000 monitors during the over two-year program period, October 2006 through December 31, 2008.

Noteworthy efficiency initiatives have recently been announced by influential industry actors. In a white paper presented at the Intel Developer Forum, Google announced that they are supporting efforts to promote high-efficiency power supplies for personal computers and servers.[13] Their initial plan is different from the 80 Plus program in that it does not specify efficiency levels (it calls for a shift from multivoltage power supplies to a single 12-volt standard), but similar in that it supports giving incentives to computer manufactures that design and incorporate high-efficiency power supplies (Markoff 2006). Google has started a “GoogleBlog” to track this efficiency initiative[14] and provides the following feedback loop email for further inquires: efficient-psu@google.com.

Dell has also recently launched an energy efficiency product strategy. The strategy relies largely on promoting ENERGY STAR products, but specifically features the following four measures: [15]

1. Their new desktop OptiPlex 745 powered by Intel® Core™ 2 Duo processors that are claimed to deliver 30% better performance with 40% power savings compared to their predecessors. The computer also incorporates Dell's HyperCool thermal-management technology allowing it to run quieter and cooler, which reduces the power needed to cool the machine during operation,
2. Dell claims their ninth-generation PowerEdge™ servers can lower power consumption by up to 25%, providing performance gains up to 196 percent in performance per watt. These servers incorporate high efficiency power supplies and low form factor hard drives that reduce thermal output.

[12] See www.80PLUS.org for additional program information.
[13] “High-Efficiency Power Supplies for Home Computers and Servers” by Urs Hölzle and William Weihl was presented September 26, 2006.
[14] Located at: http://googleblog.blogspot.com/2006/09/towards-more-efficient-computing.html
[15] See http://www.dell.com/content/topics/global.aspx/corp/environment/en/energy?c=us&l=en&s=corp for specific details on Dell’s energy efficiency initiative.

3. Their Inspiron™ and Latitude™ notebooks and the Precision™ mobile workstation now ship with sleep-state enabled, automatically putting the machines into sleep mode after 15 minutes of inactivity.
4. Their external power supplies for all Inspiron and Latitude noterbook products are designed to meet the Energy Star requirements.

Dell also provides an easily accessible Web site with system-specific power consumption information for all of their products at: http://www.dell.com/content/topics/global.aspx/corp/environment/en/prod_datasheets?c=us&l=en&s=corp&~ck=anavml.

The Google and Dell initiatives serve as two key indicators that major industry players are embracing energy efficiency as a business and marketing strategy—thus creating fertile opportunities for PG&E to develop key industry allies for future efficiency programs.

Table 4.1-2 Key Product Criteria for ENERGY STAR Office Equipment

	Active (Low Power)*	Sleep	Off	Default Time to Sleep Mode	2004 Market Penetration
Desktop PCs (<200W)	See note**	< 15W**	NA**	< 30 minutes	98%
Laptop PCs	See note**	See note**	NA**	< 30 minutes	98%
Monitors	See note***	≤ 2 watts	≤ 1 watt		95%
Printers					100%
0 < ppm < 10	NA	< 10	NA	< 5 minutes	
10 < ppm < 20	NA	< 20	NA	< 15 minutes	
20 < ppm < 30	NA	< 30	NA	< 30 minutes	
30 < ppm < 44	NA	< 40	NA	< 60 minutes	
44 < ppm	NA	< 75	NA	< 60 minutes	
Scanners	NA	< 12 Watts	NA	< 15 Minutes	75%
Copiers					90%
0 < cpm < 20	None	NA	≤ 5	≤ 30 minutes	
20 < cpm < 44	3.85 x cpm + 5	NA	≤ 15	≤ 60 minutes	
44 < cpm	3.85 x cpm + 5	NA	≤ 20	≤ 90 minutes	
Fax machines					99%
0 < ppm < 10	NA	< 10	NA	< 5 minutes	
10 < ppm	NA	< 15	NA	< 5 minutes	
Multi-Function Devices					98%
0 < ipm ≤ 10	NA	≤ 25	NA	≤ 15 min	
10 < ipm ≤ 20	NA	≤ 70	NA	≤ 30 min	
20 < ipm ≤ 44	3.85 x ipm + 50	≤ 80	NA	≤ 60 min	
44 < ipm ≤ 100	3.85 x ipm + 50	≤ 95	NA	≤ 90 min	
100 < ipm	3.85 x ipm + 50	≤ 105	NA	≤ 120 min	
Broadband Devices		None			
Home Router		None			
VoIP		None			

Source: ENERGY STAR (2006)

ppm = pages per minute; cpm = copies per minute; ipm = images per minute

*Low Power refers to the lowest power state a copier and/or multi-function device can automatically enter within some period of copier inactivity, without actually turning off.

**New Computer Specification will become effective July 20, 2007. It will cover desktop computers, game consoles, intergrated computer systems, notebook computers, desktop-derived servers, and workstations. For desktops, intergrated computers, desktop-derived serveres adn gaming consols: the Idle State levels will be based on category (A, B, and C) and will respectively be: 50.0W, 65.0W, and 95.0W; Sleep mode will be <= 4.0W; and Standby (Off mode) will be <=2.0. For notebooks and tablets: the Idle State will be based on category (A and B) and will repectively be <=14.0W and <=20.W; Sleep mode will be <=1.7W; and Standby (Off mode) will be <=1.0W. Computers using an internal power supply will also need to have 80% minimum efficiency at 20%, 50%, an d100% of rated output and Power Factor >=0.9 at 100% of rated output.

***If X < 1 megapixel, then Y = 23; if X > 1 megapixel, then Y = 28X. Y is expressed in watts and rounded up to the nearest whole number and X is the number of megapixels in decimal form.

4.1.4 Usage Characteristics

The duty cycle assumptions for the small office equipment category are presented in Table 4.1-2. A number of sources were used to develop the duty cycle, as detailed in Appendix Table 1. The general duty cycle definitions are described below:

Active Mode Definition: The mode in which the device is producing useful work.

Standby Mode Definition: The state in which the machine is on, but neither producing useful work nor or in sleep mode.

Sleep Mode Definition: A low power state that the device enters automatically after a period of inactivity or by manual selection.

Off Mode Definition: The lowest power consumption mode that cannot be switched off by the user and that may persist for an indefinite time when the appliance is connected to the main electricity supply.

Table 4.1-3 Small Office Equipment – Baseline Duty Cycle Assumptions (hours per year)

	Active	Standby	Sleep	Off
Desktop PCs	3,372	-	319	5,069
Laptop PCs	2,074	894	437	5,356
Monitors	1,861	-	881	6,018
Inkjet Printers	44	1,102	-	7,615
Laser Printers	35	698	8,027	-
Scanners	37	830	1,944	5,950
Copiers	5	25	4,364	4,366
Fax machines	183	86	8,492	-
Multi-Function Devices	139	1,326	2,915	4,380
Broadband Devices	8,760	-	-	-
Home Router	8,760	-	-	-
VoIP	365	-	8395	-

Sources: Baseline developed using a number of sources. See Small Office Equipment Appendix for detailed duty cycle sources.

4.1.5 PG&E Shipments and Stock

Small office equipment continues to grow in PG&E territory, fueled by new product introductions, lower price points, and increased usage of the Internet. Table 4.1-4 shows the results of the Residential Appliance Saturation Survey (RASS), conducted in late 2002 and 2003 sponsored by the California Energy Commission (CEC). The Survey provides a detailed snapshot of appliances

being used within PG&E households, and is used as a basis for developing future trends. The term *penetration* in the Table refers to the percentage of households that own at least one of the products (i.e., owning more than one will not affect penetration value). Computers had the highest penetration in 2003 at 71%, and home routers had the lowest at 6%.

Table 4.1-4 Small Office Equipment in PG&E Residential Territory: RASS Survey, Early 2003 (000)

Units per household	Computers	Printers	Multi-Function Devices	Copiers	Scanners	FAX	DSL Modem	Cable modem	Home Router
None	1,210	1,810	2,950	3,550	3,090	3,350	3,330	3,530	3,820
One	1,990	1,920	1,030	510	950	710	690	510	230
Two	700	270	70	20	40	10	40	20	10
Three or more	330	80	30	10	0	10	20	30	20
No response	20	170	170	170	170	170	170	170	170
Total Units (000)	**4,410**	**2,710**	**1,260**	**580**	**1,030**	**760**	**830**	**640**	**310**
Penetration (2003)	**71%**	**53%**	**27%**	**13%**	**23%**	**17%**	**18%**	**13%**	**6%**
Units per PGE household (2003)	**1.0**	**0.6**	**0.3**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**

Source: CEC (2004). Based on PG&E residential survey conducted in late 2002 and early 2003. All data is weighted based on 9,647 survey responses, representing a 4,251,000 Household Population in PG&E territory.
Note: Assumes 3.1 average for "three or more" response. Saturation reflects percentage of households that have at least one of the respective equipment.

The forecasted shipments to the PG&E Mass Market are presented in Table 4.1-5 and the forecasted installed stock is shown in Table 4.1-6. The key assumptions and sources are detailed in Appendix Table 2, and some general trends influencing the forecasts include (IDC 2005b):

- In general, product prices continue to drop as device capabilities improve.
- Internet access is a key motivator behind the increased usage of PCs in the home. In turn, this drives the sales increase of broadband devices and home routers.
- Laptop PCs continue to appeal to the mobile sector of the home office market and shipments now outnumber desktop PC shipments. The laptop stock will approach the desktop stock by 2010.
- Printers, scanners, and copiers are projected to decline, mainly due to the surging popularity of multi-function devices (MFD). Consumers are attracted to the MFDs by their versatility, low cost, and relatively small size.
- Home networking will increase as prices decline and technology becomes easier to install and maintain. Many homes will install wireless networks to share broadband Internet access across multiple PCs.

Table 4.1-5 Small Office Equipment – Forecasted Shipments to PG&E Mass Market, 2005 - 2010 (000)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Desktop PCs	630	660	680	690	700	730	3.0%
Laptop PCs	710	750	790	810	830	870	4.1%
Monitors	630	660	680	690	700	730	3.0%
Inkjet Printers	210	200	200	190	190	180	-2.7%
Laser Printers	20	20	20	20	20	20	4.0%
Scanners	110	100	90	90	80	70	-8.2%
Copiers	60	60	50	50	40	40	-8.2%
Fax machines	80	70	70	60	60	50	-8.2%
Multi-Function Devices	170	180	180	180	180	190	2.0%
Broadband Devices	260	290	340	390	450	520	15.2%
Home Router	40	50	50	60	70	80	12.3%
VoIP	120	190	190	190	190	190	9.8%
Total	3,040	3,230	3,340	3,420	3,510	3,670	3.8%

Sources: CEC (2004), Energy Solutions (2006), IDC (2005b), TIAX (2006). See Small Office Equipment Appendix for detailed assumptions.

Table 4.1-6 Small Office Equipment – Forecasted Stock in PG&E Mass Market, 2005 – 2010 (000)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Desktop PCs	3,060	3,100	3,160	3,210	3,270	3,350	1.8%
Laptop PCs	1,930	2,200	2,440	2,640	2,810	2,980	9.0%
Monitors	3,060	3,100	3,160	3,210	3,270	3,350	1.8%
Inkjet Printers	1,980	1,790	1,630	1,490	1,380	1,290	-8.2%
Laser Printers	170	160	150	140	140	130	-5.3%
Scanners	870	800	730	670	620	570	-8.2%
Copiers	470	440	400	370	340	310	-8.2%
Fax machines	630	580	530	490	450	410	-8.2%
Multi-Function Devices	1,530	1,680	1,820	1,970	2,120	2,270	8.2%
Broadband Devices	1,940	2,230	2,570	2,960	3,410	3,930	15.2%
Home Router	390	430	490	550	610	690	12.3%
VoIP	140	330	520	720	910	1,100	50.9%
Total	16,170	16,840	17,600	18,420	19,330	20,380	4.7%

Sources: CEC (2004), Energy Solutions (2006), IDC (2005b), TIAX (2006). See Small Office Equipment Appendix for detailed assumptions.

4.1.6 PG&E Energy Consumption

Table 4.1-7 presents the representative power consumption values, by usage mode, for the Baseline scenario. Several sources were used to develop the values and they are detailed in Appendix Table 3. The Baseline scenario attempts to reflect the average power consumption for all models on the market.[16]

Table 4.1-7 Small Office Equipment - Power Consumption Baseline per Unit (watts)

	Active	Standby	Sleep	Off
Desktop PCs	75	-	4	2
Laptop PCs	24	14	2	2
Monitors	34	-	1	1
Inkjet Printers	13	5	-	2
Laser Printers	161	54	7	-
Scanners	36	24	12	-
Copiers	300	63	11	-
Fax machines	350	30	9	-
Multi-Function Devices	19	11	7	7
Broadband Devices	9	-	-	-
Home Router	6	-	-	-
VoIP	6	-	4	

Sources: Baseline developed using a number of sources. See Small Office Equipment Appendix for detailed power consumption sources.

Table 4.1-8 shows the Baseline unit electricity consumption (UEC) for each device and Figure 4.1-1 highlights how the different usage modes contribute to the unit's overall consumption. Desktops, laptops, monitors, broadband devices, and home routers typically consume over 75% of their electricity in the active mode, whereas printers, scanners, copiers, fax machines, MFDs, and VoIP devices consume most of their electricity in low power modes (i.e., standby and/or sleep mode).

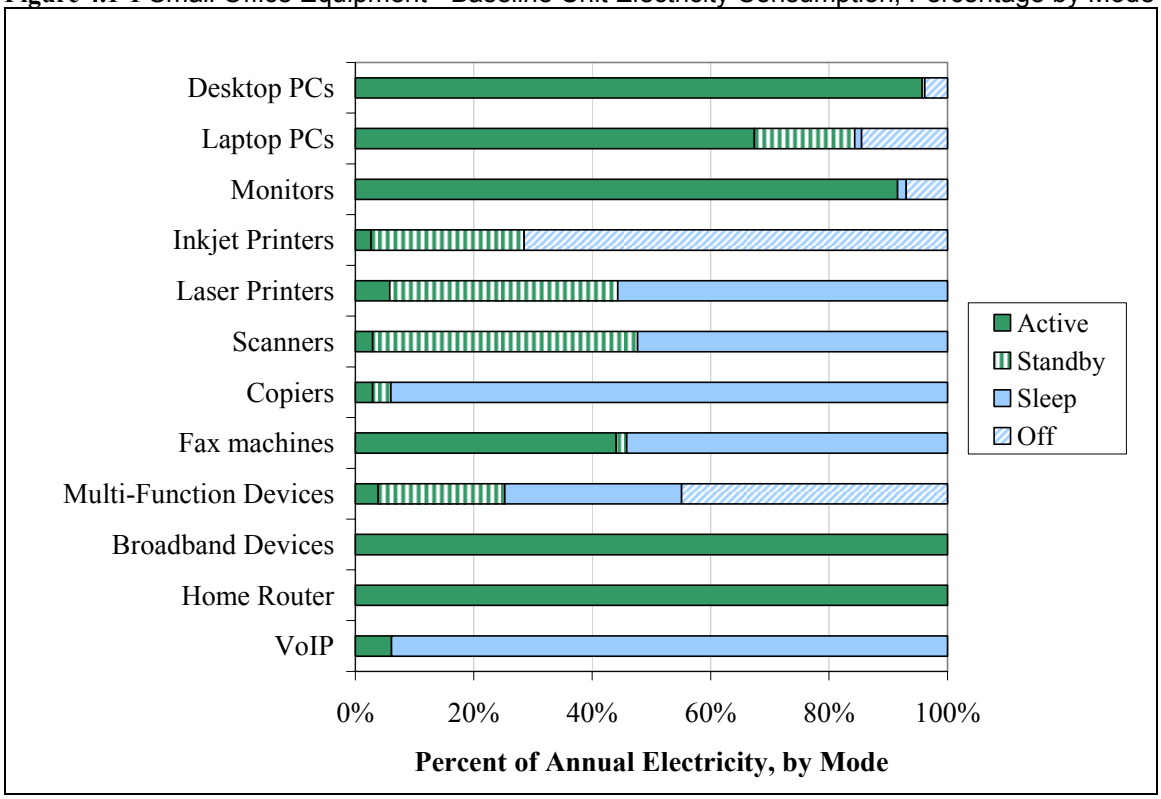
[16] See the Methodology section for a more detailed discussion on the general power assumptions development for each scenario.

Table 4.1-8 Small Office Equipment - Baseline Unit Electricity Consumption (kWh/yr)

	Active	Standby	Sleep	Off	Total
Desktop PCs	253	-	1	10	**264**
Laptop PCs	50	13	1	11	**74**
Monitors	63	-	1	5	**68**
Inkjet Printers	1	6	-	15	**21**
Laser Printers	6	38	54	-	**97**
Scanners	1	20	23	0	**45**
Copiers	2	2	48	0	**51**
Fax machines	64	3	79	-	**145**
Multi-Function Devices	3	15	20	31	**68**
Broadband Devices	79	-	-	-	**79**
Home Router	53	-	-	-	**53**
VoIP	2	-	34	0	**36**

Note: Calculated by multiplying duty cycle and baseline power consumption together.

Figure 4.1-1 Small Office Equipment - Baseline Unit Electricity Consumption, Percentage by Mode



The Baseline scenario energy consumption from small office equipment shipments is estimated to increase at 4% per year over the next five years – from 326 million kWh in 2005, to 390 million

kWh in 2010. Desktop PCs represent the greatest consumption followed by laptops, monitors, and broadband devices. These results are summarized in Table 4.1-9.

Table 4.1-9 Small Office Equipment - Forecasted First-Year Annual Energy Consumption for New Shipments to PG&E Territory, 2005-2010 (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Desktop PCs	167	174	180	182	185	193	3%
Laptop PCs	52	55	58	60	61	64	4%
Monitors	43	45	46	47	48	50	3%
Inkjet Printers	4	4	4	4	4	4	-3%
Laser Printers	2	2	2	2	2	2	0%
Scanners	5	4	4	4	4	3	-9%
Copiers	3	3	3	3	2	2	-8%
Fax machines	12	10	10	9	9	7	-9%
Multi-Function Devices	12	12	12	12	12	13	2%
Broadband Devices	20	23	27	31	35	41	15%
Home Router	2	3	3	3	4	4	15%
VoIP	4	7	7	7	7	7	10%
Total	**326**	**343**	**356**	**364**	**373**	**390**	**4%**
% of PGE Mass Market	**1.3%**	**1.3%**	**1.4%**	**1.4%**	**1.4%**	**1.4%**	

The small office equipment stock represents a significant and growing portion of PG&E's Mass Market energy consumption. As shown in Table 4.1-10, small office equipment consumed approximately 6.3% of all Mass Market electricity in 2005 – 1,660 million kWh. By 2010, the Baseline scenario forecasts an increase to 2,020 million kWh, or 8.1% of the total PG&E Mass Market.

Table 4.1-10 Small Office Equipment - Forecasted Annual Energy Consumption for Complete Stock in PG&E Territory, 2005-2010 (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Desktop PCs	809	819	835	848	864	885	2%
Laptop PCs	143	163	180	195	208	220	9%
Monitors	209	212	216	219	223	229	2%
Inkjet Printers	42	38	35	32	29	27	-8%
Laser Printers	17	16	15	14	14	13	-5%
Scanners	39	36	33	30	28	25	-8%
Copiers	24	22	20	19	17	16	-8%
Fax machines	91	84	77	71	65	59	-8%
Multi-Function Devices	104	115	124	135	145	155	8%
Broadband Devices	153	176	203	233	269	310	15%
Home Router	20	23	26	29	32	36	12%
VoIP	5	12	19	26	33	39	51%
Total	**1,656**	**1,714**	**1,782**	**1,850**	**1,927**	**2,016**	**4%**
% of PGE Mass Market	**6.6%**	**6.9%**	**7.1%**	**7.4%**	**7.7%**	**8.1%**	

Note: Calculated based on baseline electricity consumption and projected stock in PGE territory.

4.1.7 Lifecycle Costs

Table 4.1-11 presents the average lifetime energy costs to operate the small office equipment. The costs are based on a typical useful lifecycle, an average PG&E residential rate ($0.13/kWh), and an 8.15% discounted rate. Desktop PCs are by far the most expensive to operate at $137, and all the remaining products have operating costs less than $100.

Table 4.1-11 Small Office Equipment - Lifecycle Energy Costs per Unit

	Estimated Useful Life (1) (years)	Lifetime Energy Costs (2) (PV $)
Desktop PCs	5	$137
Laptop PCs	4	$32
Monitors	4	$29
Inkjet Printers	5	$11
Laser Printers	5	$50
Scanners	5	$23
Copiers	5	$26
Fax machines	5	$75
Multi-Function Devices	5	$35
Broadband Devices	5	$41
Home Router	5	$27
VoIP	5	$18

Notes: (1) Source: ENERGY STAR (2006). (2) Calculated: PV[(estimated useful life) * (unit annual electricity) * (PG&E residential rate - $0.13/kWh - Source CEC (2006))]. Discount rate = 8.15%.

4.1.8 Opportunities for Energy Savings

An Improved Case scenario is developed to highlight potential energy savings from a PG&E Customer Energy Efficiency Program targeting home and small office equipment. Table 4.1-12 shows the Baseline and Improved Case unit electricity consumption (UEC) for each device and the resulting savings. The unit savings range from a low of 8 kWh/yr for scanners, to a high of 84 kWh/yr for desktop PCs.

The detailed duty cycle and power consumption values used for the Improved Case scenario are provided in Appendix Table 1 and Appendix Table 3, respectively, and the general assumptions for each device are described below:[17]

- **Desktop PCs** – Anticipates a smaller PC form factor and improved power management (PM) that will increase the average amount of time that a computer is in sleep mode.
- **Laptop PCs** – Assumes a 90% PM enabled rate and a 25% standby mode efficiency gain.
- **Monitors** – Assumes that monitors are 25% more efficient than the ENERGY STAR Tier 2 specification (Energy Solutions 2005).

[17] With the noted exceptions, these assumptions are based on the "Greening of IT" scenario presented in TIAX (2006).

- **Inkjet Printers** – Average of lowest quartile of measured power values and assumes a 25% reduction in printer usage.
- **Laser Printers** – Assumes a 20% efficiency improvement from Baseline scenario.
- **Scanners** – Based on ENERGY STAR criteria (2006).
- **Fax Machines** – Based on ENERGY STAR criteria (2006).
- **Multi-Function Devices (MFD**) – Average of lowest quartile of measured power values.
- **Broadband Devices** – Power consumption is one-third of Baseline and the device is assumed to be always on with no lower power mode.
- **Home Routers** – Power consumption is one-third of Baseline and assumes that routers enter sleep mode when occupants are asleep and at work.
- **Voice over Internet Protocol (VoIP)** – Assumes a more efficient sleep mode operation and assumes one hour per day of phone usage.

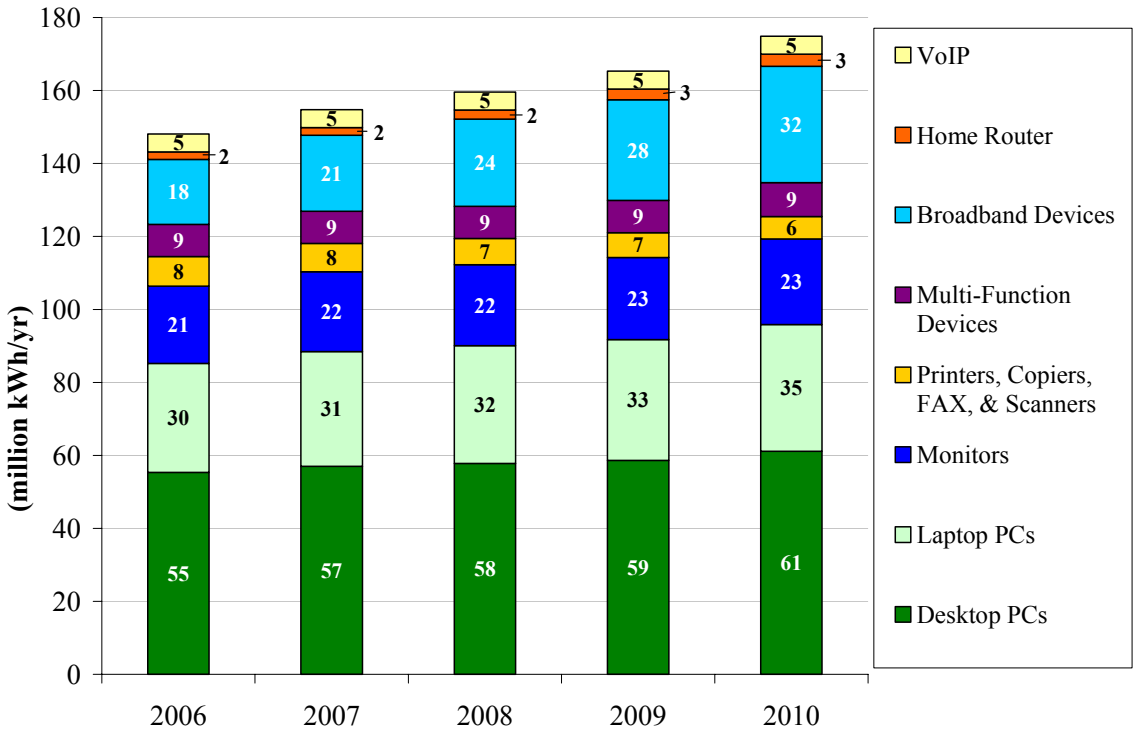
Table 4.1-12 Small Office Equipment – Unit Energy Savings with Improved Case Scenario

	Unit Annual Electricity Consumption (kWh/yr)		
	Baseline	Improved Case	**Savings**
Desktop PCs	264	180	**84**
Laptop PCs	74	34	**40**
Monitors	68	36	**32**
Inkjet Printers	21	12	**9**
Laser Printers	97	78	**19**
Scanners	45	37	**8**
Copiers	51	25	**26**
Fax machines	145	94	**51**
Multi-Function Devices	68	19	**49**
Broadband Devices	79	18	**61**
Home Router	53	11	**42**
VoIP	36	10	**26**

Sources: Baseline and Improved Case scenarios developed using a number of sources. See Small Office Equipment Appendix for detailed sources and assumptions.

Figure 4.1-2 displays the potential energy savings if 100% of all new shipments to the PG&E Mass Market met the improved case scenario. The major savings occur from desktops, laptops, monitors, and broadband devices. The annual savings for each device stays fairly constant from 2006 to 2010, with the notable exception of broadband devices. The potential savings from broadband equipment will increase nearly 80% from 2006 to 2008, reflecting the increased penetration of high-speed Internet access into the home and small offices.

Figure 4.1-2 Small Office Equipment - First-Year Annual Energy Savings with Improved Case Scenario – 100% Market Share for New Shipments to PG&E Mass Market (million kWh/yr)



See Small Office Equipment Appendix for detailed values.

4.1.9 Future Work

The significant energy savings potential within the small office segment warrants future work exploring related PG&E energy efficiency program options. The PG&E Monitor Rebate Program will play an important role by establishing key relationships with consumer electronics retailers while laying the groundwork to add additional measures—such as TVs and computers—cost-effectively as standardized test methods and specifications become available. See Section 5. [Program Recommendations and Conclusions] for a more detailed discussion on recommended PG&E program intervention, delivery types, and key dates.

4.2 Televisions

4.2.1 Overview

Television continues to be the dominant media device in today's homes. Even with the rising popularity of computers and game consoles, TV still reigns supreme. Televisions will soon outnumber people in the United States and the average household is now watching 8 hours and 11 minutes of TV per day, up 12.5% from a decade ago (Nielsen 2005). The market is rapidly evolving and the ubiquitous cathode ray tube TV with an analog signal will soon be surpassed by digital technology. As TV prices drop, consumers are buying models with larger screen sizes that consume more power than today's average TVs. In PG&E territory, the 2005 TV energy consumption was approximately 1,290 million kWh/yr, or 5.2% of PG&E's total Mass Market consumption. By 2010, the Baseline scenario consumption is expected to increase 63% to 2,100 million kWh/yr.

There is a growing set of terms and classifications used to describe the new display technologies and picture qualities. We use four major display categories to analyze market trends, energy consumption characteristics and, subsequently, energy savings. The four categories, along with a brief description, are:

- **CRT –** The Cathode Ray Tube (CRT) is the standard TV technology and is used in most existing sets. Images are created as an electron beam fires across a specialized vacuum "tube" onto the back side of a phosphor-coated screen. CRT screen sizes are limited to 37 inches as the screens become impractically big and heavy with larger screens. The limited screen size has caused consumers to shift from CRTs to "flat-panel" displays and projection systems that offer larger, "home theater" experiences.

- **LCD –** The Liquid Crystal Display (LCD) technology is one of the methods used to create the increasing popular "flat-panel" TV. An LCD display has two polarizing transparent panels with a liquid crystal solution sandwiched in between. As a light source behind the panel shines light though the display, each little crystal acts like a shutter on a window and either allows light through or blocks it, creating an image. In general, LCDs typically offer longer lifespans and better contrast performance compared to plasma displays. One major drawback commonly mentioned with LCDs is color-shift – when the color of the image on the screen changes from different viewing angles.

- **Plasma -** Plasma, or plasma display panel (PDP), is the other major TV technology used to create "flat-panel" TVs. Plasma displays consist of two transparent glass panels with a thin layer of pixels sandwiched in between. Each pixel is composed of three gas-filled cells that glow red, green, and blue. A grid of tiny electrodes sends an electric current though the individual cells and causes the gas to ionize (hence, the name "plasma"). The ionized gas excites the cells' phosphors – causing them to glow – and creates an image. The common concerns expressed towards Plasma TVs are about their short life-expectancy and the vulnerability to screen burn-in from static images such as stock tickers or video games. As with most promising and evolving technologies, manufacturers are introducing models that address these issues.

- **Projection -** Rear projection televisions have typically been referred to as a "big-screen" or "wide-screen" TVs and, until recently, primarily used three CRTs to beam images onto the back of a 40-inch or greater screen. To minimize footprint and weight, new rear projection TVs have been introduced and are referred to as Micro-Display Systems. These systems utilize Digital Light Processing (DLP), LCD, or liquid crystal on silicon (LCoS) technology.[18] Within the projector category, we also include front projection video systems – units that transmit images forward onto a screen that is 100 inches in diameter or greater – but their market share is minimal. In 2005, front-projection systems made up less than 0.01% of all TVs sold in the U.S. (Taub 2006).

The major shift in the TV market has been the transition from analog to digital television (DTV). This change was spurred by the Telecommunications Act of 1996, which stipulated that all TV broadcast signals eventually transition from analog to digital signals – thus, freeing up parts of the broadcast signal for public safety and government use. The subsequent Digital Television Transition and Public Safety Act of 2005 set February 17, 2009, as the final date when all entities must comply. After this date, consumers will either need to have TVs that are capable of receiving a digital signal or will need to install set-top boxes that convert the digital signal to an analog signal.[19] The transition to DTV has led to significant improvements in video and sound quality and has also increased the use of services such as captioning, on-screen programming information, and a choice of viewing angles.

The digital television signal can currently be transmitted in either *standard* or *high* definition. A digital TV receives the signal and then displays the picture in one the following three picture resolutions: standard definition television (SDTV), enhanced definition television (EDTV), and high definition television (HDTV). LCDs, plasmas, and new projection models are mostly EDTV or HDTV, while current CRT models are available in a mix of analog and digital technologies. The three key resolution levels are described below. An in-depth technical discussion of all the display types and resolution terminology is beyond the scope of this report,.

- **Standard Definition Television (SDTV) –** This is the lowest resolution DTV with a picture quality comparable to a current analog TV. The format includes 480-line resolution in both interlaced (480i) and progressively scanned (480p) formats. (Interlaced TVs show half the pixels at any one instance and progressive scan formats show all the pixels at once). The typical resolution is 640 x 480 (horizontal x vertical pixels).

[18] Digital Light Processing (DLP) is a new technology developed by Texas Instruments that uses over a million tiny mirrors housed on a special kind of microchip call a Digital Micromirror Device. The image is typically sharper than LCD projection systems and can be seen clearly in a normally lit room.

Liquid crystal on silicon (LCoS) is similar to LCD but utilizes a "reflective" technology rather than the "transmissive" LCD technology. In LCoS, liquid crystals are applied to a reflective mirror substrate and as the liquid crystals open and close, the light is either reflected from the mirror below, or blocked. The modulation of the light creates the image.

[19] These digital-to-analog set-top boxes, or digital television adaptors (DTA), will prolong the useful life of existing analog CRT TVs. The market trends and energy characteristics of set-top boxes are an important consideration and are discussed in Section 4.3.

- **Enhanced Definition Television (EDTV) –** These TVs are capable of displaying a higher resolution than SDTVs but lower than HDTV. The typical resolution is 852 x 480 and EDTVs are considered a low-cost alternative to HDTVs.

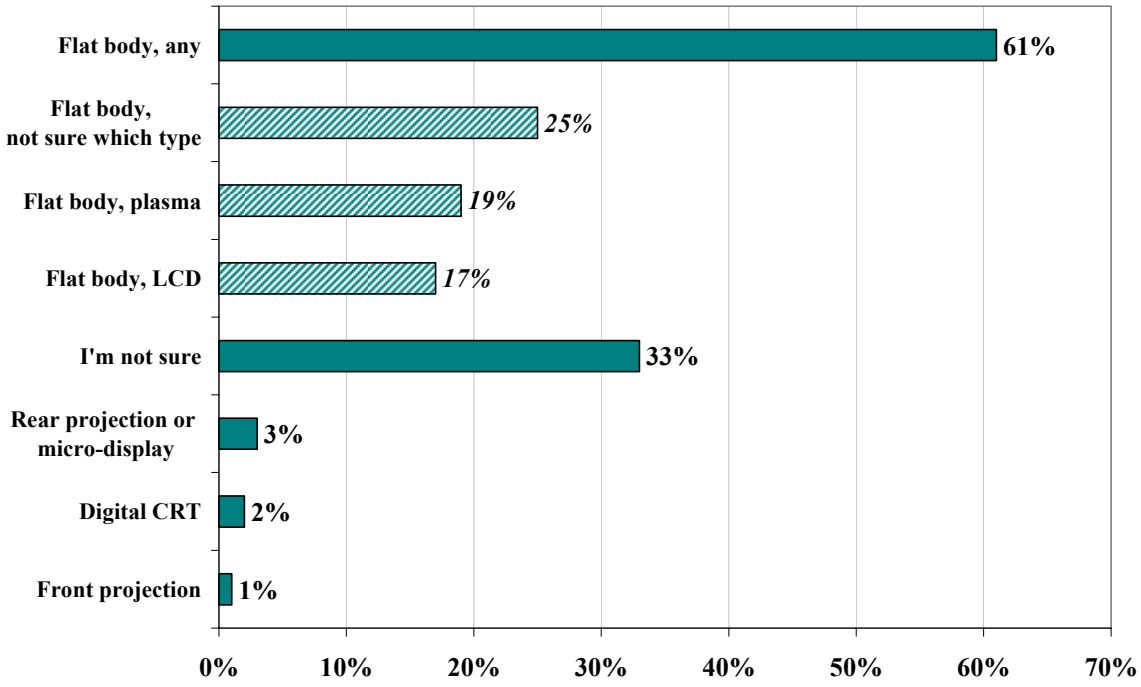
- **High Definition Television (HDTV) –** These TVs offer the highest resolution and a wider aspect ratio (16:9) than traditional TVs. HDTVs have up to 2 million pixels, or 13 times more than a standard analog TV. The typical display resolutions are 1280 x 720 and 1920 x 1080.

4.2.2 Market Trends

The television market is in the midst of a comprehensive change; digital models continue to erode the market share of analog models and will soon dominate sales. Mintel, a leading market research firm specializing in consumer electronics, reported that U.S. DTV sales have nearly tripled between 2002 and 2005, rising from $5 billion to $14 billion (2005b). Mintel's consumer research survey found that 18% of respondents said they own a DTV as of September 2005, and an additional 20% are planning to buy one within a year.

Within the DTV segment, there is an overwhelming consumer preference for flat screen monitors, either LCD or plasma models. Figure 4.2-1 shows the results of a Mintel survey that asked 910 adults which type of DTV they would like to purchase within a year and 61% said a flat body. Thirty-three percent of the respondents said they were not sure and only 6% said they prefer a projection or CRT model. It is important to note that these values reflect a *preference* and not their *actual* purchases, but they give a strong indication that consumers will prefer flat screen monitors independent of price constraints. As flat screen prices do drop, consumers are now finding new locations for their TVs – such as their kitchens, bathrooms, and offices – that previously would have been too small for a bulky CRT model.

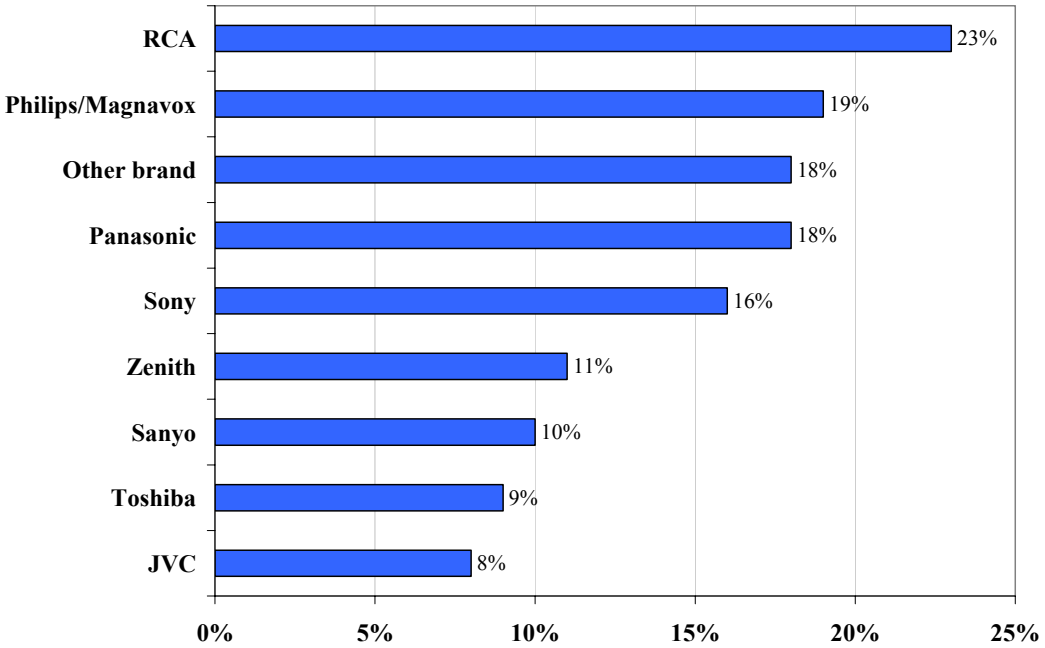
Figure 4.2-1 Type of DTV Consumers Want to Buy in the Next Year, September 2005



Base: 910 adults aged 18+, with access to the Internet, who plan to buy a DTV/HDTV in the next 12 months.
Source: Mintel (2005b)

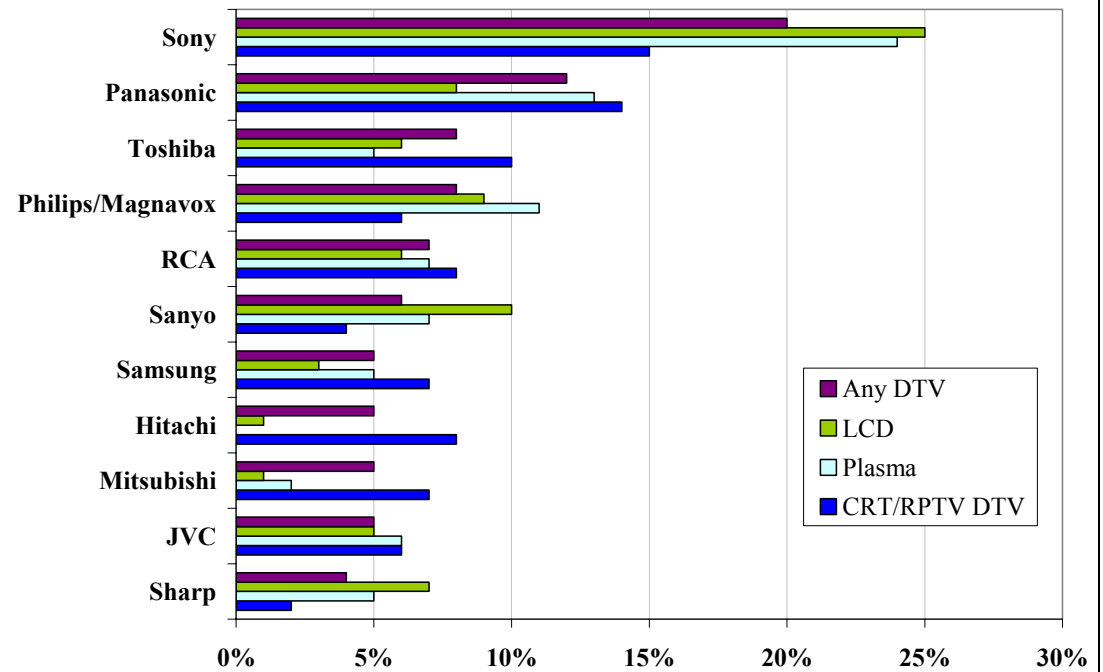
Figure 4.2-2 details the leading TV brands, by *current ownership*, in the U.S during May 2004 to May 2005. RCA was the leading brand at 23%, followed by Phillips/Magnavox (19%), Panasonic (18%), and Sony (16%). When analyzing the consumers' most recent *digital* TV purchase, the market share shifts. As shown in Figure 4.2-3, Sony was the leading brand for all types of DTVs at 20%, but there were ten brands within the 4% to 12% range. This shows that there is no dominant player in the DTV segment and many brands are vying for increased market share. Some brands show strength in certain categories, while others have equal footing for each display type. For example, Toshiba, Mitsubishi, Samsung, and Hitachi did the best with their CRT and projection sales, while Sharp, Sony, Phillips, and Sanyo performed well with their LCD and plasma units. The sales of JVC and RCA were similar across all display technologies.

Figure 4.2-2 Ownership of TV, by brand, May 2004-May 2005



Base: 20,694 adults aged 18+ who own a TV. Values do not add up to 100% based on multiple replies. Source Mintel (2005b).

Figure 4.2-3 Most Recent Digital Television Purchase, by Brand and Type, May 2004-May 2005



Base: 20,647 adults aged 18+, with access to the Internet, who have recently purchased a television. Values do not add up to 100% based on multiple replies. Source Mintel (2005b).

Table 4.2.1 provides a snapshot of all U.S. TV sales during the month of September, 2005. The top five selling TV brands – Sony, Magnavox, Toshiba, Samsung, and Panasonic – made up nearly 50% of sales, or $459.5 million out of $943.8 million. All of these top-selling brands are included in the sample set used to develop representative power consumption values for this report (as discussed in Section 4.2.6).

Table 4.2-1 Retail Value U.S. Sales of All Televisions, by Top Five Brands, September 2005

	Market share (%)	Sales at current prices ($M)
Sony	13.8	130.2
Phillips/Magnavox	9.5	89.7
Toshiba	9.4	88.7
Samsung	8.4	79.2
Panasonic	7.6	71.7
Top five suppliers	**48.7**	**459.5**
Other	51.3	484.3
Total television sales	**100**	**943.8**

Source: Mintel (2005b)

The average selling price of TVs is dynamic, especially in the DTV segment, but general trends show an annual decrease of 10% to 26% over the next few years. Notably, the average selling prices continue to drop even as screen sizes and picture quality increase. Table 4.2-2 shows the current and forecasted prices for different display types as reported by two market research firms, Mintel and iSuppli. Although there is variation between the two estimates, both firms report plasma displays as the most expensive TVs, followed by projection units, LCDs, and then CRTs or direct view TVs. iSuppli estimates that all average selling prices for TVs will be under $1,000 by 2009. As is typical in the technology sector, Mintel suspects that declining prices may lead to market exits and consolidation since suppliers will find it more difficult to maintain profit margins (2005b). It will be beneficial for PG&E to monitor these developments consistently so it can leverage any potential programs with the largest market players.

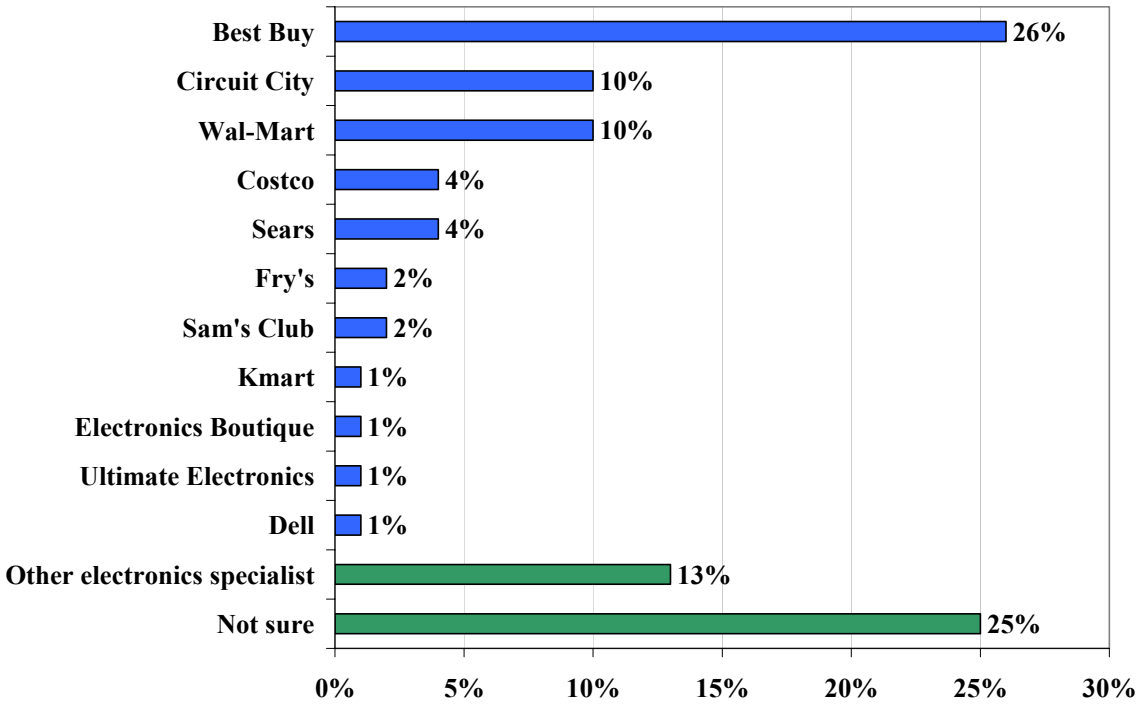
Table 4.2-2 Current and Forecasted Average Selling Price, by TV Display Type

Report	Mintel (1)		iSuppli (2)						CAGR
Year	2003	2005	2004	2005	2006	2007	2008	2009	(04-09)
CRT	NA		$319	$302	$268	$241	$213	$184	-10%
LCD	$530	$754	$1,682	$1,352	$1,236	$1,044	$851	$674	-17%
Plasma	$4,649	$1,953	$3,823	$2,774	$2,491	$1,935	$1,379	$877	-26%
DLP	NA		$3,102	$2,483	$2,184	$1,770	$1,357	$966	-21%
Direct View Digital	$957	$595	NA						
Rear Projection	$1,505	$1,443							
Front Projection	$1,062	$563							

Notes:
1) Source: Mintel (2005b). 2005 Values are estimates.
2) Source: EPA (2006). Report references iSuppli's Television Systems Market Tracker - Q4 of 2005

Consumer preference for specific TV retailers is shown in Figure 4.2-4. This is an important consideration when analyzing energy-efficiency program opportunities and the potential medium to reach customers. The Mintel customer survey asked 910 adults, "Where did you/do you plan to buy your DTV/HDTV?" (2005b). Over a quarter of all respondents (26%) said Best Buy, signifying its dominance in the consumer electronics (CE) segment. Circuit City and Wal-Mart were equally popular at 10% each, followed by Costco (4%), Sears (4%), Fry's (2%), and Sam's Club (2%). A quarter of the respondents were not sure and 13% mentioned a wide range of electronics specialty stores.

Figure 4.2-4 Purchase/planned Purchase of DTV, by Retailer, September 2005



Base: 910 adults aged 18+, with access to the Internet, who own or plan to buy a DTV. Source: Mintel (2005b).

4.2.3 Applicable Standards and Efficiency Programs

A number of voluntary and mandatory TV efficiency programs have been developed on the state, national, and international levels, and consist primarily of specifications for standby mode power. However, there is a growing recognition that active mode energy consumption dominates overall energy use and, consequently, a number of programs have recently focused on active mode specifications. The voluntary ENERGY STAR program and the mandatory California Energy Commission standard are the most relevant programs for TVs sold in PG&E territory. Yet, the international standards may serve as future guidelines for developing potential efficiency programs in PG&E territory. Table 4.2-3 summarizes the key programs that address TV energy consumption.

The California Energy Commission recently adopted a Title 20 appliance energy efficiency standard for TV standby power. The standard became effective January 1, 2006 and requires standby power to be less than or equal to 3W.

The ENERGY STAR TV specification was launched in 1998 and currently only specifies standby mode power consumption. The standby mode power level has decreased in subsequent phases and the current and final Tier 3 specification – effective since July 1, 2005 – requires a TV's standby mode power to be less than or equal to 1W. ENERGY STAR is now developing an active mode power specification and has recognized its importance in allowing consumers to identify the most energy-efficient models (EPA 2006). The timeline includes opportunities for interaction by many stakeholders and sets Spring 2007 as a target date for the release of a final revised specification. The effective date would then be a year later, in 2008.

A key step in this process will be the development of a new test procedure that measures the amount of energy consumed in active mode. The most commonly used testing procedure is IEC 62087, which was developed by International Electrotechnical Commission and defines the methods for measuring power consumption of audio, video, and related equipment. Unfortunately, IEC 62087 does not reflect "real world" conditions as it relies on a static, three-bar black and white test pattern (NRCD/Ecos 2005b). The procedure under reports the energy consumption of newer technology displays that consume more power while displaying bright, dynamic video. There is currently an international effort underway to establish a harmonized global test procedure that is able to measure all the new display technologies and reflect typical operating conditions. The international community was expected to determine the testing procedure by the end of 2006. Two key meetings were held in June 2006 – the Energy Efficiency in Domestic Appliances and Lighting conference in London and the Society for Information Display conference in San Francisco. The development of the active mode test procedure should be keenly monitored by PG&E as its timing and method could inform future energy efficiency program decisions.

Table 4.2-3 U.S. and International Energy Efficiency Standards and Specifications for Televisions

Country / Organization	Standby Mode	Active Mode	Voluntary	Mandatory	Testing Procedure
US EPS - ENERGY STAR	≤ 1 watt	Developing (tentative 1/08)	✓		
California Energy Commission	≤ 3 watts	none		✓	IEC 62087
EU - Group for Energy Efficiency Appliances (GEEA)	≤ 0.75 EEI	none	✓		IEC 62087; EEI
EU - Eco Label	≤ 1 watt or ≤ 9 watt w/IRD	≤ 0.65 EEI	✓		IEC 62087; EEI
EU - European Commission's Code of Conduct	Test and list	Test and list	✓		IEC 62087
Austrailian Greenhouse Office	≤ 1 watt	developing	✓		IEC 62087
Korea - Energy Boy	≤ 3 watts - TVs ≤ 4 watts - TV/combo	none	✓		IEC 62087
Japan - Top Runner	Varies based on screen size and technology			✓	IEC 62087
China - Chinese National Institute of Standards (CNIS)	≤ 3 watts - Mandatory ≤ 4 watts - Voluntary	1.5 EEI - Mandatory; 0.75 EEI - Voluntary	✓	✓	IEC 62087; EEI

Notes:

EEI = Energy Efficiency Index. The EEI is a formula that provides a sales-weighted energy efficiency index based on active and standby consumption, screen size, and technology type.

Sources: AGO (2004e) and NRDC/Ecos (2005b).

4.2.4 Usage Characteristics

American households are watching television at record levels. During the 2004-05 season, Nielsen Media Research (2005) reported that the average American household tuned into television 8 hours and 11 minutes per day.[20] This is the highest level ever recorded since Nielsen Media Research started their measurements in the 1950s, representing a 2.7% increase from the previous season and a 12.5% increase from a decade ago. The average per person viewing was reported at 4 hours and 32 minutes per day, an increase of 30 minutes over the last ten years.

The Nielsen values are based on physical measurements indicating when the television is turned on (e.g., in active mode) and provide a solid basis for developing a representative television duty cycle. This method is much more useful than relying on a self-reported survey or a study that only measures the amount of time a person is actually *watching* the TV (and thus may not capture the amount of time that a TV is on without any active viewers). A recent study from the Center for Media Design at Ball State University highlights the caution that should be applied when using self-reported surveys. The Ball State research team conducted a first of its kind study using direct observation to understand how consumers interact with all types of media. They found several startling differences between observed results and self-reported results. For instance, they found

[20] Nielsen measured the viewing season from September 20, 2004 to September 18, 2005.

that people under reported their TV and computer usage by nearly three times (Papper et al. 2005).

The representative average duty cycle for each PG&E TV in use is developed by the following calculation:

$$\textbf{Active Mode (hrs/day)} = \frac{\text{average hours of TV watched per household per day}}{\text{TVs per household}}$$

$$\textbf{Standby Mode (hrs/day)} = 24 \text{ hrs/day} - \text{Active mode (hrs/day)}$$

This weighted average accounts for the fact that a households' primary TV is in active mode more often than supplementary TVs. Table 4.2-4 shows the current and forecasted viewing trends for PG&E territory and Table 4.2-5 displays the duty cycle assumption used in this study. For simplicity, we use the 2006 viewing trends to develop a PG&E average duty cycle of 3.4 hours per day in active mode, and 20.6 hours in standby mode. It would be appropriate to use the Primary TV duty cycle (4.5 hours active, 19.5 hours standby) when comparing individual TVs, but this would overstate usage in a macro analysis.

Table 4.2-4 Current and Forecasted Television Viewing Trends, 2005 - 2010

	Hours of television watched per day					
	2005	**2006**	**2007**	**2008**	**2009**	**2010**
Per household - Nielson (1)	8.2	8.3	8.4	8.6	8.7	8.8
Per person - Nielson (1)	4.5	4.6	4.7	4.7	4.8	4.8
Per PGE TV - Calculated (2)	3.6	3.4	3.3	3.1	3.2	3.0

Notes:

1) Source: Nielson (2005). Forecasted using historic growth trends through September 2005. Nielson Media Research measures usage from the TV view season (Sept-Sept).

2) Calculated by dividing per household viewing hours by TVs per PGE household. Values decrease because the latter trend is growing faster than the former.

Table 4.2-5 Television Duty Cycle Assumptions

	Hours per Day	
	Active Mode	**Standby Mode**
Primary TV (1)	4.6	19.4
PG&E - weighted average (2)	3.4	20.6

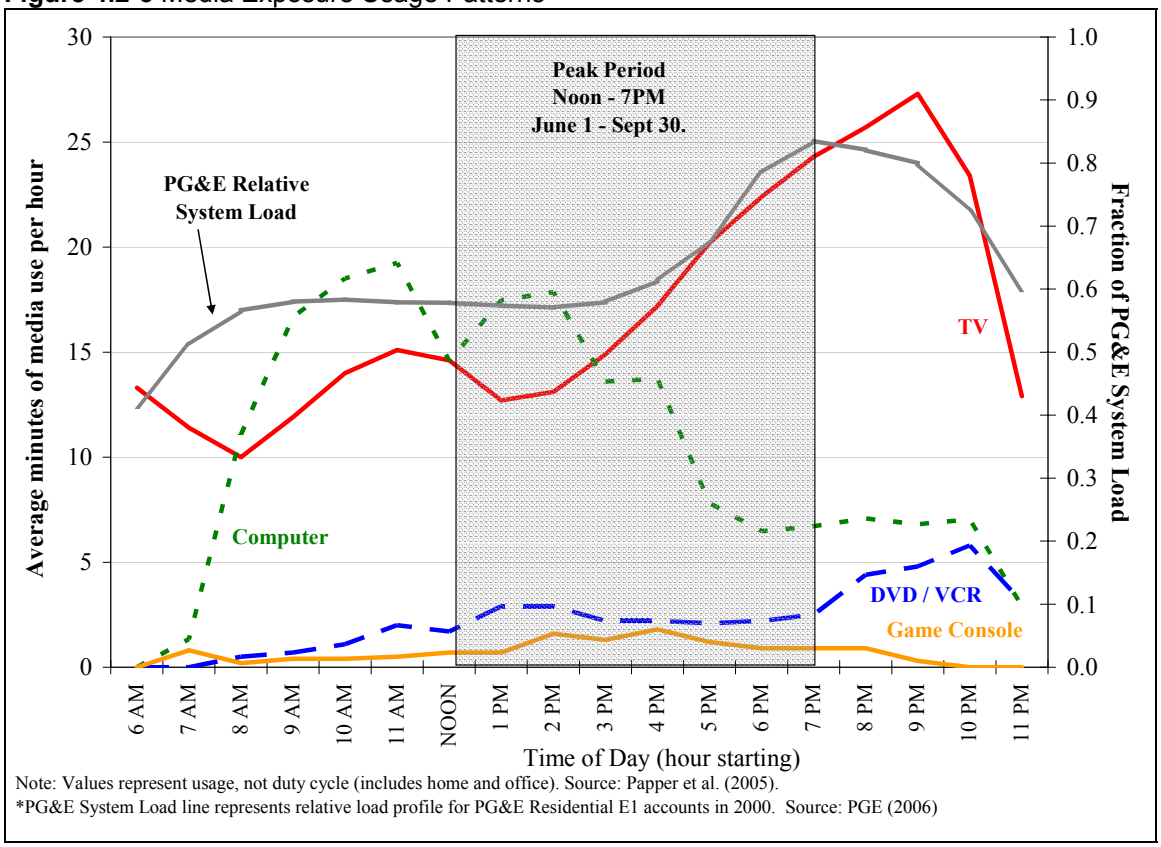
Notes:

1) Source: Nielsen (2005)

2) Weighted average used for overall PG&E energy forecast. Calculated by dividing per household viewing hours [Niesen (2005)] by TVs per PGE household [(CEC 2004) and EPA (2006)].

The Ball State study (Papper et al. 2005) provides some insights into how media usage fluctuates throughout the day and subsequently affects the PG&E system load. Figure 4.2-5 shows a typical usage profile from 6 a.m. to midnight compared to a relative PG&E load profile.[21] The television usage is fairly flat throughout the morning and into the afternoon. At 2 p.m., usage ramps up to a peak at around 9 PM. This ramp-up occurs in the latter half of PG&E's peak period, but does not crest until about two hours after the peak hours. The figure also highlights television's dominant status in the American household. The Ball State study found that as usage from competing media – primarily the personal computer – has risen, TV use has also continued to increase.

Figure 4.2-5 Media Exposure Usage Patterns



Note: Values represent usage, not duty cycle (includes home and office). Source: Papper et al. (2005).
*PG&E System Load line represents relative load profile for PG&E Residential E1 accounts in 2000. Source: PGE (2006)

4.2.5 PG&E Shipments and Stock

The number of TVs in PG&E's Mass Market segment will continue to rise as people buy new TVs faster than they retire their old ones. For instance, a common household trend is to buy a newer technology TV (e.g., LCD, plasma, or projection) and then move an older CRT to another location within the home, such as a child's bedroom. In 2003, the California Statewide Appliance Saturation Study (CEC 2004) found that PG&E households had over 8 million working TVs,

[21] The media exposure profiles are based on direct observations of 394 people conducted in March, April, May, and June 2005. The profiles include all media exposure, primarily in the home or office environment.

representing approximately 1.9 TVs per household and 0.7 TVs per person.[22] Trends indicate that approximately 14.9 million TVs will be in use in the PG&E territory by 2010, surpassing the one TV per person threshold. Table 4.2-6 and Figure 4.2-6 illustrate these trends.

Table 4.2-6 Televisions - Forecasted Residential Stock in PG&E Territory, 2005 - 2010

	2005	2006	2007	2008	2009	2010
Total TVs in use (000) (1)	9,800	10,690	11,660	12,700	13,830	14,960
Est. PG&E households (000) (2)	4,410	4,480	4,560	4,630	4,710	4,780
TVs per household	2.2	2.4	2.6	2.7	2.9	3.1
Est. PG&E res. pop. (000) (3)	12,660	12,860	13,090	13,290	13,520	13,720
TVs per person	0.8	0.8	0.9	1.0	1.0	1.1

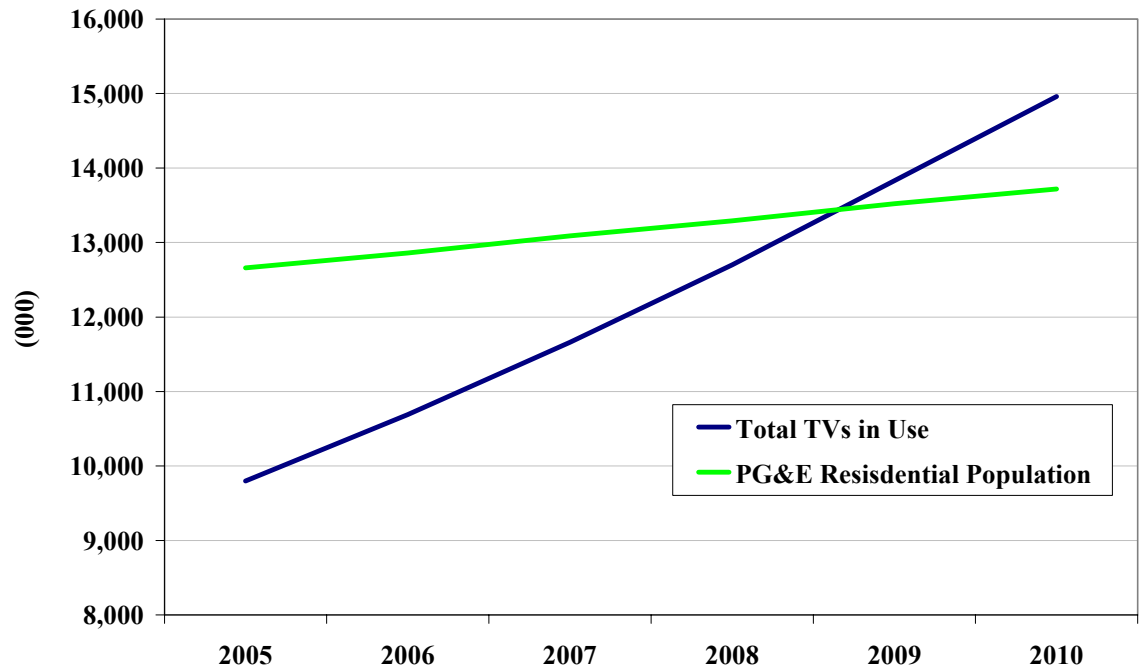
Notes:

(1) Source: Forecasted based on 2003 PG&E television stock values [CEC (2004)] and projected shipments [EPA (2006)]. Assumes that 1 televison is retired for every 4 purchased.

(2) Calculated based on PG&E growth trend from 2002 to 2005. Source: CEC (2004) and PG&E (2005).

(3) Calculated: (PG&E households) * (2.87 average persons per household; source: U.S. Census (2006)).

Figure 4.2-6 Television and Residential Population Growth Trends in PG&E Territory, 2005-2010



Sources: Total TVs - Forecasted based on 2003 PG&E television stock values [CEC (2004)] and projected shipments [EPA (2006)]. PG&E Population - Calculated: (PG&E households) * (2.87 average persons per household; source: U.S. Census (2006)).

[22] See Appendix Table 5 for detailed values.

As the total number of TVs in use increases, TV technology has become more diverse. The decreasing price points and increased popularity of LCD, plasma, and projection models will continue to chip away at the dominant market share held by CRTs. A leading TV market research firm, iSuppli, estimates that by 2009, only 15% of TV shipments will consist of CRT models, down from 75% in 2004 (EPA 2006). Furthermore, iSuppli forecasts that in 2009, 71% of shipments will be flat panel models measuring 30 inches or more.

Our forecasted number of TV shipments and stock in PG&E territory is developed using iSuppli's growth trends combined with the current PG&E TV stock. Table 4.2-7 shows that shipments are expected to grow from 1.17 million in 2005 to 1.51 million in 2009. LCD TVs will see the greatest increase in market share during this time period, rising from 19% to 58%. Table 4.2-8 highlights how the drastically changing shipment distribution will affect the complete PG&E Mass Market stock. CRTs will make up the majority of the stock through 2010, but their estimated stock share will decrease from 90% in 2005 to 63% in 2010. By 2010, we estimate that LCDs will account for 23% of the stock, while plasmas and projection units make up 7% and 6%, respectively.

Table 4.2-7 Televisions - Forecasted Mass Market Shipments in PG&E Territory, 2005 – 2009 (000)

	2005		2006		2007		2008		2009	
	Units	Share	Units	Share	Units	Share	Units	Share	Units	Share
CRT	750	64%	590	50%	470	36%	300	22%	230	15%
LCD	220	19%	360	30%	530	41%	710	51%	870	58%
Plasma	80	7%	120	10%	170	13%	220	16%	240	16%
Projection	120	10%	120	10%	130	10%	150	11%	170	11%
Total	**1,170**		**1,190**		**1,300**		**1,380**		**1,510**	

Source: EPA (2006). Report references iSuppli's Television Systems Market Tracker - Q4 of 2005. iSuppli forecasts North American shipments. This forecast assumes that 4% of North American shipments go to PG&E customers, based on the population ratio (12.9 million PGE residential population / 326 million N.A. population = 4%). Population sources: PG&E (2005) and CIA (2006).

Table 4.2-8 Televisions – Forecasted Mass Market Stock in PG&E Territory, 2005-2010

Estimated TV Stock (%)	2005	2006	2007	2008	2009	2010	CAGR (05-10)
CRT	90%	87%	83%	78%	72%	65%	-6%
LCD	5%	7%	9%	13%	17%	21%	32%
Plasma	2%	3%	3%	4%	6%	7%	29%
Projection	3%	4%	4%	5%	6%	6%	18%
Estimated TV Stock (000 units)	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**CAGR (05-10)**
CRT	8,820	9,290	9,670	9,880	9,930	9,780	2%
LCD	520	740	1,100	1,630	2,330	3,210	44%
Plasma	190	270	390	560	780	1,020	40%
Projection	270	390	510	640	790	960	29%
Total	**9,800**	**10,690**	**11,670**	**12,710**	**13,830**	**14,970**	**9%**

Note: Forecasted based on current TVs per household and projected TV shipments in PG&E territory. Ratio of LCD, Plasma, and Projection stock percentatges are consistent with projected shipments. Assumes that CRTs are being retired at a greater rate than being replaced be other CRTs.

4.2.6 PG&E Energy Consumption

The energy consumption characteristics in our study are based on over 260 TV measurements presented in four separate reports. They cover a wide range of technology types and screen sizes.[23] Appendix Table 6 details the sample size for each report and the corresponding high, low, and average power measurements for each display type. Using data from all four reports, we develop the power consumption baseline presented in Table 4.2-9.

The power consumption data reveal that active mode power varies greatly for each display type. In active mode, the average power consumption for CRTs is 82W with a measured range from 41W to 200W. NRDC and Ecos Consulting (2004b) note that direct view CRTs typically have a 200W "ceiling" because their screen size is currently limited to 37 diagonal inches. LCD units have the lowest Baseline average at 62W, with measurements ranging from 24W to 214W. Plasma units have the highest Baseline average of 204W and also have the greatest range from 65W to 451W. The data for projection units shows an average of 169W, with a low of 94W and a high of 276W.

We set the standby mode Baseline at 3W based on the recent California Energy Commission Title 20 standard. The standard became effective January 1, 2006 and requires all TVs sold within California to have a standby power level no greater than 3W. The 3W standby level is lower than the average from our four-report sample set, but its use will accurately reflect the estimated energy consumption and potential savings from future TV shipments to PG&E territory.[24]

In addition to looking at the power consumption of different display types, NRDC and Ecos Consulting (2004b) analyzed the effect that screen size and resolution have on active mode power use. Their findings are summarized below:

- **Screen Size:** As one might expect, there is a general correlation between increases in power consumption and increases in screen size. However, there is also a wide range of power consumption levels at each screen size. This indicates a wide range of efficiency levels among similarly sized models. The power consumption for

[23] The four reports were authored by the Australian Greenhouse Office (AG0 2004e); CNET (2005); Natural Resource Defense Council and Ecos Consulting (NRDC/Ecos 2005b); and the U.S. Environmental Protection Agency / Lawrence Berkeley National Laboratory (EPA 2006).

[24] The average standby mode power from the four-report sample set varied much less between the display types, ranging from a low of 4.1W for CRTs and LCDs to a high of 9.3 for projection units. Plasma units had a standby average of 6.7W. While the Baseline *averages* are relatively tight across display types, some models within each category had significant standby loads, approaching the 40W to 50W range (Probably sources of high standby wattage include the presence of integrated digital video recorders (DVRs) in some models.

projection technologies is less affected by screen size since they rely on similar lamps that can project images onto different screen sizes.

- **Resolution:** In general, TVs with greater resolution capabilities use more active mode power. Although, similar to screen size, this is a very broad trend and efficiency levels vary widely. For example, there are EDTVs and HDTVs available today that use roughly the same amount of power as a similarly sized analog TV. In addition, the testing results showed that active mode power consumption can vary by a factor of 2.5 among EDTVs and HDTVs of similar size and features.[25]

The current power consumption trends indicate that there is a wide range of efficiency levels for each display type, screen size, and resolution level. This indicates that there are opportunities for an energy efficiency program to promote the most efficient models on the market without imposing incremental costs or sacrificing functionality. However, the active mode power levels of most TVs are unfortunately not available to consumers and policymakers. This adds importance to the activities underway to measure and report active mode power consumption.

Table 4.2-9 Televisions - Power Consumption Baseline per Unit

		Sample Size (n)	Low (W)	High (W)	Baseline Mean (W)
Active Mode	CRT	125	41	200	**82**
	LCD	53	24	214	**68**
	Plasma	38	65	451	**204**
	Projection	44	94	276	**169**
Standby Mode	CRT	54	0.5	50.0	**3.0**
	LCD	42	3.9	18.5	**3.0**
	Plasma	28	0.7	37.0	**3.0**
	Projection	39	0.4	45.0	**3.0**

Source: Weighted active mode baseline based power measurements from four reports - AGO (2004e); EPA (2006); NRDC/Ecos (2005b); and CNET (2005). Standby baseline based on 3W CEC standard. See Television Appendix for detailed values from each report.

It is important to note that these power consumption values are not *shipment-weighted* averages and do not *precisely* represent the market. Generating shipment-weighted averages is the most exact way to evaluate energy use but the data collection required to do so is extensive and beyond the scope of this report. The Baseline values developed for this report are based on over 260 TV power measurements that capture a large range of brands, display types, screen sizes, and resolution capabilities and are appropriate to use for forecasting energy and potential savings opportunities.

[25] The report cites an example of two similar featured 36-inch HDTVs with 16:9 widescreen aspect ratios. One TV consumed 140 watts in active mode whereas the other consumed 350 watts.

Table 4.2-10 shows the electricity consumption for each representative type of TV display based on two different duty cycle scenarios. The *Primary TV* scenario is based on a duty cycle for a household's primary TV and includes more time per day in the active mode (4.6 hrs/d active, 19.4 hrs/day standby). The *PG&E – Weighted Average* takes into account that supplementary TVs are in active mode less than the primary TV and is more appropriate for a system-wide energy assessment for PG&E. The energy estimates highlight the importance of active mode power on overall energy consumption, and the importance of developing active mode specifications for efficiency programs such as ENERGY STAR. An average TV spends only a few hours a day in active mode, but this period accounts for roughly 79% to 94% of its annual energy consumption.

Table 4.2-10 Televisions - Unit Annual Electricity Consumption Estimates (kWh/yr)

Display Type	Primary TV			PG&E - Weighted Average			Active Mode %
	Active	Standby	Total	Active	Standby	Total	
CRT	137	21	158	104	22	126	87% - 82%
LCD	113	21	135	86	22	108	84% - 79%
Plasma	341	21	363	259	22	281	94% - 92%
Projection (DLP)	283	21	304	214	22	237	93% - 91%

Note: Estimates vary based on two different duty cycle assumptions. PG&E weighted average takes into account that supplementary TVs are in active mode less than primary TV.

Table 4.2-11 forecasts the first-year annual energy consumption for new TV shipments to PG&E's Mass Market. The annual energy consumption from new shipments is estimated to increase from 170 million kWh/yr in 2005 to 231 million kWh/yr in 2009, representing an overall 8% CAGR. The largest growth during this period will be from LCD and plasma TVs, with 41% and 31% CAGRs, respectively. The CRT energy consumption will continue to decline throughout this time period at the rate of approximately 26% per year. By 2008, the first-year energy consumption from new LCD, plasma, and projection shipments, respectively, will all surpass the consumption from CRT shipments.

The forecasted annual energy consumption for the complete mass market stock in PG&E territory was estimated to be 1,289 million kWh/yr in 2005. By 2010, the overall energy consumption is expected to increase to 2,099 million kWh/yr. CRTs will account for the overwhelming majority of the *stock* energy consumption throughout this period but will decrease from 87% of overall consumption in 2005 to 59% in 2010. The proportion of overall TV consumption within PG&E's Mass Market sector is estimated to rise from 5.2% of overall Mass Market consumption in 2005 to 7.5% in 2010. Table 4.2-12 summarizes these results.

Table 4.2-11 Televisions - Forecasted First-Year Annual Energy Consumption for New Shipments to PG&E Mass Market, 2005-2009 (million kWh/yr)

	2005	2006	2007	2008	2009	CAGR (05-09)
CRT	95	75	59	39	29	-26%
LCD	24	39	58	77	95	41%
Plasma	23	33	48	62	68	31%
Projection	28	28	31	36	39	9%
Total	**170**	**175**	**195**	**214**	**231**	**8%**
% of PGE mass market	**0.7%**	**0.7%**	**0.7%**	**0.8%**	**0.8%**	

Note: Calculated based on baseline electricity consumption using "PG&E Weighted Average" duty cycle and projected shipments to PGE territory.

Table 4.2-12 Televisions - Forecasted Annual Energy Consumption for Complete Mass Market Stock in PG&E Territory, 2005-2010 (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
CRT	1,115	1,175	1,223	1,249	1,256	1,237	2.1%
LCD	56	80	119	177	253	348	43.9%
Plasma	53	76	110	158	219	287	39.9%
Projection	64	92	121	152	187	227	28.9%
Total	**1,289**	**1,423**	**1,573**	**1,735**	**1,915**	**2,099**	**10.2%**
% of PGE mass market	**5.2%**	**5.6%**	**6.0%**	**6.5%**	**7.0%**	**7.5%**	

Note: Calculated based on baseline electricity consumption using "PG&E Weighted Average" duty cycle and forecasted PGE television stock.

4.2.7 Lifecycle Costs

The lifecycle costs presented in Table 4.2-13 represent a *typical* purchase made in 2005 for each display type. The first costs are based on iSuppli's average selling price estimates (EPA 2006) and the present value lifetime energy costs are based on a 9 year estimated useful life, a $0.13/kWh electricity rate, and an 8.15% discount rate.[26] The lifecycle costs will continue to drop as average selling prices drop, and energy costs will make up a larger percentage of the overall lifecycle cost. The energy costs for a CRT are currently about 26% of its lifetime costs, whereas they are roughly 6% to 8% of the lifetime costs of LCD, plasma, and projection units. Using the estimates in Table 4.2-13, the total lifecycle cost for all 2006 projected PG&E shipments is over $1.4 billion.

[26] See Table 4.4-2 for detailed average selling price estimates.

Table 4.2-13 Televisions - Lifecycle Costs per Unit

	First Costs (1) ($)	Estimated Useful Life (2) (years)	Lifetime Energy Costs (3) (PV $)	Total - Lifecycle Costs ($)
CRT	$302	9	$102	$404
LCD	$1,352	9	$88	$1,440
Plasma	$2,774	9	$227	$3,001
Projection	$2,483	9	$191	$2,674

Notes: (1) Source: EPA (2006). Report references iSuppli's Television Systems Market Tracker - Q4 of 2005. (2) Source: ENERGY STAR (2006). (3) Calculated: PV[(estimate useful life) * (unit annual electricity) * (PG&E residential rate - $0.13/kWh - Source CEC (2006))]. Discount rate = 8.15%.

4.2.8 Opportunities for Energy Savings

As mentioned earlier, the power consumption measurements reveal that there is a wide range of efficiency levels for each display type, screen size, and resolution level. For our Improved Case scenario, we assume a 25% efficiency gain in active mode power and set standby power at 1 watt. This follows the NRDC/Ecos (2005b) model of observing that within each display category, there are TVs that consume 25% less power in active mode than the Baseline average. The 1 watt standby assumption is based on the current ENERGY STAR specification. Appendix Table 7 details the specific Improved Case power levels for each display type.

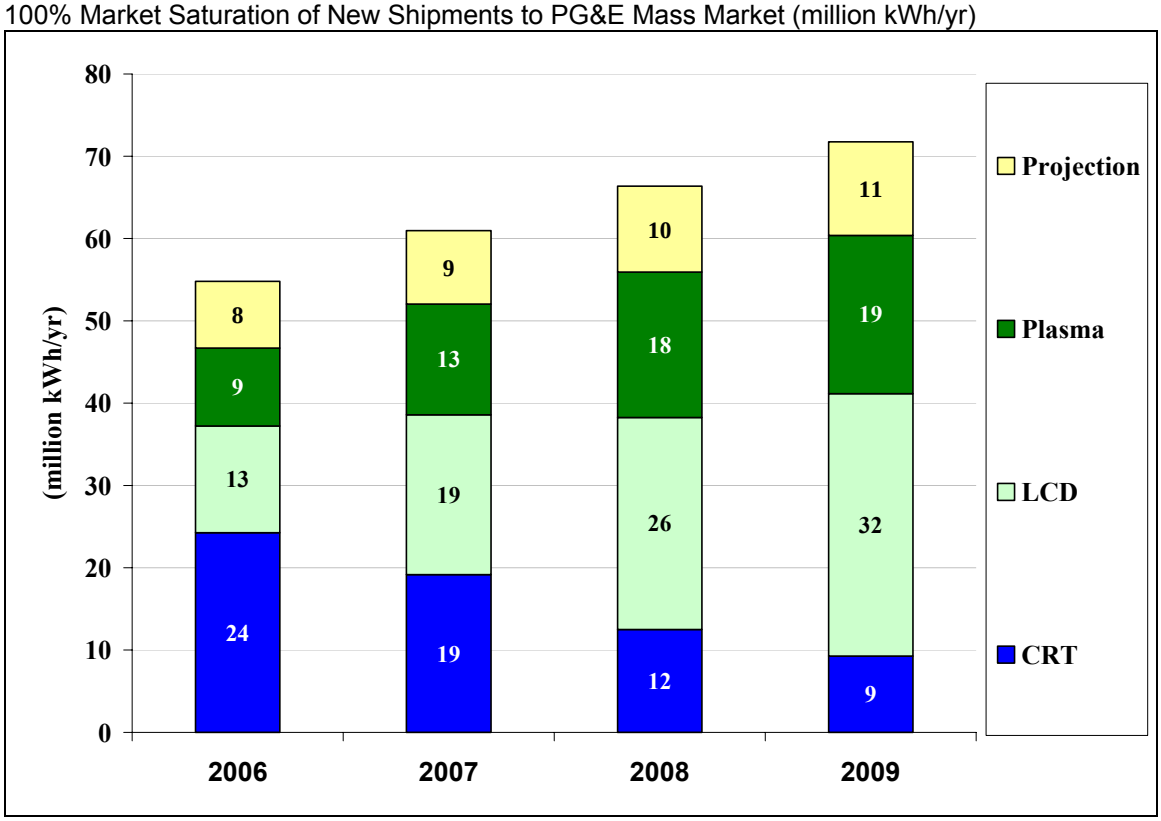
Table 4.2-14 shows the annual energy savings per unit with the Improved Case scenario. The savings range from 36 kWh/yr for an average LCD unit to 80 kWh/yr for a plasma model. Figure 4.2-7 shows the potential energy savings if 100% of all new shipments to the PG&E Mass Market met the Improved Case scenario. The potential savings range from 54.8 million kWh/yr in 2006 to 71.7 million kWh/yr in 2009. A range of savings, based on 5%, 25%, and 50% sales penetration of Improved Case shipments, is presented in Appendix Table 8.

Table 4.2-14 Televisions - Energy Savings per Unit with Improved Case Scenario

	Unit Annual Electricity Consumption (kWh/yr)		
	Baseline	Improved Case	**Savings**
CRT	126	85	**41**
LCD	108	72	**36**
Plasma	281	202	**80**
Projection	237	168	**69**

Note: Improved case scenario assumes 25% efficiency gain in active mode power and sets standby power at 1 watts. See television appendix for specific power values, by mode.

Figure 4.2-7 Televisions - First-Year Annual Energy Savings with Improved Case Scenario – 100% Market Saturation of New Shipments to PG&E Mass Market (million kWh/yr)



4.2.9 Future Work

An energy efficiency program that targets active mode energy use holds greatest potential for savings – considerably more than a standby mode-only program. The recent CEC Title 20 standard that limits standby power to 3W will achieve statewide energy savings, but has also reduced the savings potential for a voluntary program targeting this mode. Unfortunately, the active mode power consumption for most TVs is currently unavailable. This will begin to change with the determination of the new active mode test procedure (targeted for the end of 2006) and the subsequent ENERGY STAR specification (targeted effective date January 2008). See Section 5. [Program Recommendations] for a more detailed discussion on recommended PG&E program intervention, delivery types, and key dates.

4.3 Set-Top Boxes

4.3.1 Overview

Set-Top Boxes (STBs) represent the fastest growing product category within this report. Their stock in PG&E's Mass Market is estimated to increase 133% from 2005 to 2010, and the Baseline Scenario energy consumption to rise from 820 million kWh/yr to 1,910 million kWh/yr. Perhaps the most significant STB energy characteristic is the fact that, on average, about 80% of the energy consumption occurs in the standby mode, when most users perceive the device as being "off". Because STBs must be ready to receive updated content from service providers, their average power draw in standby mode is nearly the same as that in active mode. Therefore, the most promising energy savings will come from the development of a true low power mode (e.g, a "sleep" mode) for when the STB is not in use.

In general, the term set-top box has traditionally described devices that receive and convert an external signal into viewable content for a television. However, the distinction has been blurred over the last several years and can now include multiple technologies with varied functionality – from the traditional analog cable box to game consoles to standalone digital video recording (DVR) devices. Within the context of this study, the following set-top box categories are covered in detail:[27]

- **Digital cable box –** This category includes *all* STBs that receive and convert digital cable signals into viewable content for televisions.

- **Digital satellite receiver –** This category includes *all* STBs that receive and convert digital satellite signals into viewable content for televisions.

- **Digital video recorders (DVRs) –** This category includes STBs that are similar to a VCR but records television data in digital format on a hard drive and has the common functionality of recording, playback, fast forwarding, rewinding, pausing, and skipping directly to any part of the program. The most widely used standalone DVR is TiVo™.

- **Television over Internet Protocol (IPTV) –** This category includes STBs that receive and convert broadband Internet signals into viewable content for television. An IPTV STB can provide functionality that includes video-on-demand (VOD), Electronic Program Guide (EPG), Web browsing, e-mail viewing, and a variety of interactive and multimedia services. IPTV is often referred to as Telco TV.

Increasingly, STBs have been developed with combined functionality, such as a digital cable box with DVR capability. For this report, the market trends and energy characteristics presented for DVRs are for *standalone* DVR units only. Trends and characteristics for the *digital cable box* and *digital satellite* categories include all types of those devices, respectively (e.g., a digital cable box with DVR capability is captured within the *digital cable box* category).

[27] Set-top boxes used in conjunction with Voice over Internet Protocol (VoIP) are analyzed in Section 4.1, Home and Small Commercial Offices.

Another important set-top box is the **Digital Television Adapter (DTA)**, which is a device that converts a digital television signal into viewable content for analog televisions. As discussed in the previous Television section, analog TVs will require a DTA after February 17, 2009, the federally mandated date for all broadcasting entities to have shifted from analog to digital signals. The California Energy Commission recently adopted a Title 20 Appliance Standard for DTAs, effectively eliminating the need for a future CEE program involving these units.

4.3.2 Market Trends

The market trends for cable, satellite, and IPTV STBs are developed primarily from two IDC reports:

1) *Worldwide and U.S. Digital Set-Top Box 2005-2009 Forecast and Analysis* and
2) *U.S. Digital Cable, Satellite, and Telco TV Subscriber 2005-2009 Forecast.*

The IDC trends are based on primary and secondary research sources from service providers, STB and equipment vendors, and component suppliers. The DVR trends are developed from an iSuppli (2005) market forecast. The key trends influencing the PG&E shipment and stock forecasts include[28]:

- **Subscriber growth –** This is the most important driver for digital STB shipments. At the end of 2005, IDC estimates that there were 56 million *digital* cable, satellite, and IPTV subscribers in the United States, up 12% from 2004.[29] Total U.S. subscribers are expected to surpass 81 million by the end of 2009. Satellite STB shipments will exceed cable boxes each year in the forecast, although their overall market share will decrease.

- **Multiple boxes per home –** Households will use multiple STBs to connect more than one television to a subscription service.

- **Advanced Boxes –** Advance cable and satellite boxes with DVR and/or HD capability will drive shipments over the next few years. In 2004, DVR cable and satellite STBs represented 30% of worldwide shipments.

- **Launch of IPTV –** Three of the leading U.S. regional Bell operating companies (RBOCs) – Verizon, SBC, and BellSouth – plan on launching IPTV services within the forecast period. IPTV STB shipments will depend largely on their success.

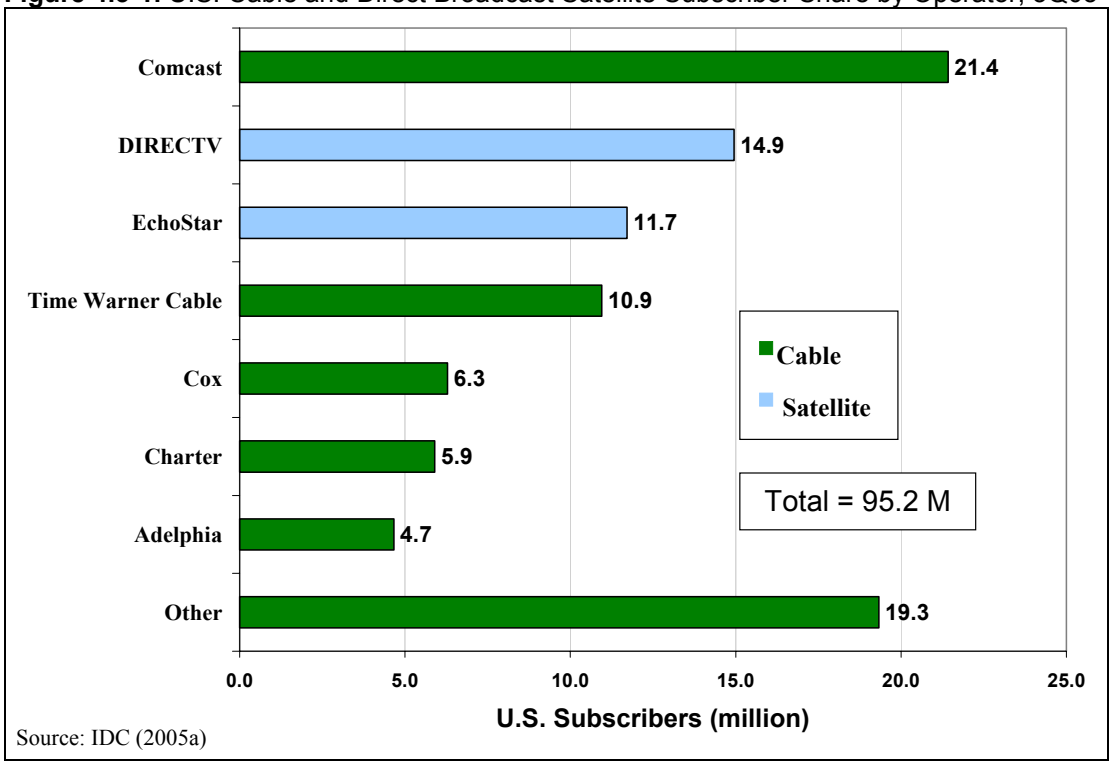
- **DVR popularity –** Strong growth is predicted for DVRs as consumers embrace their advanced features relative to a VCR. New service offerings – such as TiVo's plan to partner with NetFlix and allow customers to download movies to their machines – should further increase sales.

[28] Sources: IDC 2005a and IDC 2005c for digital cable, digital satellite, and IPTV STBs; iSuppli (2006) for DVR STBs.
[29] This value is for digital subscribers. The *analog* and *digital* subscribers totaled 92 million.

IDC estimates that there were 95.2 million cable and satellite TV subscriptions in the United States at the end of 2005. Many of these cable and satellite subscribers receive STBs directly from service operators. Therefore, understanding who the service operators are will be essential for a future STB energy efficiency program.

Figure 4.3.1 shows the subscriber share by service operator for the third quarter of 2005. Comcast is the market leader with 21.4 subscribers, or 22.5% of total subscribers. DIRECTV and EchoStar are the two main satellite operators, serving a combined 27 million subscribers, and DIRECTV has the slight market share lead at 56%. Time Warner is the number two cable provider, followed by Cox, Charter, and Aldephia.

Figure 4.3-1. U.S. Cable and Direct Broadcast Satellite Subscriber Share by Operator, 3Q05



Source: IDC (2005a)

Cable and satellite service providers offer an array of set top boxes as part of a TV subscription service. STBs are typically leased to the consumer for a monthly or annual fee or are included as part of a term subscription. The level of service (i.e., the number of channels, features, and degree of access) determines which STB the service providers will offer. All the major service providers including Comcast, Direct TV, DishNetwork, and Time Warner Cable offer programmable video recording capabilities by up-selling a service package that includes an STB with an integrated digital video recorder (DVR) for an additional monthly fee of six to ten dollars.

Since Pay TV packages are viewed as a service rather than a product, the actual make and model of the STB is often not revealed to the consumer nor is it usually relevant to the consumer's decisionmaking. A quick survey of the Web sites of top cable and satellite television

providers indicates that the majority of them do not openly disclose which STB they are providing (in the case of DIRECTV they offer a self-branded STB manufactured by another company). Rather, the service providers market their service's features as this is typically the basis for consumer action. It is probable that consumers view STBs as a homogenous product with little or no brand differentiation, and that the service providers change their STB stock often as STB manufacturers compete for orders on both price and features.

Retail outlets such as Best Buy and Circuit City offer satellite service subscriptions for DIRECTV in which the consumer receives a STB from the service provider as part of the subscription or pays an additional monthly fee to lease an STB with extra features, such as HD capability and DVR. This sales channel is similar to ordering the service directly from the service provider except the consumer has the opportunity to experience the functionality firsthand before committing to installation. (As in their direct subscriber service, DIRECTV markets a self-branded STB in this retail offering.)

Manufacturers of STBs do not readily disclose the sleep mode/passive standby power consumption figures for their STBs. These manufacturers market their products to television service providers and compete based on features (HD, DVR, on demand programming, etc) and price.

4.3.3 Applicable Standards and Efficiency Programs

The next couple of years should see new developments in STB testing, standards, and voluntary programs that could influence a PG&E Customer Energy Efficiency program. However, there is still some uncertainty regarding the timing and scope of new testing procedures and programs.

ENERGY STAR launched a STB specification in 2001, but officially suspended the specification on February 2, 2005. The Tier 1 criteria, outlined in Table 4.3-1, defined three STB categories and set maximum power consumption levels for the low power mode. By November 2004, there were six manufacturing partners[30] and 25 qualifying products in the marketplace (EPA 2005). The Tier 2 specification set 7W as the maximum for standby mode power. ENERGY STAR determined that the Tier 2 criteria was not conducive to current market conditions and suspended the entire specification indefinitely.

The most commonly used STB testing procedure is IEC 62087, developed by International Electrotechnical Commission (IEC), which defines the methods for measuring power consumption of audio, video, and related equipment. IEC 62087 is currently not ideal for testing STBs, as it does not adequately address STBs with advanced functionality and the potential for a STB to have a "sleep" mode (EPA 2005).

The lack of a well-established standard for testing the sleep mode/passive standby energy consumption of STBs creates a situation where there is no mechanism to differentiate energy-efficient STBs from standard STBs. Industry groups and standards bodies are in the midst of

[30] Funai Corporation, Hughes Network Systems, LG Electronics, Motorola, Pace Micro, and Sony Electronics.

formulating a testing standard for STBs. Such a standard will be an important step towards developing any type of incentive program that promotes the top tier of efficient STBs.

An international community of stakeholders is currently working to improve STB testing procedures and to provide recommendations for standards and/or voluntary efficiency programs. A Web site[31] has been created to track the effort of the "International Set Top Box Harmonization Initiative" and the stated objectives are (APEC 2006):

- To ensure uniform adoption, and refinement, of the international test protocol for Set Top Boxes (STBs), IEC 62087;
- To identify a number of performance specifications for STBs to facilitate testing comparisons and possible rationalization of STB performance requirements; and
- To propose a concrete set of STB initiatives to the wider international consumer electronics community.

On July 31, 2006, the Consumer Electronics Association (CEA) published CEA-2013, *Digital STB Background Power Consumption* that provides sleep mode power measurement testing procedures for basic and advanced STBs. An additional test procedure, CEA-2022 is currently in draft form and will address the measurement of On state power in STBs.

The results of these efforts will be important to track while considering a PG&E CEE program.

Table 4.3-2 reviews the California, U.S., and international efforts related to STB energy efficiency. The California Energy Commission recently adopted a Title 20 appliance standard for DTAs, effectively eliminating the need for a future CEE program involving these units. The current language sets 8W as the maximum active mode power level and 1W as the maximum standby mode power level. The PG&E Codes and Standard team is currently conducting research on digital cable and satellite STBs, and may recommend new Title 20 language to the CEC that addresses these units. If the CEC does pass new Title 20 regulations for STBs, it will not be before 2009.

The EU Code of Conduct's voluntary specification and Australia's (tentative) mandatory regulation will be important activities to monitor in the near term. Their level of success will help inform decisions regarding a PG&E CEE program. The EU Code of Conduct is a voluntary agreement in which signatories are encouraged to provide information regarding the power consumption of the equipment they produce. The agreement sets base power consumption targets for different types of STBs (e.g. the active mode level for digital cable boxes is 7W) and then allows power allowances for additional features (e.g., a 2.2W additional allowance for an internal hard disk drive, a 0.7W for a wireless interface, etc). The Australian Greenhouse Office (AGO 2004c) introduced a similarly structured mandatory regulation that will tentatively become effective in October 2006. It will be important to identify which STBs meet these specifications and evaluate if these STBs could be promoted by a CEE program in PG&E territory.

[31] http://www.apec-esis.org/settopbox

Table 4.3-1 ENERGY STAR Specifications for Set-Top Boxes (SUSPENDED AS of JULY 2005)

Product Category	Standby / Low Power Mode	
	Tier 1	Tier 2
Category 1 • Analog Cable TV Set-top Box • Advanced Analog Cable TV Set-top Box • Digital TV Converter Set-top Box • Internet Access Device • Video Game Console • Videophone Set-top Box • Set-top Box (e.g., Internet access device) with Cable Modem for enhanced communications in low-power mode	**≤3 watts**	One specification for all set-top boxes: **≤7 watts** (for satellite systems, add 5 watts for each LNB)
Category 2 • Digital Cable TV Set-top Box • Satellite TV Set-top Box • Wireless TV Set-top Box • Personal Video Recorder	**≤15 watts** (for satellite systems, add 5 watts for each LNB)	
Category 3 • Multifunction Device (i.e., a physically integrated device that has the core function of a satellite TV set-top box, digital cable TV set-top box, wireless TV set-top box, or personal video recorder plus one or more additional functionalities, such as an Internet access device or video game console)	**≤20 watts** (for satellite systems, add 5 watts for each LNB)	

Source: ENERGY STAR (2006).

Table 4.3-2 U.S. and International Energy Efficiency Standards and Specifications for Set-Top Boxes

Country / Organization	Passive Standby Mode	Active Standby Mode	Voluntary	Mandatory	Effective Date
US EPS - ENERGY STAR	Suspended		✓		NA
California Energy Commission - DTA	≤ 1 watts	≤ 8 watts		✓	01/01/07
California Energy Commission - Digital cable and satelitte STBs	Potential for Title 20 2008			✓	2009-2010
Austrailian Greenhouse Office*	≤ 1 watts	≤ 8 watts*		✓	Tentative - October 2006
EU Code of Conduct*	≤ 9 watts ≤ 3 watts	≤ 9 watts ≤ 6, 7, 8 watts**	✓		until 12/31/05 after 12/31/05
EU Code of Conduct - DTAs	≤ 2 watts	≤ 11 watts	✓		after 12/31/04
EU - GEEA*	≤ 1 watts	≤ 9 watts ≤ 6, 7, 8 watts**	✓		until 12/31/05 after 12/31/05
EU - GEEA - DTAs*	≤ 2 watts	≤ 11 watts*	✓		until 12/31/05
Korea - Energy Boy	≤ 3 watts	NA	✓		after 1/1/02
China - Chinese National Institute of Standards (CNIS)	in development				NA

Sources: AGO (2004a); AGO (2004c); and ENERGY STAR (2006).
*Allowances for additional components up to 15 watt maximum
** Values for terrestrial, cable, and satellite, respectively

4.3.4 Usage Characteristics

Table 4.3-3 shows the duty cycle assumptions from three STB technical reports and the duty cycle used for the Baseline and Improved Case scenarios. We assume that the STB box duty cycle is similar to the "Primary TV" duty cycle (as presented in the previous Television section) because most STBs are used in conjunction with a household's primary TV. There is some variation in the different assumptions but the effect on energy consumption is minimal due to the small difference in active and standby mode power.[32]

Table 4.3-3 Set-Top Boxes - Various Duty Cycle Assumptions

	Hours per Day	
Source	**Active Mode**	**Standby Mode**
Austrialian Greenhouse Office (2004)	4.5	19.5
NRDC / Ecos (2005)	5.0	19.0
Rosen el al. (2001)	5.3	18.7
Current Study*	**4.5**	**19.5**

Sources: AGO (2004c); Rosen et al. (2001); NRDC/Ecos Consulting (2005a).
*Based on Nielsen (2005).

[32] As discussed in the forthcoming Section 4.3.6.

4.3.5 PG&E Shipments and Stock

The set-top box market continues to grow, driven by gains in digital subscribers and the demand for replacement boxes with increased functionality. Table 4.3-4 shows the results of the CEC sponsored *Residential Appliance Saturation Survey* (RASS), conducted in late 2002 and 2003. RASS provides a detailed snapshot of STBs being used within PG&E households at that time, and is used as a basis for developing future trends. Digital cable boxes had the highest household penetration (24%), followed by digital satellite boxes (16%), analog cable (12%), and DVRs (9%). IPTV was not widely used at the time and was not included in the RASS study.

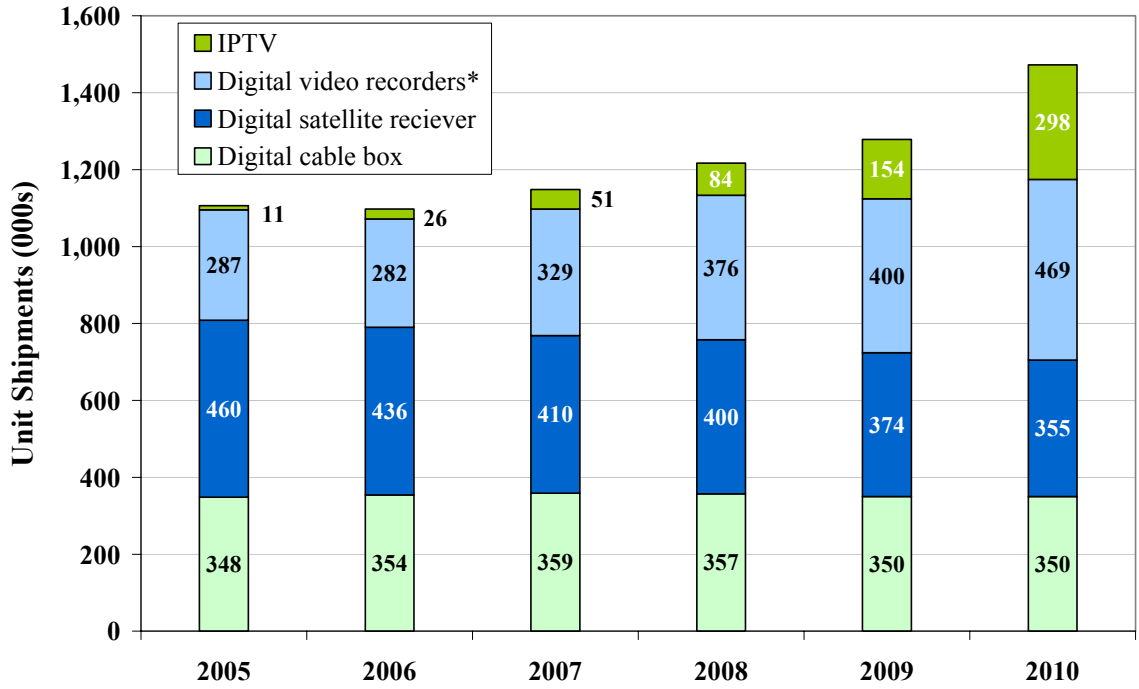
Table 4.3-4 Set-Top Box Stock in PG&E Residential Territory - RASS Survey, Early 2003 (000)

Survey Response (per Household)	Analog cable boxes	Digital cable boxes	Digital satellite boxes	Digital video recorders
None	3,713	3,210	3,536	3,865
One	411	718	454	318
Two	85	232	209	44
Three or more	24	74	34	7
No response	18	18	18	18
Total Boxes (000)	**655**	**1,411**	**977**	**428**
Penetration (2003)	**12%**	**24%**	**16%**	**9%**

Source: CEC (2004). PG&E residential survey occurred in late 2002 and early 2003. All data is weighted based on 9,647 survey responses, representing a 4,251,000 Household Population in PG&E territory. Note: Assumes 3.1 average for "three or more" response. Penetration reflects the percentage of households that have at least one of the respective equipment.

The forecasted STB shipments to the PG&E Mass Market are presented in Figure 4.3-2 and the forecasted installed stock is shown in Table 4.3-5. The RASS study is used to establish a baseline stock in 2003 and trends from IDC (2005a, 2005c) and iSuppli (2005) are used to forecast future shipments and stock. The market trends discussed in Section 4.2.3 are key drivers for the forecast.

Figure 4.3-2 Set-Top Boxes - Forecasted Shipments to PG&E Mass Market, 2005 – 2010



*Stand alone DVRs only (e.g., TiVo). Source: IDC (2005c) for digital cable box, digital satellite reciever, and IPTV. iSuppli (2005) for digital video recorders. See Set-Top Box Appendix for detailed values.

Table 4.3-5 Set-Top Boxes - Forecasted Stock in PG&E Mass Market, 2005 – 2010 (000)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Digital cable box	2,100	2,460	2,810	3,170	3,520	3,870	13%
Digital satellite reciever	1,890	2,330	2,740	3,140	3,510	3,870	15%
Digital video recorders*	930	1,210	1,540	1,920	2,320	2,790	25%
IPTV	40	60	110	200	350	650	75%
Total	**4,960**	**6,060**	**7,200**	**8,430**	**9,700**	**11,180**	18%

*Stand alone DVRs only (e.g., TiVo). Sources: Calculated based on CEC (2004) survey; IDC (2005b) shipmement data for cable, satellite, and IPTV; and iSuppli (2005) market data for DVRs.

4.3.6 PG&E Energy Consumption

The energy consumption characteristics for STBs are based on over 150 STB measurements presented in four separate technical reports.[33] Appendix Table 10 details the sample size for each report and the corresponding high, low, and average power measurements for each STB category. Using data from all four reports, we develop the power consumption baseline presented in Table 4.3-6. Table 4.3-7 provides the unit electricity consumption (UEC).

[33] The four reports were authored by the Australian Greenhouse Office (AG0 2004c); Lawrence Berkeley National Laboratory (Rosen et al 2001); Natural Resource Defense Council and Ecos Consulting (NRDC/Ecos 2005a); and Rainer et al 2005.

The data reveal that there is little difference in power consumption between the active mode and standby mode power. The difference is only 1 or 2 watts for digital cable boxes, digital satellite boxes, DVRs, and IPTV. The DVR average (31W active, 30W standby) is the highest for all STBs, followed by digital cable, digital satellite, and IPTV. Additional energy trends identified by NRDC and Ecos Consulting (2005b) – based on 39 STB measurements – include:

- **Advanced STB functionality increases power consumption.** On average, HD functionality adds 5 to 10 watts of power use, and DVR features contribute about 10 watts. These advanced STBs are excepted to gain market share over the next few years and will likely shift the average power consumption upward.

- **Power consumption varies for STBs with similar functions.** For example, the RCA 1 and Sony 2 are both standard digital satellite receiver STBs, yet the RCA 1 consumes less than half the energy of the Sony 2.[34] This holds true for single function cable boxes and for multifunction STBs with HD and DVR capability. For CEE program development, this finding suggests that efficient boxes could be promoted within each STB category.

- **The STB manufacturer does not indicate efficiency level.** The power measurements included boxes from eight manufactures[35] and none was a clear "winners" in efficiency. In fact, two manufactures – Dish and Motorola – had the highest and lowest energy consuming models, respectively, within the multifunction Cable/Satellite DVR and single function cable box categories.

[34] The RCA 1 model number is DRD22RD. The Sony 2 model number is Sat B-2.
[35] Dish, Hughes, Motorola-General Instruments, Pac Micro, RCA, Samsung, Scientific Atlanta, and Sony.

Table 4.3-6 Set-Top Boxes - Power Consumption Baseline per Unit

		Sample Size (n)	Low (W)	High (W)	Baseline Mean (W)
Active Mode	Analog cable box	42	5.4	23.4	**12**
	Digital cable box	20	10.9	35.3	**19**
	Digital satellite reciever	53	6.9	34.0	**16**
	Digital TV adapter	13	10.0	35.3	**17**
	Digital video recorders	6	17.2	47.4	**31**
	IPTV	NA	NA		**15**
Standby Mode	Analog cable box	42	2.4	18.0	**11**
	Digital cable box	20	10.9	35.3	**18**
	Digital satellite reciever	52	8.0	23.0	**14**
	Digital TV adapter	12	1.9	21.5	**8**
	Digital video recorders	6	16.9	44.3	**30**
	IPTV	NA	NA		**14**

Source: AGO (2004); Rosen et al. (2001); NRDC/Ecos (2005a); Rainer et al (2005). See Set-Top Box Appendix for detailed values from each report. Baseline is developed with sample-weighted values.
NA = Not Available

Table 4.3-7 Set-Top Boxes - Unit Annual Electricity Consumption Estimates (kWh/yr)

	Active	Standby	Total
Digital cable box	31	128	**159**
Digital satellite reciever	26	98	**125**
Digital video recorders	51	213	**264**
IPTV	25	100	**124**

Note: Calculated by multiplying duty cycle and baseline power consumption together.

Table 4.3-8 forecasts the Baseline scenario annual energy consumption for new STB shipments to PG&E's Mass Market. The annual energy consumption from new shipments is estimated to increase from 190 million kWh/yr in 2005, to 261 million kWh/yr in 2010, representing an overall 5% CAGR. The forecasted Baseline scenario energy consumption for the complete Mass Market stock was estimated to be 820 million kWh/yr in 2005. By 2010, the overall energy consumption is expected to increase to 1,914 million kWh/yr. Table 4.3-9 summarizes these results.

Table 4.3-8 Set-Top Boxes - Forecasted First-Year Annual Energy Consumption for New Shipments to PG&E Mass Market, 2005-2010 (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Digital cable box	55	56	57	57	56	56	0.1%
Digital satellite reciever	57	54	51	50	47	44	-5%
Digital video recorders*	76	74	87	99	106	124	10%
IPTV	1	3	6	10	19	37	93%
Total	**190**	**188**	**201**	**216**	**227**	**261**	**5%**
% of PGE Mass Market	**0.8%**	**0.8%**	**0.8%**	**0.9%**	**0.9%**	**1.0%**	

Note: Calculated based on baseline electricity consumption and projected shipments to PGE territory. *Stand alone DVRs only (e.g., TiVo).

Table 4.3-9 Set-Top Boxes - Forecasted Annual Energy Consumption for Complete PG&E Mass Market Stock, 2005-2010 (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Digital cable box	334	391	448	505	560	616	13%
Digital satellite reciever	235	290	341	391	437	481	15%
Digital video recorders*	246	321	407	506	612	736	24%
IPTV	5	8	14	24	44	81	77%
Total	**820**	**1,009**	**1,210**	**1,426**	**1,653**	**1,914**	**19%**
% of PGE Mass Market	**3.3%**	**4.0%**	**4.8%**	**5.7%**	**6.6%**	**7.7%**	

Note: Calculated based on baseline electricity consumption and complete set-top box stock. *Stand alone DVRs only (e.g., TiVo).

4.3.7 Lifecycle Costs

The lifecycle energy costs for STBs is presented in Table 4.3-10. The costs are based on a typical useful lifecycle of 4 years, an average PG&E residential rate ($0.13/kWh), and a discounted future (8.15% discount rate). DVRs are by far the most expensive to operate at $113, while IPTV and digital cable and satellite STBs average between $50 and $70.

Table 4.3-10 Set-Top Box - Lifecycle Energy Costs per Unit

	Estimated Useful Life (1) (years)	Lifetime Energy Costs (2) (PV $)
Digital cable box	4	$68
Digital satellite reciever	4	$53
Digital video recorders	4	$113
IPTV	4	$53

Notes: (1) Source: DEG and Energy Solutions (2004). (2) Calculated: PV[(estimate useful life) * (unit annual electricity) * (PG&E residential rate - $0.13/kWh - Source CEC (2006))]. Discount rate = 8.15%.

4.3.8 Opportunities for Energy Savings

Widespread implementation of energy saving strategies for STBs is not straightforward and will require a coordinated effort between manufacturers, regulators, and energy experts. Currently, the primary energy savings options for set-top boxes are:[36]

- **Sleep Mode Utilization** – Incorporating a true low power mode, or "sleep" mode, while the STB is not in use will achieve significant energy savings. The current low power mode for most STBs (standby mode, or when users perceive the device as being "off") draws nearly the same amount of power as in active mode and is responsible for about 80% of overall energy consumption.

  Achieving a true sleep mode in STBs without disabling communication functions between it and the service provider is, however, a difficult task. According to the ENERGY STAR Program, introducing sleep mode would likely require a complete redesign of service provider networks. In standby mode, STBs receive information from the network provider for updating electronic program guides, channel maps, and security keys (Fanara, 2004). The drive to add features to STBs and keep costs competitive with other manufacturers' STBs results in manufacturers leaving out power management features. In addition, the STB software prioritizes functionality over power management which leads to increased power consumption. To address these shortcomings, software developers must take into consideration power management when designing the software and the hardware must be designed to integrate power management features. (Dale, 2003)

- **Software Controls** – An advanced low-power sleep mode would need accompanying software that could power down or turn off sections of the circuitry during this period.

- **Enhanced Network Communication** – Most cable and satellite STBs require a continual 24-hour connection with content providers to download programming and perform other

[36]Source: NRDC/Ecos (2005a) and supported by Amann (2004); DEG and ES (2004); and Rainer et al (2005).

subscription services. To utilize a low-power sleep mode fully, STBs would need the capability to "wake-up" as necessary to perform their useful functions.

- **Hardware Component Efficiency** – This includes developing and incorporating more efficient memory storage and display components for set-top boxes, such as Flash cards and LCD displays. Flash cards – widely used in desktop PCs – could possibly replace the STB temporary memory storage devices that require relatively more energy to continually download and update programming information. Another possible strategy is to include "power partitioning" chips, or chips that allow the STB to operate at different power voltage and frequency levels. NRDC/Ecos (2005a) cites two examples of readily available technologies that could possibly be incorporated into STBs – AMD's Cool and Quiet technology and Intel's Demand Based Switching technology.

- **Power Supply Efficiency** – There is some opportunity to achieve energy savings through increased power supply efficiencies. The Electric Power Research Institute evaluated the power supply efficiency of four STBs and measured a low of 68% and a high of 82%. The range is not dramatic, but indicates an opportunity for incremental savings (NRDC/Ecos 2005a).

The Improved Case scenario assumes the use of these techniques. The resulting unit electricity savings are presented in Table 4.3-11. The Improved Case assumptions for cable and satellite STBs are based on the EU Code of Conduct specifications. Since many STBs are adding increased functionality, we assume an additional power consumption allowance of 2.2W.[37] For DVRs, the Improved Case scenario is based on the device with the second lowest power measurement in our sample set. Since the energy characteristics of IPTV STBs are not readily available, we assume a 20% efficiency improvement for these devices. Appendix Table 11 details the specific power consumption values and assumptions for each STB category.

The unit savings range from 25 kWh/yr for IPTV to 123 kWh/yr for the digital cable box. Figure 4.3-3 shows the first-year annual energy savings with a 100% Improved Case market share for new STB shipments to PG&E's Mass Market. The total savings potential exceeds 110 million kWh each year, primarily from cable boxes, satellite receivers, and DVRs.

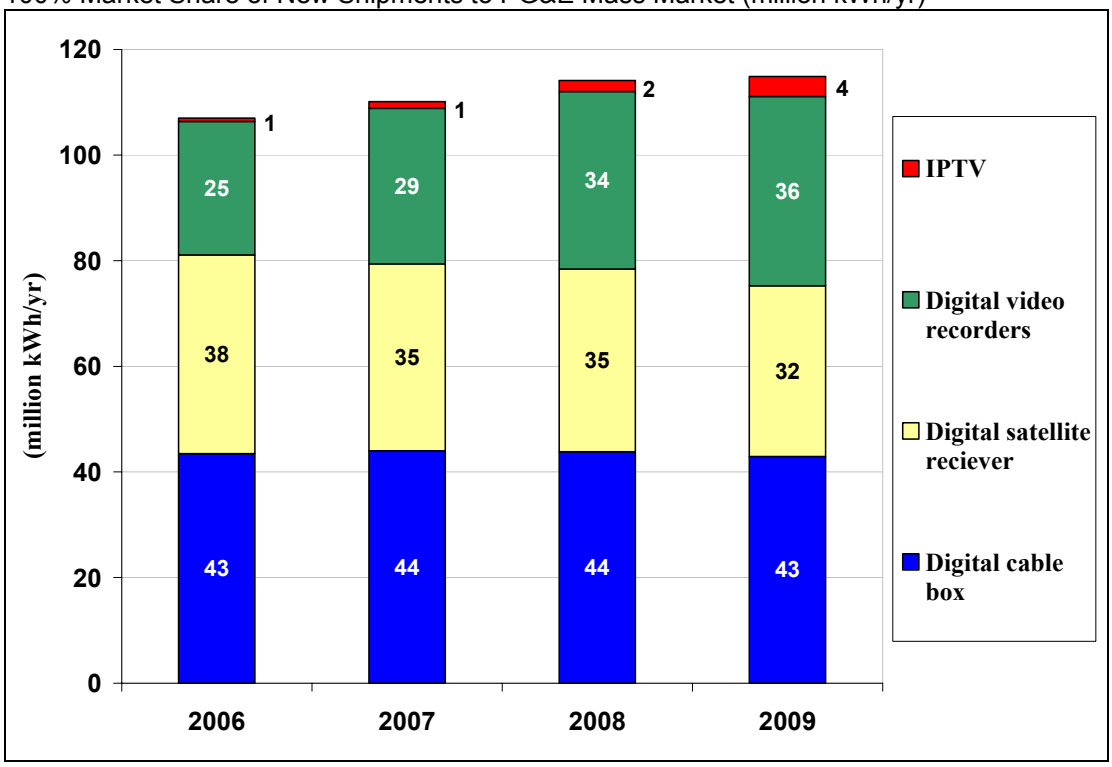
[37] This is a power consumption allowance for an internal hard disk drive, such as found in DVR combination STB. The power consumption allowance for the Improved Case scenario can also serve as a proxy for other types of cable and satellite STBs without an internal hard disk drive, but with other features, such as an Ethernet interface, a wireless interface, or a Serial USB interface.

Table 4.3-11 Set-Top Boxes – Unit Energy Savings with Improved Case Scenario

	Unit Annual Electricity Consumption (kWh/yr)		
	Baseline	Improved Case	**Savings**
Digital cable box	159	36	**123**
Digital satellite reciever	125	38	**86**
Digital video recorders	264	174	**90**
IPTV	124	99	**25**

Note: Improved case assumptions are based on EU Code of Conduct specifications for cable boxes (7W active standby, 3W passive standby) and satellite recievers (8W,3W). For active standby mode power, we assume an additional power consumption allowance for an internal hard disk drive (2.2W), bringing the total to 9.2W for cable and 10.2W for satellite. For DVRs, the device with the second lowest tested power draw was used. Since limited testing data is available on IPTV, we assume a 20% efficiency improment. See Set-Top Box Appendix for specific power values, by mode.

Figure 4.3-3 Set-Top Boxes - First-Year Annual Energy Savings with Improved Case Scenario – 100% Market Share of New Shipments to PG&E Mass Market (million kWh/yr)



4.3.9 Future Work

There is currently limited power consumption data for most STBs on the market. Therefore, a near-term PG&E program that targets active mode energy consumption would need to employ a

unique certification process. Future work concerning set-top boxes and a potential energy efficiency program should include:

- Monitoring the ongoing efforts by the International Set-Top Box Harmonization Initiative and the CEA standards to stay up-to-date on new testing protocols and other efficiency and standard initiatives.

- Monitoring the success of the European Union's Code of Conduct voluntary partnership and Australia's tentative mandatory energy performance standard. PG&E should identify which STBs meet these specifications (see Table 4.3-2) and evaluate if these STBs could be promoted by a PG&E efficiency program.

- Engaging the major cable and satellite providers within PG&E territory and discussing opportunities to distribute efficient STBs to their customers. A CEE program partnership with one or more major providers could leverage substantial energy savings.

See Section 5. [Program Recommendations and Conclusions] for a more detailed discussion on recommended PG&E program intervention, delivery types, and key dates.
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4.4 Home Entertainment Systems

4.4.1 Overview

The market for home entertainment systems continues to experience steady sales as new product innovations attract consumers to the latest technology. Home entertainment systems in the context of this report consist of recording, playback, and amplifying devices used in conjunction with televisions and audio speakers. They include DVD players, home theater systems (consisting of receiver/DVD player and speakers, also known as “home theater in a box”), component stereos (separate receivers and tuners), compact stereos (integrated tuner, CD player, and speakers), and portable stereos (boom boxes). Televisions, the most significant energy users within a home entertainment system, are evaluated separately in the previous Section 4.2.

Home entertainment systems have high penetration rates throughout PG&E Territory and consume more energy in standby mode than during active modes. Thus, there is potentialfor energy savings with an efficiency program that focuses on standby mode power consumption.

4.4.2 Market Trends

Over the past few years within the home entertainment system (HES) segment, manufacturers have generally moved from producing low-cost, high-volume products to producing high-cost, low-volume products. While the sales value of home entertainment equipment has increased over the last couple of years, the number of units sold has actually decreased (Mintel 2005a). The market is shifting away from analog products, such as VCRs and analog televisions, toward higher value products such as DVD players and flat panel television displays. There is also a growing shift toward portable audio devices, such as iPods™ and MP3 players. As prices drop for these new digital products, we could likely see a shift back to the low-cost, high-volume scenario.

Table 4.4-1 shows a typical range for the selling price of home entertainment equipment. There is wide variation in the price offers for each technology based on brand name and functionality. The emergence of DVD recorders with integrated hard disk drives (HDDs) is an example of manufacturers shifting their new product offerings toward the higher price points. The new DVD recorder with HDD typically costs three to four times more than a typical DVD player.

Table 4.4-1 Home Entertainment Equipment Selling Prices

	Selling Price	
	Low	**High**
DVD		
Single Disk, Play only	*$40*	*$200*
Multi-disk, Play/record	*$130*	*$400*
DVD recorder with HDD	*$600*	*$800*
Home Theater System	$100	$3,000
Component Stereo	$40	$1,000
Compact Stereo	$50	$300
Portable Stereo	$25	$250

Source: Best Buy (2006).
HDD = Hard Disk Drive

In 2004, there was a 12% increase in U.S. audio/video sales revenue, primarily led by new digital technologies. Sales are expected to level out in the next few years as digital product saturate the market. Mintel estimates that between 2006 and 2009, the sales of home audio and video products are expected to increase at an annual rate of 1% per year with the increase in video sales offsetting a decline in audio sales (Mintel 2005a).

DVD sales peaked in 2003 and have declined over the last two years. However, two competing DVD player formats, HD-DVD and Blu-ray, came to market in 2006 and will vie for market share. They, in turn, may spark an increase in sales volume.[38] It will be important to monitor the energy consumption of these products in the future. They are currently not well-characterized enough to include in this report.

Mintel reports that home theater systems show sales growth in the home audio segment whereas other audio products – such as compact systems and home radios – show losses. Yet despite their losses, the other audio products still comprise a large share of home electronics sales. In 2004, compact home audio systems and home radios comprised an estimated 31% ($995 out of $3,208 million) of all home audio equipment U.S. sales (Mintel 2005a).

While sales for many of the home entertainment equipment are down, their numbers in PG&E territory are significant. Table 4.4-2 shows the estimated home entertainment equipment stock in PG&E territory. There are approximately 9 million pieces of home entertainment equipment in PG&E territory, representing a significant electric load.

[38] HD-DVD and Blu-ray both use blue lasers (shorter wavelength than the red lasers used in DVDs and CDs) to read and write data, allowing more information to be stored on a single disk. Both formats are able to read current-generation DVDs, although the next generation HD-DVD format will have a storage capacity of 15GB or 30GB, and Blu-ray will have 25GB or 50GB capacities. Blu-ray relies on Sun Microsystems' Java software, whereas HD-DVD uses a technology called iHD that Microsoft and Toshiba developed (Shakland 2005).

Table 4.4-2 Home Entertainment Systems - Estimated PG&E Mass Market Stock (000)

	US 1998 (1)	CA 2001 (2)	PG&E 2003 (3)	PG&E - 2006 Current Study Baseline (4,5)
DVD	2,000	NA	2,940	**4,150**
Home Theater	NA	NA	620	**900**
Stereos	115,000	10,000	3,750	**4,450**
Component Stereos	*74,000*	*4,500*	*1,470*	***1,600***
Compact Stereos	*47,000*	*4,500*	*930*	***1,250***
Portable Stereo	*68,000*	*3,000*	*1,350*	***1,600***

Notes: (1) Source: Rosen (1999); (2) Source: EIA (2001); (3) Source: CEC (2004); (4) Source: Digital Bits (2006); (5) Source: Palenchar (2006). Estimates based on 2003 PG&E figure plus factory sales in 2004 and 2005 as reported by the CEA (12% sold to California, and 42% of California sales to PG&E territory).

4.4.3 Applicable Standards and Efficiency Programs

In the absence of U.S. federal standards, the California Energy Commission has recently enacted a state standard to regulate the amount of passive standby power a home entertainment system component consumes.[39] The standard stipulates that standby mode power must not be greater than 3W. It is expected that the majority of products will easily meet this standard as the current average for most (HES) products is between 2W and 3W.[40] In addition, the voluntary ENERGY STAR Program has established a passive standby criteria of no greater than 1W.

In addition to the CEC and ENERGY STAR specifications, international bodies have established levels of energy efficiency for other operating modes. Following California's lead, the EU and Australia will be imposing mandatory energy efficiency standards for home entertainment equipment within the coming years. Table 4.4-3 and Table 4.4- 4 summarize these energy efficiency programs for DVD players and home theater systems, respectively. Similar tables for component stereos, compact stereos, and portable stereos can be found in the Home Entertainment System Appendix.[41]

[39] See Appendix Table 13 for usage mode definitions for Home Entertainment Systems.
[40] The exception is compact stereos at 4W. Table 4.4-8 shows average Baseline power values.
[41] See Appendix Tables 14, 15, and 16.

Table 4.4-3 U.S. and International Energy Efficiency Standards and Specifications for DVD Players

Country / Organization	Off Mode	Passive Standby Mode	Play (On) Mode	Voluntary	Mandatory	Effective Date
US EPA - ENERGY STAR	none	≤ 1 watts	none	✓		2004
California Energy Commission	none	≤ 3 watts	none		✓	2006
Australian Greenhouse Office	≤ 1 watts ≤ 0.3 watts	≤ 4 watts ≤ 1 watts	none		✓	2006 2012
EU - Group for Energy Efficient Appliances (GEEA)	≤ 0.5 watts	≤ 1 watts	≤ 11 watts	✓		2004
Nordic Swan	none	≤ 2 watts	≤ 15 watts	✓		after 3/19/2003

Sources: AGO (2003a) and Energy Star (2006).

Table 4.4-4 U.S. and International Energy Efficiency Standards and Specifications for Home Theater Systems

Country / Organization	Off Mode	Passive Standby Mode	Play (On) Mode	Voluntary	Mandatory	Effective Date
US EPA - ENERGY STAR	none	≤ 1 watts	none	✓		2004
California Energy Commission	none	≤ 3 watts	none		✓	2006
Australian Greenhouse Office	≤ 1 watts ≤ 0.3 watts	≤ 4 watts ≤ 1 watts	none		✓	2006 2012
EU Negotiated Agreement	NA	≤ 8 watts ≤ 1 watts	none		✓	until 12/31/06 after 12/31/06
EU - Group for Energy Efficient Appliances (GEEA)	NA	≤ 1 watts	none	✓		2004
Nordic Swan	Must Have Off Switch	≤ 1 watts	≤ 40 watts	✓		after 3/19/2003

Sources: AGO (2004b) and Energy Star (2006).

4.4.4 Usage Characteristics

Home entertainment systems enhance the entertainment experience of the user by improving the quality of video and audio applications. DVD players, home theater systems, and component stereos are most often purchased to complement a television within the entertainment system.

According to a recent study on media exposure conducted by Ball State University, DVD players are typically used in the evening hours after 8 p.m., and usage also increases on the weekends

(Papper, 2005).[42] Home theater systems and stereos are likely to follow similar usage patterns as other home entertainment equipment, with the most frequent use occurring in the evening hours after the typical workday and throughout the day on the weekends. Since home theater systems and component stereos are integrated with televisions, their usage likely increases slightly earlier than DVD players.

Home entertainment system components spend the majority of their lifespan in passive standby mode, typically the lowest power demand mode. Table 4.4-5 shows the Home Entertainment System duty cycle assumptions used in this report. (Appendix Table 13 provides duty cycle definitions for each operating mode).

Table 4.4-5 Home Entertainment Systems - Duty Cycle Assumptions

	Duty Cycle (hrs/yr)			
	Play	**Active standby**	**Passive standby**	**Off**
DVDs	365	840	7,555	NA
Home theaters	730	2,008	5,621	402
Component Stereo	1,664	1,402	5,694	NA
Compact Stereo	964	1,664	6,132	NA
Portable Stereo	526	1,139	4,468	2,628

Sources: Energy Star (2006); Rosen (1999); AGO (2004b)
NA = Not applicable. Note that 'Off' for home theaters means the component is turned off at the machine and cannot be turned on using a remote control (also known as hard off). In this mode, the component may still be drawing power. 'Off' for portable stereo means unplugged and drawing no power.

4.4.5 PG&E Shipments and Stock

Shipments to the PG&E mass market are forecasted to decline over the next five years as product saturation begins to take hold. Table 4.4-6 shows the projected shipments for home entertainment equipment in PG&E territory. DVD player sales are projected to fall in the next couple of years and then level off as the sales of new format DVD players offset the decline in conventional DVD players. The Consumer Electronics Association predicts that in 2007, 100,000 next generation DVD players will be sold in the U.S. with approximately 5,000 being sold in PG&E Territory (CEA 2006). Sales of home theaters, component stereos, compact stereos, and portable stereos are projected to decline about 5% per year over the next five years.

[42] A DVD usage profile is included in the Television section, Figure 4.2-5 Media Exposure Usage Patterns.

Table 4.4-6 Home Entertainment Systems – Forecasted New Shipments to PG&E Mass Market, 2005 - 2010 (000)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
DVDs	825	725	650	620	650	700	-3%
Home theaters	190	182	173	164	156	148	-4.9%
Component Stereo	80	76	73	69	65	62	-5.0%
Compact Stereo	335	318	302	287	272	256	-5.2%
Portable Stereo	210	200	190	181	172	163	-4.9%
Total	1,640	1,500	1,390	1,320	1,320	1,330	-4.1%

Sources: Digital Bits (2006); Palenchar (2006); and Mintel (2005a). DVD Sales Projections for 2006 assumes sales decline equals the average annual decline between 2003 and 2005 (12.5%); This sales projection further assumes that the decline levels off (10% decline in 2007, 5% decline in 2008, and 5% increase in 2009) as next generation DVD players become available. Home Theater and Stereo projections based on Mintel Report stating 5% annual decline in sales (2005-2009).

While *shipments* of home entertainment equipment are projected to fall, the *stock* in the PG&E Mass Market is forecasted to rise as more equipment is purchased than retired. This is also attributable to a growing trend of having multiple devices in use in each household. Table 4.4-7 summarizes these trends. DVD players, home theater, and compact stereo stocks will increase the most between 2005 and 2010, at the rate of approximately 9%-10% per year. Component stereos and portable stereos show only a moderate stock growth.

Table 4.4-7 Home Entertainment Systems - Forecasted Stock in PG&E Mass Market, 2005 – 2010 (000)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
DVDs	4,150	4,630	5,070	5,480	5,910	6,380	9%
Home theaters	900	1,020	1,140	1,250	1,350	1,450	10%
Component Stereo	1,600	1,650	1,700	1,750	1,790	1,830	3%
Compact Stereo	1,250	1,410	1,560	1,700	1,840	1,970	10%
Portable Stereo	1,600	1,700	1,800	1,890	1,970	2,050	5%
Total	9,500	10,410	11,270	12,070	12,860	13,680	7.6%

Notes: Forecasts based on PG&E stock values [CEC (2004)] and projected shipments based on market trends [Mintel (2005)]. Projections assume that approximately 1 out of 3 DVD, home theater, and component stereo purchases are for replacement purposes; and assumes that approximately 1 out of 2 of compact and portable stereo purchases are for replacement purposes

4.4.6 PG&E Energy Consumption

Table 4.4-8 shows the unit Baseline power consumption values used for home entertainment equipment. Note that the passive standby mode power consumption for home entertainment equipment is similar across the different products. The active standby for home theaters and component stereos differs from the other equipment because the speakers associated with these products require higher power draws relative to the other products. The power consumption values are developed from multiple sources and detailed values are available in Appendix Table 17 and 18.

Table 4.4-8 Home Entertainment Systems - Baseline Power Assumptions per Unit

	Baseline Power Consumption (watts)			
	Play	**Active standby**	**Passive standby**	**Off**
DVDs	16	14	2	NA
Home theaters	38	36	3	0.1
Component Stereo	41	39	2	1.6
Compact Stereo	22	17	4	NA
Portable Stereo	7	5	2	0.0

Source: Weighted baseline is developed from multiple reports: ACEEE (2006); AGO (2003a); AGO (2004b); AGO (2004f); ENERGY STAR (2006), and Rosen (2000). See Home Entertainment System Appendix for detailed values from each report.

Table 4.4-9 shows the unit electricity consumption for each kind of home entertainment equipment, and Figure 4-15 shows the percentage of annual electricity consumed in each mode. Note that DVD players, compact stereos, and portable stereos consume more electricity annually in passive standby mode than in play mode, and home theater systems consume more annual electricity in the two standby modes than in play mode. This suggests that much of the energy savings can be addressed by reducing standby power consumption.

Table 4.4-9 Home Entertainment Systems - Annual Electricity Consumption Estimates per Unit (kWh/yr)

	Play	**Active standby**	**Passive standby**	**Off**	**Total**
DVDs	6	12	16	NA	34
Home theaters	28	73	14	0.0	115
Component Stereo	68	55	10	NA	133
Compact Stereo	21	29	25	NA	76
Portable Stereo	3	6	9	0	19

Note: Unit electricity calculated by multiplying duty cycle and baseline power consumption together.

Figure 4.4-1 Home Entertainment Systems - Percent of Annual Electricity Consumed by Mode

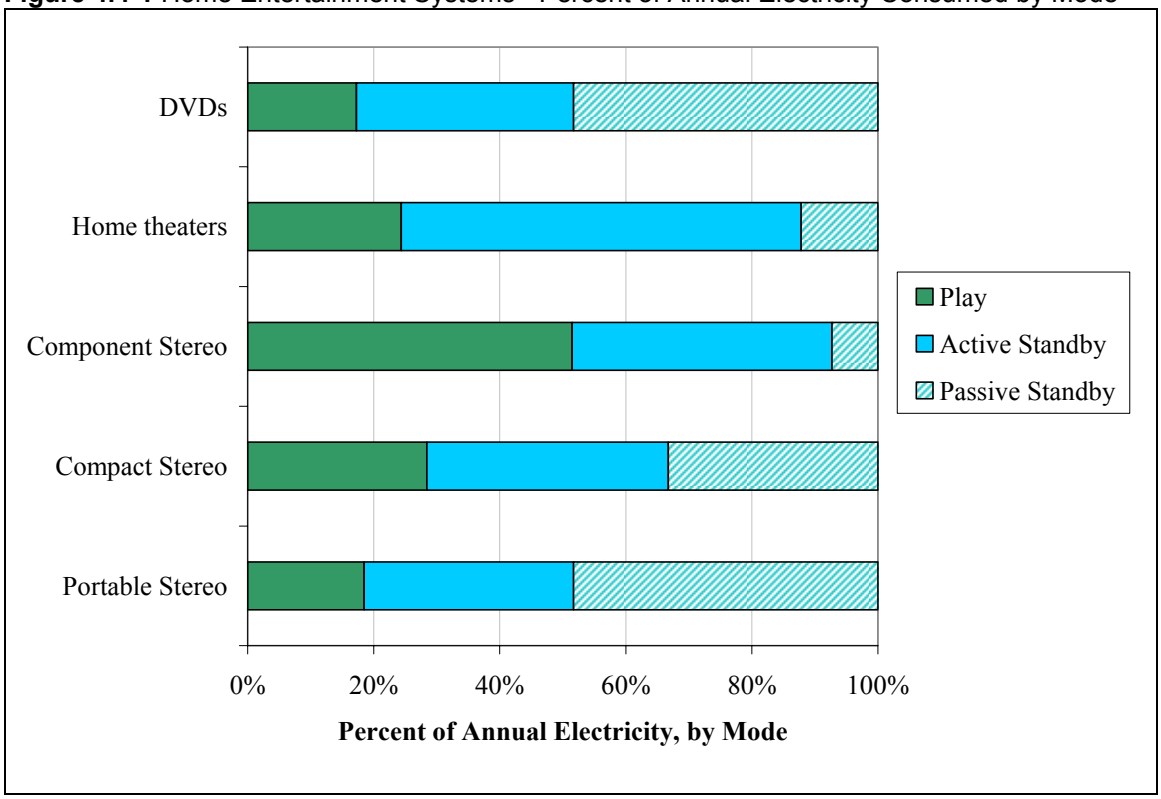


Table 4.4-10 shows the forecasted first-year annual energy consumption for new shipments to the PG&E Mass Market. In 2005, new shipment annual energy consumption was approximately 0.4% of the PG&E's total Mass Market consumption. This consumption is forecasted to decline over the next 5 years by an annual average of 4 percent.

Table 4.4-10 Home Entertainment Systems - Forecasted First-Year Annual Energy Consumption for New Shipments in the PG&E Mass Market (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
DVDs	28	24	22	21	22	24	-3%
Home theaters	22	21	20	19	18	17	-5%
Component Stereo	11	10	10	9	9	8	-5%
Compact Stereo	25	24	23	22	21	19	-5%
Portable Stereo	4	4	4	3	3	3	-5%
Total	**89**	**83**	**78**	**74**	**72**	**71**	**-4%**
% of PG&E mass market	**0.4%**	**0.3%**	**0.3%**	**0.3%**	**0.3%**	**0.3%**	

Note: Calculated based on baseline electricity consumption and projected shipments to PG&E territory.

Table 4.4-11 displays the forecasted annual energy consumption for the complete home entertainment equipment stock in PG&E's Mass Market segment. This equipment stock consumed an estimate 580 million kWh/yr in 2005, or 2.3% of PG&E's Mass Market consumption, and is forecasted to rise approximately 7% percent per year over the next 5 years.

Table 4.4-11 Home Entertainment Systems - Forecasted Annual Energy Consumption for Complete PG&E Mass Market Stock (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
DVDs	140	156	170	184	199	215	9%
Home theaters	104	118	131	144	156	167	10%
Component Stereo	212	219	225	232	237	243	3%
Compact Stereo	94	107	118	129	139	149	9%
Portable Stereo	30	31	33	35	36	38	5%
Total	**580**	**630**	**678**	**724**	**767**	**811**	7%
% of PG&E mass market	**2.3%**	**2.5%**	**2.7%**	**2.8%**	**3.0%**	**3.2%**	

Note: Calculated based on baseline electricity consumption and forecasted stock in PG&E territory.

4.4.7 Lifecycle Costs

The lifecycle costs for home entertainment equipment are listed in table 4.4-12. The cost of the equipment is significantly greater than the electricity costs of operating the equipment. This is due to low hours of operation in the active standby and play modes and suggest that buying new equipment to save money in energy costs will not result in a payback during the lifespan of the equipment.

Table 4.4-12 Home Entertainment Systems - Lifecycle Costs per Unit

	First Costs (1) ($)	Estimated Useful Life (2) (years)	Lifetime Energy Costs (3) (PV $)	Total - Lifecycle Costs ($)
DVDs	$125	7	$23	$148
Home theaters	$600	9	$93	$693
Component Stereo	$300	9	$107	$407
Compact Stereo	$150	9	$61	$211
Portable Stereo	$80	5	$10	$90

Notes: (1) Source: Energy Star (2006), Best Buy (2006) - median price of home theater systems, component stereos, compact stereos, and portable stereos on Best Buy website. (2) Source: Energy Star (2006), Rosen (1999); Home theater assumed to have the same useful life as component stereo. (3) Calculated: PV[(estimate useful life) * (unit annual electricity) * (PG&E residential rate - $0.13/kWh - Source CEC (2006))]. Discount rate = 8.15%.

4.4.8 Opportunities for Energy Savings

Table 4.4-13 shows the annual electricity per unit for the Baseline and Improved Case scenarios and the resultant savings. The Baseline and Improved Case energy savings are based on duty cycles listed in Table 4.4-5 and the power consumption values shown in Appendix Table 17. The Baseline power consumption is developed using an average of reported values from various sources. The Improved Case power consumption for passive standby mode is based on the Energy Star specification of 1W, while the active standby and play mode consumption is based on the average of the low and Baseline values.[43] The average savings per unit ranges from 7 kWh/yr for a portable stereo to 47 kWh/yr for the component stereo.

Table 4.4-13 Home Entertainment Systems - Improved Case Annual Electricity Savings per Unit

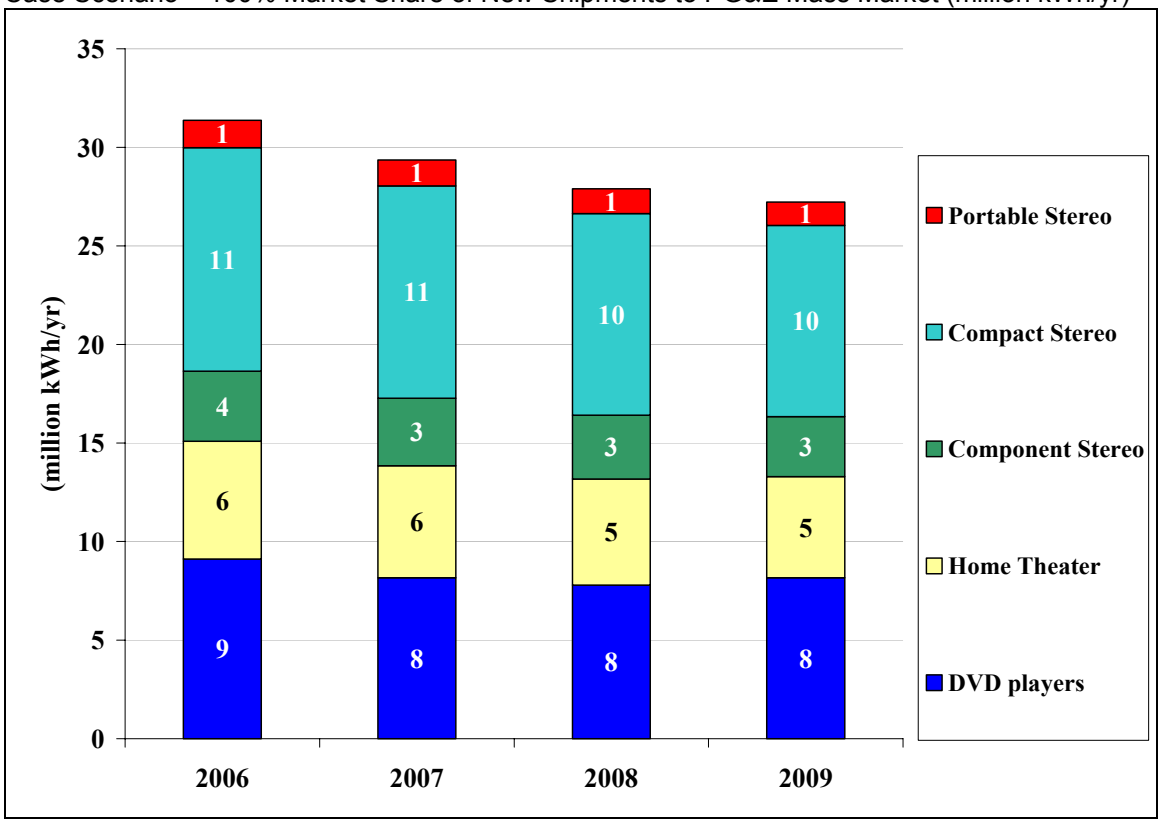
	Unit Annual Electricity (kWh/yr)		
	Baseline	Improved Case	**Savings**
DVD	34	21	**13**
Home theater	115	82	**33**
Component Stereo	133	86	**47**
Compact Stereo	76	40	**36**
Portable Stereo	19	12	**7**

Notes: Baseline unit energy use is calculated by multiplying duty cycle and baseline power consumption together. Improved case unit energy use is calculated by multiplying duty cycle and baseline power consumption together.
See Home Entertainment System Appendix for detailed values from each report.

The energy savings from 100% sales penetration of the Improved Case home entertainment equipment is shown in Figure 4.4-2. The total is highest in 2006, at 32.7 million kWh, and then declines about 5% per year – in step with declining shipments. The greatest savings potential is found in compact stereos with over 10 million kWh per year of technically achievable energy savings. This is especially relevant since only 28% of compact stereos sold in 2004 met the ENERGY STAR criteria, leaving much of the energy savings yet to be captured. This contrasts with DVD players, which show the next highest energy savings potential, However, since 62% of DVD players sold in 2004 were ENERGY STAR-rated they present less opportunity for capturing energy savings.

[43] Additional savings would be achieved if the Improved Case active standby and play mode consumption was based on the lowest measured product. However, by taking the average of the Baseline and low measurements, the Improved Case scenario represents a broader range of efficient products currently on the market.

Figure 4.4-2 Home Entertainment Systems - First-Year Annual Energy Savings with Improved Case Scenario – 100% Market Share of New Shipments to PG&E Mass Market (million kWh/yr)



4.4.9 Future Work

In terms of a future PG&E efficiency program for HES equipment, the greatest savings potential would come from targeting *active standby* and *play* mode power. The recent CEC Title 20 standard that limits *passive standby* power to 3W will achieve statewide savings, but has also reduced the savings potential of a voluntary program targeting this mode. ENERGY STAR keeps a database of passive mode power for HES equipment, but unfortunately, there is limited data on active standby and play mode power consumption. Therefore, a program that targets energy consumption in these two modes would need a unique testing and certification process. See Section 5. [Program Recommendations and Conclusions] for a more detailed discussion on recommended PG&E program intervention, delivery types, and key dates.

4.5 Smart White Goods

4.5.1 Overview

Smart white goods (also known as smart appliances) combine the traditional functionality of kitchen and laundry appliances with entertainment, communication, networking, and computer functions. These products have experienced minimal market penetration and the energy savings potential from these products is largely up for speculation. With the growing interest in these products and the potential to integrate them with the Internet, this product segment is worth monitoring for future developments. However, there is significantly more energy consumption (and savings potential) from the other consumer electronics discussed in this report and we recommend apportioning the bulk of any future efforts towards those products.

Smart White goods are appliances typically found in the kitchen or laundry room. They combine the traditional appliance functions with electronics that permit other concurrent uses of the appliance for entertainment, communication, networking or computing. These appliances are a cornerstone of the networked home, a notion that envisions linking home systems together to add convenience to people's lives.

Although the concept of managing home systems remotely via a wireless broadband connection is still far from actual practice, the first pieces of a networked home are now emerging. Several manufacturers such as LG, Samsung, Maytag, GE, and Whirlpool have or have had kitchen appliances in or near the market that incorporate higher technology such as Internet connectivity, advanced sensors, and entertainment applications. Moreover, a study completed by the Internet Home Alliance states that 42% of U.S. households are interested in new technology in a connected home (Dawson 2005).

4.5.2 Market Trends

The price of smart appliances exceeds the average price of their conventional counterparts, but the price differential is not as great when compared to top-of-the-line conventional appliances. Table 4.5.1 shows the selling price range of conventional and smart appliances that are/were available for retail sale in the US. Smart appliances fall near the high end of the selling price range of conventional appliances because smart features are typically added to high-end conventional appliances.

Table 4.5-1 Smart Appliances - Selling Price Range

	Selling Price Range	
	Low	**High**
Conventional Refrigerators	$800	$7,500
Internet ready	*$5,000*	*$8,000*
Integrated TV	*$3,150*	*$3,350*
Conventional Ranges	$400	$1,600
Whirlpool Polara	*$1,400*	*$1,800*

Sources: Home Appliance Magazine (2006), Semi Homemade (2006), Best Buy (2006), Time (2006)
Prices for refrigerators are based on ~25 cu ft capacity, side by side doors, with through the door ice service. Prices for ranges are based on electric ranges with glass cook tops.

The high selling prices did not deter a few manufacturers from offering smart appliances. One of the first serious attempts to market smart appliances was LG Electronics' Internet Refrigerator, which hit the retail market in the fall of 2002 at a cost of $8,000. Envisioned as the hub of a home, interconnected digital network, the refrigerator features a LAN port to enable Internet access, a 15-inch LCD screen, video and audio functionality, and a digital camera. The LG refrigerator was soon pulled off the US market due to poor sales resulting from its high price, according to LG's director of merchandising Tim Kavanaugh. Samsung followed LG's lead with their Homepad Internet refrigerator at a more accessible price point of $5,000. This product too has been pulled off the U.S. market due to low sales.

Another appliance that has received much attention is the Whirlpool Polara range which can function as a refrigerator to keep food from spoiling and then be programmed to cook the food at a set time. Connecting this range to a network so it can be controlled remotely via a broadband connection has already been tested in a pilot program called Mealtime by the Internet Home Alliance, a collaborative research consortium whose objective is to advance the connected home. Despite the benefits of this product, the Polara range sales have been weak and the product is no longer on the U.S. market.

One of the few products presently on the U.S. market that combines electronics and traditional appliance functionality is LG's refrigerator with built-in TV. This product lacks the Internet connectivity of the LG's previous offering, but it has a substantially lower price point (around $3,500), which may appeal to more consumers.

Despite the added benefits of smart appliances, the offerings available (or no longer available) demonstrate weak market penetration that lags far behind other high-tech household goods such as HDTVs and DVD players. Hindered by high prices and the fact that white goods are major appliances that consumers purchase only every 10 years or so, many analysts are skeptical about the potential market for smart white appliances. They claim that the price premium for such goods is not commensurate with the added value provided by such technology. Combined with the long lifecycles for white goods in general, demand for these products lags behind supply.

Smart appliances have received a boost in one market niche: the luxury home. According to the National Kitchen and Bath Association, the most popular trend in kitchen design is the inclusion of an entertainment area (CEA 2004). The smart appliance segment in the luxury home market will likely experience growth as homebuilders pre-wire kitchens to provide Internet connectivity and as kitchen designers incorporate entertainment options into kitchens. However, as with other emerging technologies, growth in this segment will depend on early adopters among upper income households.

4.5.3 Applicable Standards and Efficiency Programs

Since smart appliances are a niche technology, there are no *specific* industry standards for regulating their energy consumptions. Some are covered by the federal standards that exist for refrigerator/freezers.

4.5.4 Usage Characteristics

The intent of media-enhanced appliances is to allow households to maintain the kitchen as the center of the home while providing the added functionality of entertainment, communication, and networking. Enabling appliances to connect to the Internet provides additional control as well as monitoring functions from a remote location. In addition, Internet-enabled appliances can access information over the Internet to enhance operation. Even without an Internet connection, smart appliances can provide the user additional information on how best to use the functions of an appliance as well as advanced monitoring to better control operation.

Smart appliances are likely to be used in much the same way as conventional appliances with the addition of activities afforded by the their smart features. As a result, their duty cycles will probably be similar to those of conventional appliances. Energy consumption may increase during the operation of the smart portion of the appliance, which would likely take place in the morning and then again in the evening when customers return from work and school.

Their enhanced functionality may allow smart appliances to be compatible with automated demand response programs, especially if the appliance can be connected to the Internet. In a future scenario, customers could enroll in a program in which they receive discounted rates in exchange for giving the utility authority to power down their smart appliance via the Internet in a demand response situation. In another scenario, the smart appliance can monitor real time prices of electricity and control energy consumption based on the price, with a higher price signaling a period of high demand. The Public Interest Energy Research's (PIER) Demand Response Research Center is currently evaluating this scenario with appliances in a critical peak pricing situation.

4.5.5 PG&E Shipments and Stock

Smart appliances are a niche market and only a small number of units have been sold. Many of the first smart appliances that debuted in the early 2000s are no longer available for sale in the

United States. Data for shipments and stock of smart appliances in the PG&E service territory is not readily available at the time of this report.

4.5.6 PG&E Energy Consumption

The energy consumption of a smart appliance will likely vary depending on the use of its electronic componentry. If the appliance is designed with advanced electronics to optimize power demand, then the appliance may have lower power consumption than a comparable non-smart appliance. However, if the added electronics serve only for additional functionality (i.e. entertainment, network connectivity, etc.) with no consideration of power demand, then the appliance will likely have higher consumption than a comparable non-smart appliance.

4.5.7 Lifecycle Costs

Smart appliances tend to have a higher upfront cost compared to conventional appliances. However, energy consumption and useful life are roughly equivalent to a comparable conventional appliance. Taking these factors into consideration, smart appliances tend to have higher life cycle costs than their conventional counterparts.

4.5.8 Opportunities for Energy Savings

The energy savings potential for smart appliances is likely best realized if the appliance can respond to changes in system demand. This functionality would need to be developed on several fronts, from a wider application of time-of-use metering and Internet connection to utility system data to the appliance's ability to process this information and adjust power consumption accordingly. .

In fact, using Internet connections to manage appliance function is one area where the potential of smart appliances is being fostered by pilot projects. One organization sponsoring a networking technology pilot project is the Internet Home Alliance (IHA).[44] In addition to their Mealtime pilot, the IHA has launched a new pilot program named Laundry Time that links a washer and dryer to Internet-connected devices such as computers and cell phones to allow the user to monitor and be notified of their laundry's status. This project involves Whirlpool, Panasonic, and Microsoft and is currently being demonstrated in three Atlanta homes. According to the IHA, the technology is at least a year off (no sooner than the third quarter of 2007).

Another technology pilot is being conducted under the Gridwise program, which is run by the Pacific Northwest National Laboratory.[45] The Gridwise project combines real-time pricing and automated controls to manage appliance operation and reduce energy consumption in peak periods. Users can set their Internet-connected gateway box software to operate the thermostat and water heater according to parameters set for cost saving, comfort, or a mix of both. A second part of the Project is the Grid Friendly Appliance, which presently involves clothes dryers with a computer chip that can vary the energy consumption in response to grid instability. The computer

[44] For more details on the Internet Home Alliance, see: http://www.caba.org/iha/
[45] For more details on the Gridwise program, see: http://readthis.pnl.gov/MarketSource/ReadThis/B2842_not_print_quality.pdf

chip responds to fluctuations in the current frequency and turns down or off the heating element while keeping the dryer turning. The next step is to incorporate the Grid Friendly Appliance project with Internet connectivity to allow for networked appliances that can respond to real-time pricing.

4.5.9 Future Work

Smart appliances are a small niche market with limited near-term energy savings relative to other products covered in this report (e.g., televisions, computers, and set-top boxes). However, consumer electronics can evolve rapidly and this market segment should be continually monitored for future energy savings opportunities. Resources that give the latest information on smart appliances include:

- In-Stat Reports including: "*Smart Appliances: Bringing the Digital Home Closer to Reality*," "*Networking Technology Brings Intelligence Into Today's Smart Home*," and "*Internet Based Home Control and Enabled Products*,"
- MIT-TIAX Placelab,
- University of Texas at Arlington's Smart Home,
- Internet Home Alliance,
- Powerline Communications,
- Association of Home Appliance Manufacturers (AHAM),
- Pacific Northwest National Laboratory Gridwise, and
- PIER Demand Response Research Center.

These organizations are presently engaged in smart appliance research on various levels and can be contacted to monitor emerging trends.

4.6 Personal Electronics Chargers

4.6.1 Overview

Handheld and portable electronic devices comprise a broad array of consumer products that provide mobility by incorporating rechargeable batteries. Energy Solutions examined the battery charging systems of nine key product categories – chosen based on their prevalence within PG&E households:

- Cell phones
- Cordless phones
- Laptop PCs
- Digital cameras
- Portable audio (e.g., MP3 players, iPod™, etc.)
- Personal Digital Assistants (PDAs)
- Rechargeable batteries (i.e., standalone battery chargers for common battery types such as AA, AAA, C, or D cells)
- Personal hygiene (e.g., electronic toothbrushes and shavers)
- Other (includes miscellaneous charging devices that are not as numerous as the above categories but collectively represent a significant portion of the overall segment, e.g., rechargeable flashlights, cordless kitchen tools, etc.).

In general, the following three components are required to charge a portable electronic device:

1. **Power supply** – converts high voltage alternating current electricity (typically 100 to 240 volts AC) from a wall outlet into low voltage direct current electricity (typical 1.5 to 24 volts DC) that is suitable for a battery charger.

2. **Battery charger** – receives low voltage DC electricity from the power supply and uses it to replenish the charge in a rechargeable battery. Battery chargers vary widely by product and may be separate from the end-use product or built-in.

3. **Rechargeable battery** – receives DC electricity from the battery charger and stores energy chemically. The chemical energy can, in turn, be converted to electrical energy to run the end-use product. The three most commonly used rechargeable battery chemistries are: nickel cadmium (NiCd), nickel metal-hydride (NiMH), and lithium ion (Li-Ion).[46]

The *power supply* efficiency is a key aspect of the product's overall energy consumption and has recently been at the forefront of state, national, and international efficiency efforts. The California Energy Commission (CEC) recently adopted a Title 20 efficiency regulation for external power

[46] The following products are typically used with the respective batteries, as follows (NRDC/Ecos 2003):
NiCd – power tools, toys, cordless, and cordless toothbrushes;
NiMH – cell phones and older digital cameras and laptops;
Li-Ion – newest cell phones, digital cameras, laptops, and PDAs.

supplies that will achieve significant energy savings throughout California.[47] Therefore, this report focuses on the non-regulated components of the charging process – the *battery charger* and *battery* – commonly referred to as the **battery charging system (BCS)**, and how their efficiencies affect overall unit energy consumption.

4.6.2 Market Trends

Based on market research collected from various sources, we estimate that over 17 million devices with BCSs are being used in the PG&E Mass Market. This averages to roughly 4 devices for every household. By 2010, the total stock is forecasted to increase to 25 million devices, reaching approximately 5 devices per household.[48] The products that use BCSs are diverse, and therefore a broad range of market trends will affect future sales and stock. The following trends and assumptions provide the basis for our forecast scenarios:[49]

- **Cell phones –** The CEC sponsored *Residential Appliance Saturation Survey* (RASS), conducted in late 2002 and 2003, provides a detailed snapshot of cell phone saturation within PG&E households and is used as a basis for developing future trends. The survey indicated that there were over 4.6 million cells phones in use at that time, or 1.1 phones per household (CEC 2004). Globally, iSuppli estimated that cell phone shipments increased 14% from 2004 to 2005 – 713 million to 812.5 million – but expects the growth to taper off with product maturity (Kanellos 2006). We assume a lower shipment growth (4% CAGR) over the forecast period since saturation in PG&E territory is greater than it is worldwide.

- **Cordless phones** – In 2003, an estimated 128 million cordless phones were being used in the United States (Calwell and Reeder 2002). In California, there were approximately 2.2 million shipments in 2003.

- **Laptop PCs –** The RASS survey indicated that the 2003 PG&E Mass Market stock was 1.3 million. Laptop PCs continue to appeal to the mobile sector of the home office market and shipments now outnumber desktop PC shipments. TIAX (2006) estimates a 14% CAGR from 2005 to 2010.

- **Digital cameras –** IDC estimated that 27 million digital cameras were sold in the U.S. during 2005, representing a 16% increase from 2004 (Terdiman 2005). This growth is

[47] External power supplies (EPSs) are power supplies that convert the AC to DC within a housing *separate* from the product. They are commonly referred to as "AC adapters," "wall packs," "bricks," or "transformers" (Ecos et al 2004).

[48] This is comparable to the commonly quoted assumption that the average U.S. home contains 5 to 10 external power supplies (EPA 2006; Calwell and Reeder 2002). Devices with BCSs are a subset of devices with EPSs because not all devices with an EPS have a BCS. Therefore, the BCS stock estimate should be lower than the EPS stock estimate.

[49] Market data is apportioned on a population basis to develop PG&E Mass Market shipment and stock forecasts (as shown in Table 4.6-3 and Table 4.6-4). An extensive assessment of *each* product category is beyond the scope of this report, however the forecast provides a first order approximation for BCSs that can help inform future PG&E program decisions. Detailed assumptions are provided in Appendix Table 20.

expected to level off with market maturity. We assume the annual shipment growth will decline to 8% by 2010.

- **Portable audio** (e.g., MP3 players, iPod™, etc.) – The portable audio market is one of the fastest growing segments within the Consumer Electronics market. Shipments grew 250% in 2005, largely fueled by Apple's iPod™ (iSuppli 2006).

- **Personal Data Assistants (PDAs)** – The market research firm Gartner estimated that U.S. PDA sales in the first quarter of 2005 totaled 1.3 million, a 5% increase from the same period in 2004.

Accurate market data was not readily available for standalone battery chargers and electronic personal hygiene products, so we assumed a 10% and 15% household saturation, respectively.

4.6.3 Applicable Standards and Efficiency Programs

Within PG&E territory, the CEC Title 20 standards process and the voluntary ENERGY STAR certification are the most significant activities to monitor for portable electronics that use a rechargeable battery. It is important to note that both the CEC and ENERGY STAR have addressed the efficiency of external power supplies (EPSs) *separately* from battery charging systems (BCSs).

ENERGY STAR recently announced a new BCS specification on January 1, 2006, and updated the EPS specification on March 1, 2006. Manufacturers can only qualify a device under **one** specification. The EPS specification covers a wide range of products that use an external power supply to convert line voltage AC into lower voltage DC. The BCS specification applies to:

> *"... motor-driven battery charged products; products whose principal output is heat, light, or motion; battery charging systems intended to replace standard sized primary alkaline cells (e.g., AAA, AA, C, 9-volt, etc.); and other products (e.g., some digital cameras and camcorders with detachable batteries and stand-alone battery chargers whose designs are not covered by the external power supply specification* (ENERGY STAR)*."*

Therefore, the product categories studied in this section are primarily covered by the following specifications:

> **EPS specification**: cell phones, cordless phones, laptop PCs, digital cameras (some), portable audio, and PDAs.
> **BCS specification:** stand alone battery chargers, personal hygiene, and products in the "other" category (e.g., rechargeable flashlights and cordless kitchen tools).

The criteria for both specifications are summarized in Table 4.6-1 and Table 4.6-2, respectively. To be eligible for the BCS qualification, the system must not exceed a maximum *Nonactive Energy Ratio*, which is based on the *nominal battery voltage (Vb).* The maximum allowed Nonactive Energy Ratios are included in Table 4.6-1 for selected battery voltages. To be eligible

for the EPS qualification, the power supply must meet both active and no-load mode requirements in Table 4.6-2.

The key definitions for each specification are provided below (ENERGY STAR 2006).[50]

For the BCS specification:

Active Charge Mode: The condition in which the battery is receiving the main charge, equalizing cells, and performing other one-time or limited-time functions necessary for bringing the battery to the fully charged state.

Battery Maintenance Mode: The condition in which the battery is still connected to the charger, but has been fully charged. This mode may persist for an indefinite period of time.

Standby (No-Load) Mode: Lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when an appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions. Note: The standby mode is usually a nonoperational mode when compared to the intended use of the appliance's primary function. For the purposes of this specification, standby mode is the condition in which no battery is present in the charger, or when the battery is integral to a product and the product is not attached to the charger but the charger is plugged in and drawing power.

Accumulated Nonactive Energy (Ea): The energy, in watt-hours (Wh), consumed by the battery charger in battery maintenance and standby modes of operation over a defined period. For the purposes of this specification, the 48-hour period consists of 36 hours of maintenance mode operation followed by 12 hours of standby mode operation. The accumulated non-active energy is the sum of the energy used in these two modes.

Battery Capacity: The quantity of charge, measured in ampere-hours (Ah), capable of being provided by a battery during discharge, the conditions of discharge being specified.

Battery Energy (Eb): The energy, in watt-hours (Wh), deliverable by the battery under known discharge conditions. For the purposes of this specification and test methodology, the battery energy shall be measured at a constant current discharge rate of 0.2 C. The test shall begin with a fully charged battery, which is then discharged until the battery reaches its manufacturer specified cutoff voltage. The battery energy is determined by measuring and integrating the battery voltage over the course of discharge multiplied by the constant current load. This value shall be reported by the manufacturer and is subject to verification by EPA.

Nonactive Energy Ratio (ER): The ratio of the accumulated non-active energy (Ea) divided by the battery energy (Eb). ER = Ea / Eb.

[50] For consistency, the ENERGY STAR definitions are provided verbatim.

Nominal Battery Voltage (Vb): Industry standard cell voltage multiplied by the number of cells in the battery pack, normally listed on battery packaging. As of the writing of this battery charging systems specification, industry accepted nominal cell voltages for applicable chemistries include: 1.2 volts for Nickel Cadmium and Nickel Metal Hydride; 2.0 volts for sealed lead acid; and 2.5-4.2 volts for Lithium Ion (depending on material used for the positive electrode and other factors).

For the EPS specification:

Active Mode: The condition in which the input of a power supply is connected to line voltage ac and the output is connected to a dc or an ac load drawing a fraction of the power supply's nameplate power output greater than zero.

No-Load Mode: The condition in which the input of a power supply is connected to an ac source consistent with the power supply's nameplate ac voltage, but the output is not connected to a product or any other load.

Table 4.6-1 ENERGY STAR - Key Product Criteria for Battery Charging Systems (BCS)

Vb	**1.2**	**2.4**	**3.6**	**4.8**	**6**	**7.2**	**8.4**	**9.6**	**10.8**	**12**
ER	20	16.9	13.7	11.6	9.6	7.5	7	6.5	6.1	5.6
Vb	**13.2**	**14.4**	**15.6**	**16.8**	**18**	**19.2**	**20.4**	**21.6**	**22.8**	**≥ 24.0**
ER	5.1	4.5	4.3	4.2	3.8	3.6	3.5	3.3	3.2	3

Vb=Nominal Battery Voltage; ER=Nonactive Energy Ratio=Ea/Eb; Ea=Accumulated Nonactive Energy; Eb=Battery Energy

Table 4.6-2 ENERGY STAR - Key Product Criteria for External Power Supplies (EPS)

	Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode (expressed as a decimal)
Active Mode	0 to ≤ 1 watt	≥ 0.49 * P_{no}
	> 1 to ≤ 49 watts	≥ [0.09 * Ln (P_{no})} + 0.49
	> 49 watts	≥ 0.84
No-Load Mode	Nameplate Output Power (P_{no})	Maximum Power in No-Load
	0 to < 10 watts	≤ 0.5 watts
	≥ 10 to ≤ 250 watts	≤ 0.75 watts

Pno = Nameplate output power; Ln=natural logarithm

The CEC recently adopted a Title 20 efficiency regulation for *external power supplies* that will initially be based on the ENERGY STAR criteria. This standard will achieve significant energy savings in PG&E territory and throughout California. The PG&E Codes and Standard team is now conducting research on battery charging systems, and will likely recommend new Title 20 language to the CEC that specifically addresses BCSs. If the CEC does pass new Title 20 regulations for BCSs, the likely effective timeframe would be 2009 or beyond.

4.6.4 Usage Characteristics

Battery charging systems have three primary modes of operation: active charge, maintenance, and standby (no-load). These terms have each been defined in the previous section, 4.6.3. The amount of time spent in each mode is highly variably and is dependent on the type of device being charged and how a user charges the device. Therefore, we adopt and apply the NRDC/Ecos assumption that the BCS spends 50% of its duty cycle in active mode and the other 50% in the maintenance and no load modes (2003). Assuming the time spent in maintenance and no load modes is equally split, the average duty cycle follows: active mode (4380 hrs/yr), maintenance (2,190 hrs/yr), and standby (2,190 hrs/yr).

4.6.5 PG&E Shipments and Stock

The forecasted number of shipments and stock in PG&E territory is developed using the market trends discussed in Section 4.2.3. Table 4.6-3 shows that shipments are expected to grow from 7.2 million in 2005 to 9.3 million in 2010, representing a 5% CAGR. Cell phones lead the shipments followed by portable audio and digital cameras. Table 4.6-4 highlights how the growing shipment total will affect the complete PG&E Mass Market stock. We estimate that the stock will increase at an 8% CAGR, and could exceed 25 million units by 2010. The detailed sources and assumptions are provided in Appendix Table 20.

Table 4.6-3 Personal Electronic Chargers – Forecasted New Shipments to PG&E Mass Market, 2005 - 2010 (000)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Cell phones	3,340	3,540	3,720	3,860	3,980	4,080	4%
Cordless phones	760	750	730	720	700	690	-2%
Laptop PCs	710	750	790	810	830	870	4%
Digital camera	590	680	760	830	910	980	11%
Portable audio	1,300	1,520	1,730	1,850	1,950	2,040	9%
PDAs	230	240	250	260	280	290	5%
Rechargeable batteries	13	14	14	14	15	15	3%
Personal hygiene	20	20	21	22	22	23	3%
Other / Misc.	210	230	240	250	260	270	5%
Total	**7,170**	**7,740**	**8,260**	**8,620**	**8,950**	**9,260**	**5%**

Note: Estimate based on a number of sources. See Personal Electronic Charger Appendix for detailed sources and assumptions.

Table 4.6-4 Personal Electronic Chargers – Forecasted Stock in PG&E Mass Market, 2005 - 2010 (000)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Cell phones	5,740	6,210	6,640	7,040	7,380	7,670	6%
Cordless phones	5,230	5,240	5,240	5,220	5,190	5,150	0%
Laptop PCs	1,930	2,200	2,440	2,640	2,810	2,980	9%
Digital camera	950	1,390	1,800	2,190	2,550	2,890	25%
Portable audio	1,700	2,370	2,920	3,310	3,600	3,850	18%
PDAs	340	500	620	730	830	910	22%
Rechargeable batteries	450	460	480	490	510	520	3%
Personal hygiene	680	700	720	740	760	780	3%
Other / Misc.	510	570	630	670	710	740	8%
Total	**17,530**	**19,640**	**21,490**	**23,030**	**24,340**	**25,490**	**8%**

Note: Estimate based on a number of sources. See Personal Electronic Charger Appendix for detailed sources and assumptions.

4.6.6 PG&E Energy Consumption

Table 4.1-7 presents the assumed power consumption values for the Baseline and Improved Case scenarios. They are based on the NRDC/Ecos assumption that BCSs have an average *maintenance* and *standby* power consumption of 3 watts (2003). This estimate was based on over 60 BCS power measurements that revealed maintenance mode power ranges from 0W (digital camera) to 26W (power tool), and standby mode power ranges from 0W (PDA) to 7W (portable phone) (NRDC/Ecos 2003). The active charge mode power consumption is currently not well-characterized and therefore is not included in this assessment. However, the CEC has recently funded a battery charger project that will build upon the currently available data and will better characterize the average power consumption for different types of products in all operating modes.[51]

The CEC study results should be utilized in the future to inform PG&E program decisions. The PG&E Codes and Standards team will use the results to help inform future recommendations to the CEC regarding Title 20 efficiency regulations.

Table 4.6-5 Personal Electronic Chargers – Duty Cycle and Power Assumptions

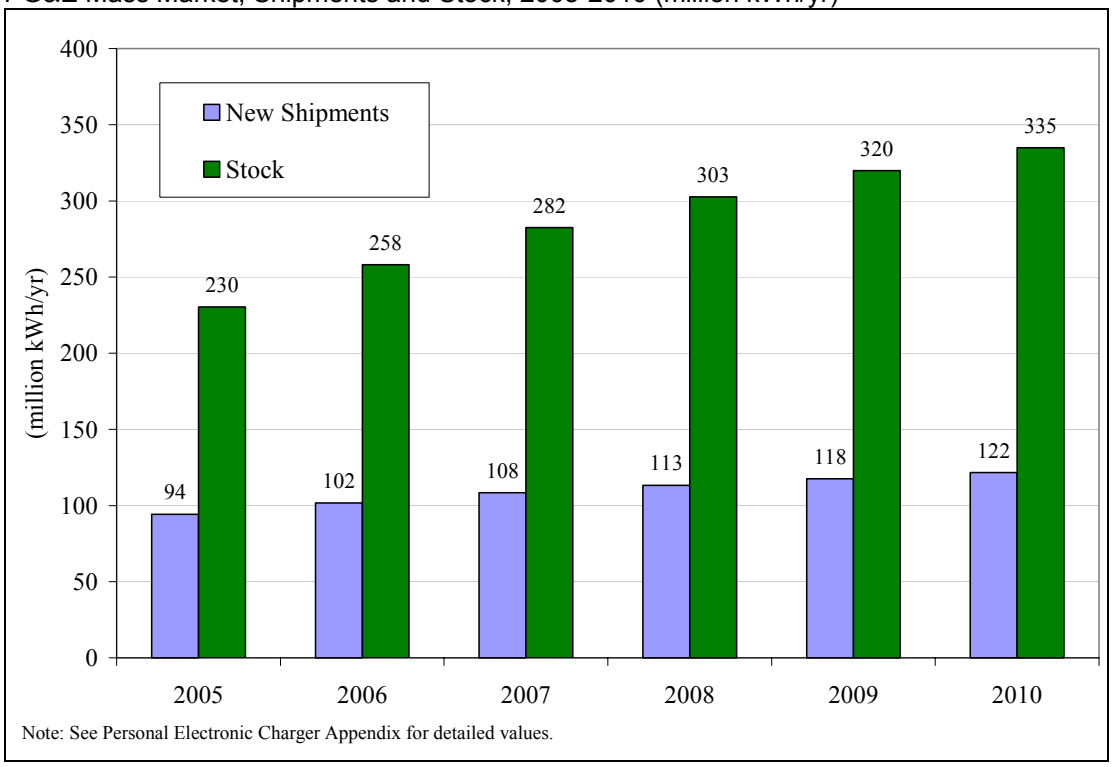
	Duty Cycle (hrs/yr)		Average Power (W)		Annual Energy Consumption (kWh/yr)		
	Maintenance	Standby	Maintenance	Standby	Maintenance	Standby	Maintenance + Standby
Baseline	2190	2190	3	3	6.6	6.6	**13.1**
Improved Case	2190	2190	1	1	2.2	2.2	**4.4**
Savings	NA		2	2	4.4	4.4	**8.8**

Source: NRDC/Ecos (2003)

[51] The project is supported by the California Public Interest Energy Research (PIER) funds (contract #500-04-030) and is being led by Ecos Consulting and EPRI Solutions.

Figure 4.6-1 shows the Baseline scenario first-year annual energy consumption for the new shipments and stock, respectively. The energy consumption from new shipments is estimated to increase at a 5% CAGR over the next five years – from 94 million kWh in 2005, to 122 million kWh in 2010. During this time period, the Baseline stock consumption rises significantly from 230 million kWh to 335 million kWh – or 0.9% of the total Mass Market energy consumption in 2005, to 1.2% in 2010.

Figure 4.6-1 Personal Electronic Chargers - Baseline First-Year Annual Energy Consumption in PG&E Mass Market, Shipments and Stock, 2005-2010 (million kWh/yr)[52]



Note: See Personal Electronic Charger Appendix for detailed values.

4.6.7 Lifecycle Costs

As with the duty cycle and energy consumption, the lifecycle energy costs are highly dependent on user behavior. The *annual* energy cost to operate a typical BCS in maintenance and standby modes is $1.70 per year – assuming the 13.1 kWh/yr Baseline consumption and a $0.13/kWh rate. The *lifecycle* operating cost is dependeant on product lifespans, which vary by device and

[52] Laptop PCs are also discussed in the Home and Small Office Equipment section (4.1). The values presented in the Home and Small Office Equipment category are for the overall unit energy consumption, whereas, the values presented in this section are specific to the battery charging system. This figure includes the Laptop PCs' BCS consumption, but to avoid double counting, the values are not included in the summary tables and figures presented the Executive Summary and Conclusion.

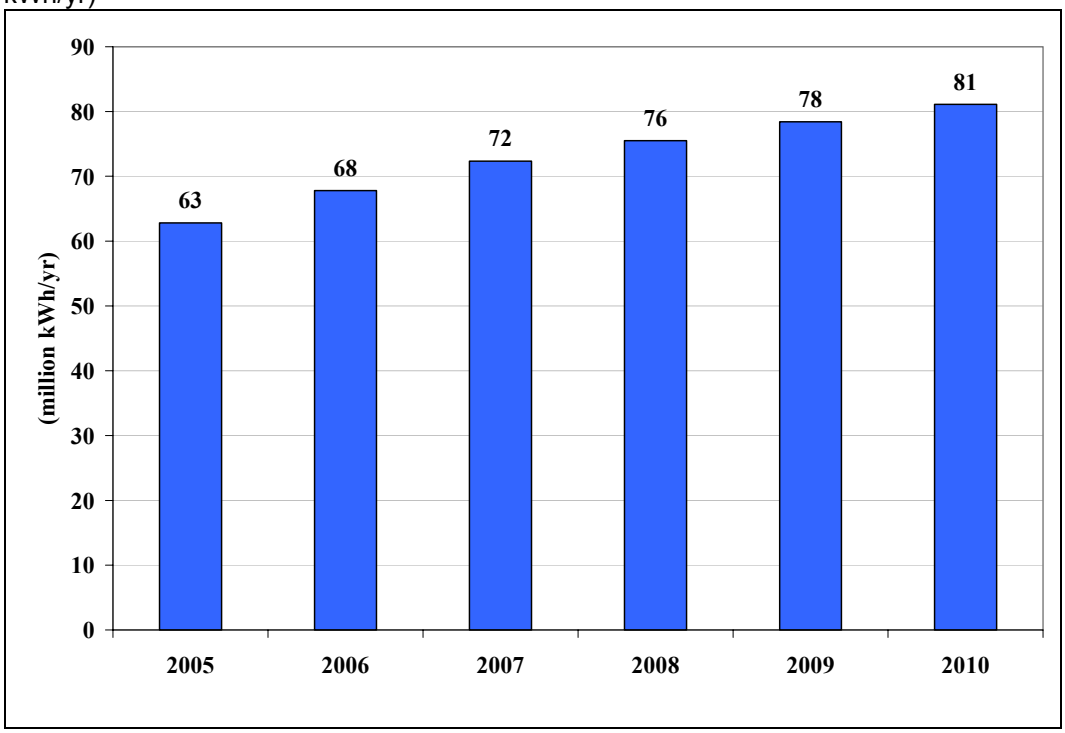
user. At the lower end, a three-year lifespan would result in a $4.40 lifecycle cost, whereas a ten-year lifespan would average $11.40.[53]

4.6.8 Opportunities for Energy Savings

As shown previously in Table 4.6-5, the Improved Case scenario assumes a 1W average power consumption for the maintenance and standby modes – an efficiency gain of 2W in each mode. Therefore, the *average* energy savings per product is 8.8 kWh/yr compared to the Baseline. These assumptions are based on NRDC/Ecos's assertion that technical solutions exist to reduce the average to 0.5W. The Improved Case scenario assumptions are a bit more conservative to include more products on the market.

Figure 4.6-2 displays the potential energy savings if 100% of all new shipments to the PG&E Mass Market meet this Improved Case scenario. The savings range from 63 million kWh in 2006, to 81 million kWh in 2010.

Figure 4.6-2 Personal Electronic Chargers - First-Year Annual Energy Savings with Improved Case Scenario – 100% Sales Penetration of New Shipments to PG&E Mass Market (million kWh/yr)



4.6.9 Future Work

Three key developments to monitor in the future will be: 1) the results of the CEC PIER battery charger study, 2) the success of the recently enacted ENERGY STAR specification, and 3) the future goals and activities of the PG&E Codes and Standards team. See Section 5. [Program

[53] These are present values (PV) based on an 8.15% discount rate.

Recommendations and Conclusions] for a more detailed discussion on recommended PG&E program intervention, delivery types, and key dates.

5 Program Recommendations and Conclusions

5.1 Overview

This study provides a starting framework to inform the development of energy efficiency programs that target consumer electronics. The scenarios presented here demonstrate the increasing presence of these products in PG&E homes and small businesses and their growing impact on Mass Market energy consumption. Fortunately, the scenarios also highlight that opportunities for energy savings exist.

An estimated 56 million of these consumer electronic products were in service in 2005. By 2010, there will be an estimated 85 million. Figure 5.1-1 reviews that the Baseline scenario energy consumption for these products could rise from 18% of PG&E's Mass Market in 2005, to 26% in 2010.

As shown in Figure 5.1-2, the Improved Case scenario reflects a lower energy pathway and highlights that *first-year* energy savings could exceed 400 million kWh per year if 100% of all new shipments met the Improved Case energy assumptions. The cumulative *lifetime* savings would be much greater as most of the products studied have lifespans ranging from 4 to 9 years. Although it is improbable that programs would influence 100% of sales, the savings showcase a technical potential that should serve to inform and motivate future policy and program decisions.

Figure 5.1-1 Forecasted Baseline Annual Energy Consumption – Consumer Electronics in PG&E Mass Market Sector (million kWh/yr)

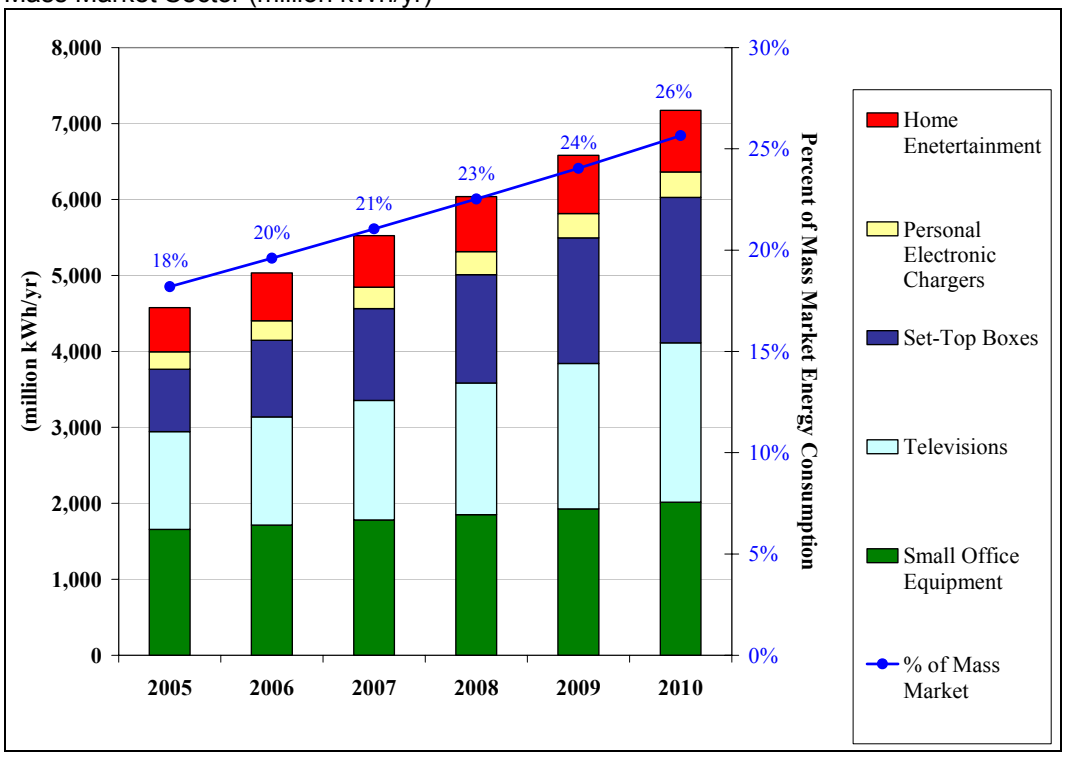
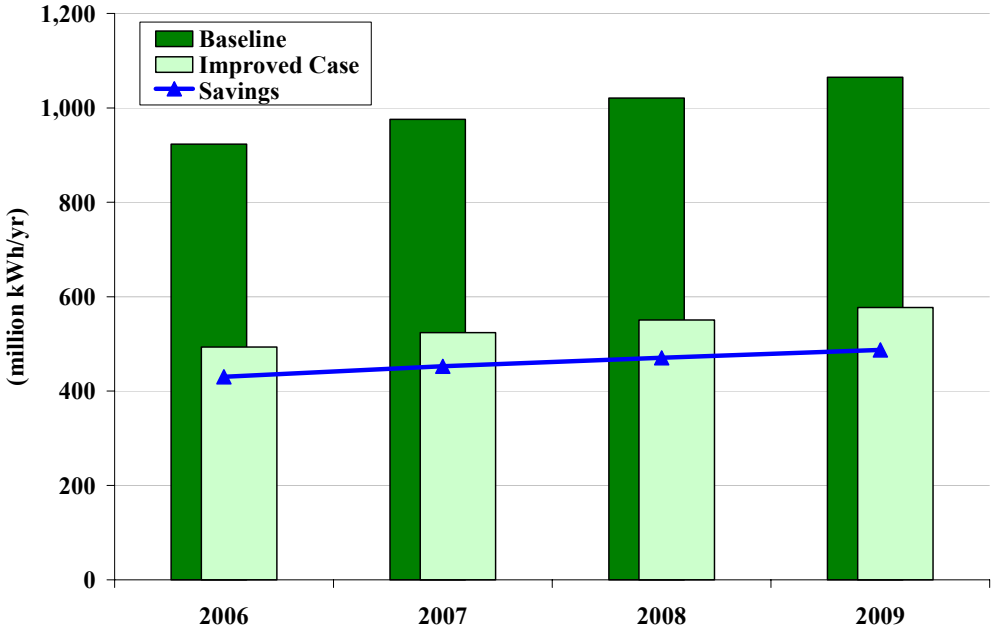


Figure 5.1-2 First-Year Annual Energy Consumption for New PG&E Shipments – Baseline and Improved Case Scenarios for all product categories in this report (million kWh/yr)



Note: Improved Case scenario represents 100% market share of Improved Case products.

5.2 Program Recommendations for Product Categories

Key program recommendations for PG&E intervention are presented in Table 5.2-1. For each product category, the table provides a *relative* recommendation level (high, medium, low, or none) for the following program aspects:

- **PG&E Program Intervention:** provides a recommendation level for PG&E pursuing a voluntary and/or codes & standards program;
- **Voluntary Program Delivery:** provides a recommendation level for the type of voluntary program delivery—upstream, midstream, and/or downstream;
- **Voluntary Program Type:** provides a recommendation level for the type of voluntary program—incentive-based and/or educational; and
- **Target End-user:** provides a recommendation level for the targeted end-user—residential and/or business customers.

In consideration of the rapidly evolving consumer electronics segment, the recommendations are not meant to be definitive and exhaustive, but rather to set priorities among the products based on their relative potential for energy savings and the feasibility of related programs.

A significant factor for program development is whether power data is readily available to inform program decisions (e.g., from an ENERGY STAR database). In general, standby and low power mode data is fairly accessible for the products covered in this report, but active mode power data is currently limited. Targeting active mode power consumption holds the greatest energy savings potential for a voluntary program in PG&E territory, particularly because the California Title 20 standards and ENERGY STAR specifications have largely addressed the low power operating modes. The development of internationally accepted test methods (particularly for televisions and set-top boxes) and new ENERGY STAR specifications (particularly for televisions and computers) will play an important role in enabling and facilitating future PG&E programs.

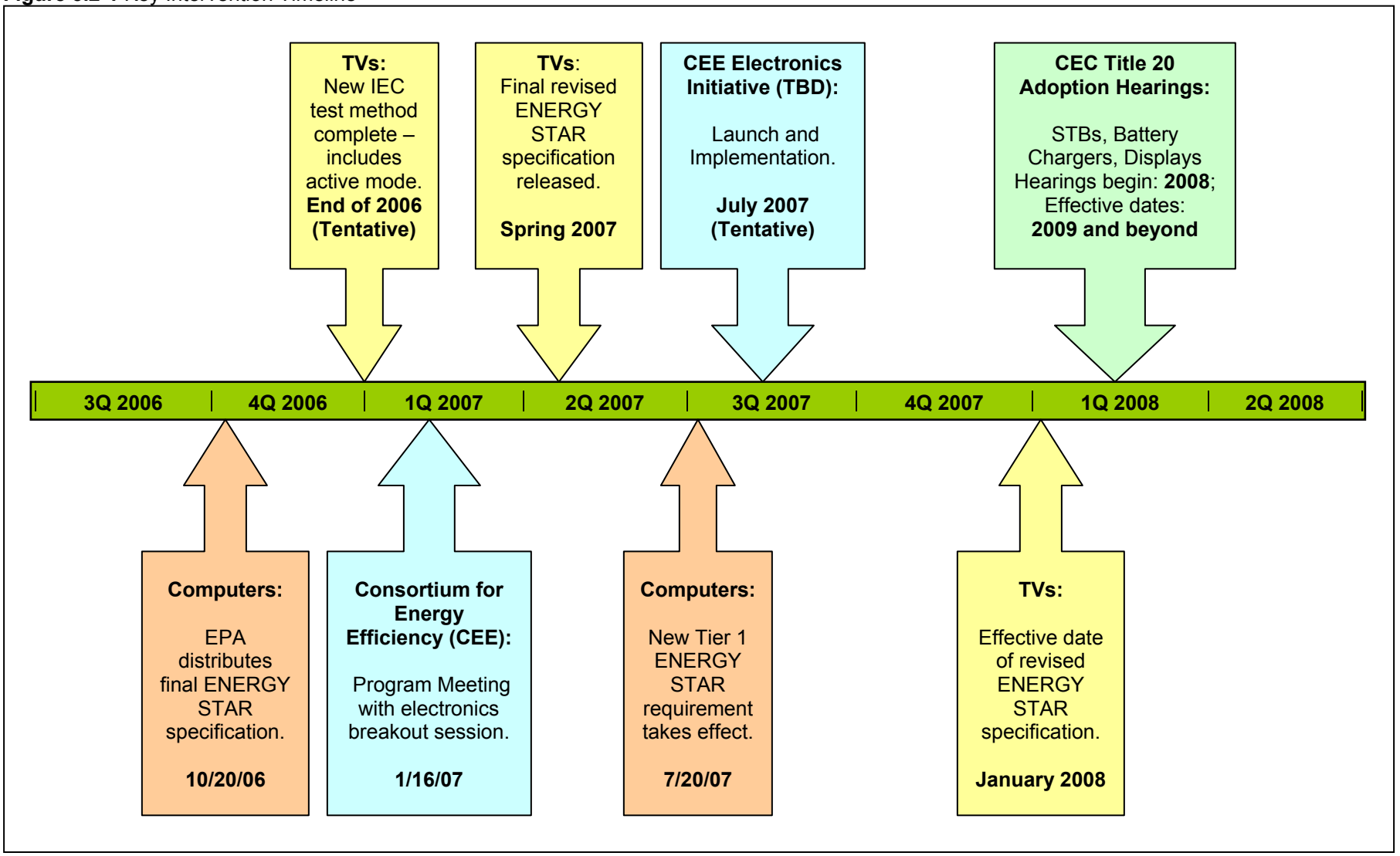
Directly following the recommendations in Table 5.2-1 below, Figure 5.2-1 displays a key intervention timeline that corresponds with our highest program recommendations.

Table 5.2-1 Program Recommendation Matrix

Product Category	PG&E Program Intervention		Voluntary Program Delivery			Voluntary Program Type		Target End User	
	Voluntary	Codes & Standards	Upstream	Midstream	Downstream	Incentive	Education	Residential	Business
Home and Small Office Equipment[1]	**High**	**Medium**	Low	**High**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
Televisions	**High**	Low	Low	**High**	**Medium**	**High**	**High**	**High**	Low
Set-Top Boxes	**Medium**	**High**	**Medium**	**Medium**	Low	**Medium**	**Medium**	**Medium**	Low
Home Entertainment Systems	Low	Low	Low	Low	Low	Low	Low	Low	None
Personal Electronic Chargers	Low	**High**	Low	Low	Low	Low	Low	**High**	Low

[1]NOTE: The voluntary program recommendations for the Home and Small Office Equipment category are for *computers*, primarily due to the forthcoming revised ENERGY STAR specification that will become effective on July 20, 2007. The codes & standards intervention recommendation is primarily for computer *monitors*.

Figure 5.2-1 Key Intervention Timeline



The key program recommendations for each product category covered in this report are as follows.

5.2.1 Home and Small Commercial Office Equipment

Our highest recommendation for a voluntary program within the home and small commercial office equipment category focuses on computers. The motivation is twofold: 1) desktop PCs and laptop PCs represent the greatest potential for energy savings within the category and 2) the forthcoming revised ENERGY STAR specification will lay the groundwork to identify and promote the most efficient computers on the market. Also, as shown previously in Figure 4.1-2, the combined potential energy savings for desktops and laptops represent more than half of the potential savings in the office equipment category.

At the time of this report's writing, the ENERGY STAR revision process for the computer specification is nearly complete and on September 22, 2006, the EPA released the Final Draft Version 4.0 specification for comment. The final ENERGY STAR Version 4.0 computer specification will be distributed on October 20, 2006, and will take effect on July 20, 2007. The ENERGY STAR computer specification revision Web site will be a valuable resource for PG&E Program Managers to stay up to date with the detailed specification requirements, stakeholder comments, and energy test data on specific computers.[54] The new specification will set much more aggressive operational mode efficiency requirements and will add a power supply efficiency requirement. As a result, the market penetration for new ENERGY STAR computers sales will fall from approximately 98% to 22%.[55]

In addition to lowering the sleep mode power level requirements and adding a standby (off) mode requirement for computers[56], ENERGY STAR has established an important new power level requirement for the "idle state" operating mode. For the purposes of the specification, ENERGY STAR defines idle as the state in which the operating system and other software have completed loading, the machine is not asleep, and activity is limited to those basic applications that the system starts by default. This is an encouraging step towards addressing total unit electricity usage and represents the evolution of ENERGY STAR beyond targeting only the sleep and standby operating modes.

PG&E could reasonably add computers to its current program offerings starting in the third quarter of 2007, after the computer specification becomes effective on July 20, 2007. Our highest recommendation for an initial program offering is for an incentive-based midstream program

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[54] See the ENERGY STAR Computer Specification Webpage for ongoing updated documents: http://www.energystar.gov/index.cfm?c=revisions.computer_spec

[55] The 98% penetration rate is an ENERGY STAR estimate from 2004 (see Table 4.1-2). The 22% estimate is based on 230 ENERGY STAR-tested data points (141 desktops and 89 notebooks from 6 different manufactures) where only 22% met all the proposed levels for the forthcoming specification (see 8/26/06 memo on the ENERGY STAR Computer Specification Webpage: http://www.energystar.gov/index.cfm?c=revisions.computer_spec. Note: The 22% estimate is model-weighted, not shipment-weighted. While ENERGY STAR made an attempt to measure diverse models from various manufacturers, there is no indication that they captured a shipment-weighted representation.

[56] The new Sleep mode requirement for a desktop will be ≤ 4.0 W (down from the current ≤ 15.0 W) and ≤ 1.7 W for a notebooks. The new Standby (Off) mode requirement will be ≤ 2.0 W for desktops and ≤ 1.0 W for notebooks.

targeting both residential and business customers. We recommend that PG&E leverage the program infrastructure being established by the recently launched PG&E Monitor Rebate program to add a similar computer measure once the new computer ENERGY STAR specification becomes effective. The potential synergies are great because the targeted midstream retailers will be the same for both computers and monitors. Therefore, an ongoing assessment of the Monitor Program during the next several months should help inform PG&E on the feasibility and ease of establishing a similar program (or additional measure) for computers.

It is expected that some computer manufactures will use the nine-month period between the release of the final specification (October 20, 2006) and the effective date (July 20, 2007) to revamp their products so that they can qualify on or after July 20, 2007. As manufacturers qualify new products, the new ENERGY STAR qualifying list will allow PG&E to establish a credible baseline to measure potential program energy savings. PG&E should use this information to inform rebate levels and to assess program cost-effectiveness. In addition, the data set should eventually provide robust enough data to serve as a basis for adjusting incentive levels. For example, it is conceivable that an initial rebate would be available for meeting the ENERGY STAR specification, and then eventually PG&E could raise the qualifying level as more efficient computers enter the market. This strategy would be similar to the Monitor Rebate Program that now sets the qualifying monitor level 25% *higher* than the ENERGY STAR level to achieve greater savings.

Another noteworthy addition to the computer specification is the inclusion of game consoles—considered to be standalone computers whose primary use is to play video games. Game consoles were beyond the scope of this study but we believe they deserve additional study based on their rising prevalence within homes and because their peak usage patterns tend to coincide with PG&E's peak period. (See Figure 4.2-5 for a typical game consol usage pattern throughout the day.) Additional research should include acquiring test data on game console energy performance because it is currently absent from the final ENERGY STAR dataset that informed the new computer specification.[57]

Even though game consoles are included within the new ENERGY STAR computer specification, the PG&E program opportunities will be different because the product segment is different. Instead of dealing with *hundreds* of desktop and laptop models, the current game console market is dominated by *three* products—Microsoft Xbox 360, Sony PlayStation 3, and the Nintendo Revolution. Therefore, an upstream intervention may prove to be the best opportunity for energy savings.

Beyond computers and monitors, we do not strongly recommend that PG&E pursue a voluntary program for the remaining products in the Home and Small Commercial Office category—printers, scanners, copiers, fax machines, multi-function devices, broadband devices, home routers, and VoIP at this time. This is primarily because they all have relatively small incremental

[57] The dataset is available at: http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Final_Computer_Dataset_092206.xls

energy savings potential per unit and because most already have high ENERGY STAR market penetration rates (e.g., printers, scanners, copiers, fax machines, and multi-function devices[58]).

We do recommend that the PG&E Codes and Standards team continue its research and support for a new computer monitor efficiency standard. The team is currently developing a Codes and Standards Enhancement (CASE) Report assessing the opportunity for a 2008 Title 20 standard for computer monitors and monitors for professional displays. It is also assessing the standards opportunities for broadband devices, home routers, and VoIP. The Title 20 adoption hearings will most likely take place in 2008, with an effective dates taking place in 2009 or beyond.

5.2.2 Televisions

We highly recommend that PG&E position itself to develop a voluntary energy efficiency program that targets televisions. As discussed previously in the Television section [Section 4.2], a program that addresses *active* mode efficiency is the most significant opportunity for energy savings. This is particularly true in California because the recent CEC Title 20 standard now limits standby power to 3W or less. Unfortunately, the existing test methods do not adequately measure active mode power consumption for all the television technologies. PG&E will therefore have to wait while the international community establishes a harmonized global test procedure that is able to measure all the new display technologies and reflect typical operating conditions. Progress is being made and a test method is likely to be completed by the end of 2006.

The new test method will subsequently inform the development of a new ENERGY STAR television specification. The current specification only addresses standby power, but the new one will establish active mode efficiency requirements. Much like computers, the forthcoming set of ENERGY STAR television power consumption data will serve as the most useful basis for establishing qualifications for PG&E incentive levels. As mentioned earlier in this report, the current power consumption trends show that there is a wide range of efficiency levels for each display type, screen size, and resolution level. This is beneficial because it indicates that a program could promote the most efficient models on the market without imposing incremental costs or sacrificing functionality.

The ENERGY STAR Web site for the ongoing television specification revision process is a good resource for staying up to date with the test procedure development, specification requirements, stakeholder comments, and power consumption data.[59] The final revised specification is expected to be released in the spring of 2007 and the effective date is targeted for January 2008. Therefore, the most realistic launch date for a PG&E program will be during the first quarter of 2008.

Our highest program recommendation is for a midstream incentive program that provides a rebate to retailers for selling qualified televisions. (Note: the qualifying level will need to be established once the new ENERGY STAR specification becomes effective and active mode

[58] See Table 4.1-2 for 2004 Market Penetration rates. With the exception of scanners (75%), all these products have penetration rates above 90%.
[59] See the ENERGY STAR Television Specification Webpage for ongoing updated documents: http://www.energystar.gov/index.cfm?c=revisions.tv_vcr_spec

power data is readily available.) The intent will be that this midstream rebate will be passed on to customers in the form of a point-of-sale “instant” rebate. Based on our discussions with midstream retailers, it is likely that some retailers will “sweeten” the deal for the consumer by increasing PG&E’s rebate offer. An educational and marketing component should be part of the program and should complement the rebate. In addition to generating attention to the qualified televisions, the rebate also provides a tracking mechanism for attributing energy savings.

A midstream television rebate program can build upon the infrastructure and relationships that PG&E develops for the Monitor Rebate Program (and potentially for a computer rebate program, as discussed above). It is conceivable that PG&E could add a midstream computer rebate offering in the third quarter 2007 and then televisions in first quarter 2008. In the interim, we recommend that PG&E stays current with the developing television test procedure and ENERGY STAR specification. Once the new test method is established, ENERGY STAR will likely test a wide variety of televisions to help inform its 25% target qualification rate. This data should be released during the specification’s comment period and should be used to help establish baseline energy savings, which can then be used to inform qualifying incentive levels, rebate amounts, and Program cost-effectiveness.

5.2.3 Set-Top Boxes

We currently give a “medium” recommendation level for a voluntary PG&E program, and a “high” recommendation for codes & standards intervention. Both types of intervention will be challenging due to the lack of an internationally harmonized test procedure, constantly changing technology with increased functionality, and varied ownership structures. However, program intervention is warranted due to the fast growth of this product category. As mentioned in Section 4.3, STBs represent the fastest growing product category within this report—their stock in PG&E’s Mass Market is estimated to increase 133% from 2005 to 2010, and the Baseline Scenario energy consumption to rise from 820 million kWh/yr to 1,910 million kWh/yr during the same period.

The PG&E Title 20 Codes & Standards team is currently developing a CASE Report that will investigate standards options including testing and listing, maximum standby power levels, minimum power supply efficiency, and communication protocol requirements. The CEC rulemaking process will begin in 2008 and any new standard would become effective in 2009 or beyond. We highly recommend this intervention because it will help drive the test procedure process and represents the best potential for achieving significant statewide savings.

Establishing a voluntary PG&E efficiency program within the near-term is less promising. While there is an international effort underway to establish a harmonized test procedure, an end date is uncertain. It could realistically be a couple of months to a couple of years before the industry uses a common procedure to test energy performance. And, unlike computers and televisions, ENERGY STAR has not released a timeframe to reinstitute or revise the suspended STB specification. All of this creates barriers to identifying and promoting the most efficient STBs for a voluntary program.

In the near term, we recommend that PG&E continue to monitor the international STB developments and position itself to pursue a possible voluntary incentive-based program when

more favorable conditions exist (e.g., a test procedure is developed that leads to greater distinctions between product efficiencies and/or a true sleep mode protocol is developed and utilized in certain STBs). Key developments to monitor in 2007 will be the use of the new Consumer Electronics Association sleep mode standard (CEA-2013: Digital STB Background Power Consumption) and the developing On mode standard (CEA-2022). When favorable conditions exist, we would recommend that an incentive program primarily target the cable and satellite service providers (e.g., Comcast, DirectTV, Echostar, etc.) because they have the greatest control over which STB goes to the end-use customer. (See section 4.3.2 for a detailed discussion on how cable and satellite service providers package STBs with their various service offerings).

5.2.4 Home Entertainment Systems

Our recommended priority for near-term PG&E program intervention in the Home Entertainment Systems category is “low”. The greatest savings potential would be to target *active standby* and *play* mode power consumption, but the power consumption data is too limited to form the basis for an incentive program. Furthermore, the recent CEC Title 20 standard that limits *passive standby* power to 3W or less will achieve statewide savings but has also reduced the savings potential for a voluntary program.

The one exception is that we recommend additional research for game consoles, which would fit within the Home Entertainment Systems product category. As mentioned previously, game consoles were beyond the scope of this study, but a limited discussion is presented in the Home and Small Commercial Office Equipment recommendations above.

5.2.5 Smart White Goods

As discussed in Section 4.5, smart white goods are a small niche market with relatively little energy savings potential compared to televisions, computers, and set-top boxes. We therefore give a “low” relative recommendation level for a near term PG&E efficiency program. However, consumer electronics can evolve rapidly and it’s in PG&E’s best interest to monitor this segment continually.

The current energy savings potential for smart appliances is likely best realized if the appliance can respond to changes in system demand. This functionality would need to be developed on several fronts from a wider application of time-of-use metering and Internet connection to utility system data to the appliance’s ability to process this information and adjust power consumption accordingly. This would position smart appliances as a technology that could yield energy savings when most needed — during periods of peak demand. Current program opportunities are likely to be small-scale pilot programs such as those described in section 4.5.8: the Laundry Time program sponsored by the Internet Home Alliance and the Gridwise program being run by the Pacific Northwest National Laboratory.

5.2.6 Personal Electronic Chargers

Due to the numerous and diverse product types within the Personal Electronics Chargers segment, we give a “high” recommendation for PG&E Title 20 Codes & Standards intervention, and a “low” recommendation for a voluntary program.

As mentioned in Section 4.6, the CEC recently adopted a Title 20 efficiency regulation for external power supplies that will achieve significant energy savings throughout California. The PG&E Codes & Standards team is now developing a CASE Report to recommend potential standards for battery charger systems. The recommendation will likely recommend that battery charger systems with nameplate input ratings of less than 2kW meet a minimum 24-hour charge and maintenance efficiency and use less than a certain maximum standby (no-load) level.

5.3 Additional Recommendations for Electronics Intervention

In addition to the product-specific recommendations discussed above, PG&E should consider the following to stay up to date with the rapidly evolving consumer electronics field and to position itself to leverage new energy saving opportunities.

- **Leverage connections within the Consortium for Energy Efficiency.** On June 16, 2006, the Consortium for Energy Efficiency (CEE) Board approved an initiative to establish an Electronics Committee. The CEE is a nonprofit corporation that develops initiatives for its North American members to promote the manufacture and purchase of energy-efficient products and services. Its members primarily include utilities, environmental groups, research organizations, and state energy offices in the U.S. and Canada. The newly formed Electronics Committee has held two conference calls to date and is pursuing the development of an Electronics Initiative. The Initiative is still in the exploratory stages but it will likely address televisions and computers as two promising products to support efficiency efforts. The Committee is also interested in working with ENERGY STAR to develop coordinated consumer education messaging for electronics. The CEE will convene regular conference calls for the Electronics Committee and will have an electronics breakout session at its Winter Meeting held in Long Beach, CA, on January 16-17, 2007. The launch and implementation for the Electronics Initiative is targeted for July 2007. We recommend that PG&E stays actively involved with these developments as a way to further identify Program opportunities and synergies.

- **Engage in the interoperability discussions for consumer electronics.** A number of electronics companies, media companies, and industry groups have created or are developing guidelines surrounding the issue of interoperability—the ability for various types of consumer electronics to communicate and function properly when used together. These guidelines should create valuable end-user benefits although energy use and power management are noticeably absent from the current guidelines and discussions. We recommend that PG&E commit resources towards strategies that can help embed power management concepts into current and future interoperability protocols as the new protocols may unnecessarily keep certain devices in higher power operating modes.

Additional analysis will be needed to determine the most influential leverage points for PG&E, but key starting points should be assessments of the HANA and DLNA initiatives. HANA, or the High Definition Audio-Video Network Alliance, aims to create guidelines that would enable HDTVs, DVRs, set-top cable boxes, DVDs, and home theaters to connect via a single IEEE 1394 cable, also known as FireWire™. Founding members included NBC Universal, Samsung, Sun Microsystems, Mitsubishi Digital Electronics, and JVC. DLNA, or the Digital Living Network Alliance, published its first DLNA Interoperability Guidelines in June 2004, and released expanded guidelines in March 2006. DLNA has over 300 members (e.g., Sony, NEC, Panasonic, Phillips, HP, Intel, etc.) and covers a wide range of products including set-top boxes, DVRs, PCs and laptops, and home theaters with hard disk drives.

- **Utilize standard definitions and a common "taxonomy" for electronics**. It will become increasingly important for energy professionals to establish a common language for describing electronics, especially as they are accounting for a significant portion of overall energy consumption. Electronics have historically been relegated to the "miscellaneous" category when describing overall residential and commercial end-use consumption. While this was appropriate in the past, it will be beneficial for efficiency advocates to establish a more robust set of definitions and classifications in the future. A useful starting point are the guidelines laid out in the recent paper presented at the 2006 ACEEE Summer Study on Energy Efficiency in Buildings called *Electronics Come of Age: A Taxonomy for Miscellaneous and Low Power Products* (Nordman and Sanchez 2006). The paper provides key definitions and a taxonomy of product types for various electronics.

5.4 Conclusions

This report highlights the growing energy impact of consumer electronics and the importance of intervention. A sufficient number of favorable conditions exist or will soon exist within the segment to develop a PG&E Customer Energy Efficiency Program for certain products.

Our highest recommendations for developing a near-term voluntary program are for televisions and computers. These two product categories both have a significantly high potential for energy savings. They also have wide enough efficiency ranges so that a Program can actively target the most efficient models on the market. Equally important, the forthcoming ENERGY STAR specifications for these products will lay the foundation to identify and promote the more energy-efficient models easily.

The voluntary program opportunities for set-top boxes (STBs) are less promising due to the lack of an adequate test procedure and the suspension of the ENERGY STAR specification. However, the potential for high energy savings make STBs an important category to track. The PG&E Title 20 Codes and Standards intervention for STBs and battery chargers will remain a critical strategy for achieving energy savings. The next steps for PG&E in terms of voluntary program development will be specific economic models for the most promising products, e.g., computers and televisions, as new data becomes available over the next several months. This will help inform the Total Resource Cost (TRC) for the programs, allowing PG&E to assess the potential performance within its overall program portfolio.

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7 Appendices

Appendix A: Home and Small Commercial Offices (Small Offices)

Appendix Table 1. Small Office Equipment - Duty Cycle Assumptions

Equipment	Duty Cycle (hrs/day)				Sources / Assumptions
	Active	Standby	Sleep	Off	
Desktop PCs	1.2	3.9	13.3	5.7	Cremer et al. (2003)
	8.1	NA	1.0	14.9	TIAX (2006) est. for 2005
	12.1	NA	0.6	11.3	TIAX (2006) est. for 2010
	7.6	6.5	1.0	8.9	Foster and Calwell (2003)
Current Study Baseline	9.2	NA	0.9	13.9	Average of TIAX (2006) and Foster and Calwell (2003) studies.
Improved Case Scenario	7.9	NA	2.4	13.7	TIAX (2006). "Greening of IT" scenario
Laptop PCs	1.2	1.8	14.4	6.6	Cremer et al. (2003)
	3.4	0.9	0	13.7	Foster and Calwell (2003) - (Commuter)
	7.1	6.5	1.0	8.9	Foster and Calwell (2003) - (Desktop replacement)
	6.5	0	2.6	15.0	TIAX (2006)
Current Study Baseline	5.7	2.4	1.2	14.7	Average of TIAX (2006) and Fost and Calwell (2003) studies.
Improved Case Scenario	4.9	0	5.4	13.7	TIAX (2006). "Greening of IT" scenario
Monitors	14.3	NA	0.3	9.4	ENERGY STAR (2006)
	20.4	NA	2.2	1.4	EPA, 2001
	5.1	NA	2.4	16.5	TIAX (2006)
Current Study Baseline	5.1	NA	2.4	16.5	TIAX (2006)
Improved Case Scenario	4.1	NA	3.4	16.5	TIAX (2006). "Greening of IT" scenario
Inkjet Printers	0.1	1.6	17.7	4.6	Cremer et al. (2003)
	0.1	4.4	NA	19.5	TIAX (2006)
Current Study Baseline	0.1	3.0	NA	21	Average of Cremer et al (2003) and TIAX (2006)
Improved Case Scenario	0.1	4	NA	19.5	TIAX (2006). "Greening of IT" scenario
Laser Printers	0.1	1.9	13.1	8.8	Cremer et al. (2003)
Current Study Baseline	0.1	1.9	22	NA	Cremer et al. (2003) for active and standby
Improved Case Scenario	0.1	2	22	NA	No change
Scanners	0.0	15.9	1.6	6.4	Cremer et al. (2003)
	0.1	7.6	0	16.3	ENERGY STAR (2006) - Conventional unit
	0.1	0.5	7.1	16.3	ENERGY STAR (2006) - ES Qualified unit
Current Study Baseline	0.1	2.3	5.3	16.3	ENERGY STAR (2006) - Average based on 75% ES saturation.
Improved Case Scenario	0.1	0.5	7.1	16.3	ENERGY STAR (2006)
Copiers	0.01	0.1	12.0	12.0	Cremer et al. (2003)
Current Study Baseline	0.01	0.1	12.0	12.0	Cremer et al. (2003)
Improved Case Scenario	0.01	0.1	10.0	14.0	Assume 2 additional hours a day in off mode
Fax machines	0.1	23.9	0	0	Cremer et al. (2003)
	0.5	23.5	0	0	ENERGY STAR (2006) - Conventional unit
	0.5	0	23.5	0	ENERGY STAR (2006) - ES Qualified unit
Current Study Baseline	0.5	0.2	23.3	0	ENERGY STAR (2006) - Average based on 99% ES saturation.
Improved Case Scenario	0.5	0	23.5	0.0	ENERGY STAR (2006)
Multi-Function Devices	0.5	5.5	0	18.0	ENERGY STAR (2006) - Conventional unit
	0.5	1.0	4.5	18.0	ENERGY STAR (2006) - ES Qualified unit
	0.1	4.4	19.5	0	TIAX (2006)
Current Study Baseline	0.4	3.6	8.0	12	Average of TIAX (2006) and ENERGY STAR (2006).
Improved Case Scenario	0.1	4	19.5	0.0	TIAX (2006). "Greening of IT" scenario
Broadband Devices	24	0	0	0	TIAX (2006)
	24	0	0	0	Cremer et al. (2003)
Current Study Baseline	24	0	0	0	Cremer et al. (2003) and TIAX (2006)
Improved Case Scenario	24	0	0	0	TIAX (2006). "Greening of IT" scenario
Home Router	24	NA	NA	NA	TIAX (2006)
Current Study Baseline	24	NA	NA	NA	TIAX (2006)
Improved Case Scenario	12	12	NA	NA	TIAX (2006). "Greening of IT" scenario
VoIP	1	NA	23	NA	TIAX (2006)
Current Study Baseline	1	NA	23	NA	TIAX (2006)
Improved Case Scenario	1	NA	23	NA	TIAX (2006). "Greening of IT" scenario

Appendix Table 2. Small Office Equipment - Shipment and Stock Assumptions and Sources

Equipment	Shipment Assumptions	Stock Assumptions
Desktop PCs	PG&E weighted adjustment (4.4%) of IDC (2005b) US Shipment projection	CEC (2004) for initial 2003 stock. Add annual shipments [IDC (2005b)] for growth trend. Assume 1 desktop computer is retired for every 5 shipments.
Laptop PCs	Growth trend based on TIAX (2006).	CEC (2004) for initial 2003 stock. Growth trend based on TIAX (2006). Assume 1 out of each 5 laptop is retired each year.
Monitors	Follows desktop PC trend.	Assume one monitor for each desktop.
Inkjet Printers	PG&E weighted adjustment (4.4%) of IDC (2005b) US Shipment projection.	CEC (2004) for initial 2003 stock. Add annual shipments for growth trend. Assume 1 out of each 5 inkjet is retired each year.
Laser Printers	PG&E weighted adjustment (4.4%) of IDC (2005b) US Shipment projection.	CEC (2004) for initial 2003 stock. Add annual shipments for growth trend. Assume 1 out of each 5 laser printer is retired each year.
Scanners	Shipments based on annual difference of stock growth and assumes a five year EUL.	CEC (2004) for initial 2003 stock. Assume opposite CAGR (-8.2%) as multi-function devices.
Copiers	Shipments based on annual difference of stock growth and assumes a five year EUL.	CEC (2004) for initial 2003 stock. Assume opposite CAGR (-8.2%) as multi-function devices.
Fax machines	Shipments based on annual difference of stock growth and assumes a five year EUL.	CEC (2004) for initial 2003 stock. Assume opposite CAGR (-8.2%) as multi-function devices.
Multi-Function Devices	PG&E weighted adjustment (4.4%) of IDC (2005b) US Shipment projection.	CEC (2004) for initial 2003 stock. Add annual shipments for growth trend. Assume 1 MFD is retired for every 5 shipments.
Broadband Devices	Shipments based on annual difference of stock values.	CEC (2004) for initial 2003 stock. Add annual shipments [TIAX (2006)] for growth trend.
Home Router	Shipments based on annual difference of stock values.	CEC (2004) for initial 2003 stock. Add annual shipments based on IDC (2005b) for CAGR for networked small offices.
VoIP	Shipments based on annual difference of stock values.	TIAX (2006) for 2005 and 2010 stock. Growth trend for 2006-2009.

Appendix Table 3. Small Office Equipment - Power Consumption Assumptions and Sources

Equipment	Power (W)				Sources / Assumptions
	Active	Standby	Sleep	Off	
Desktop PCs	80	25	4	NA	Cremer et al. (2003)
	55	25	1.5	NA	ADL (2002)
	61	61	34	3	Foster and Calwell (2003)
	75	NA	4	2	TIAX (2006)
Current Study Baseline	75	NA	4	2	TIAX (2006)
Improved Case Scenario	60	NA	2	1	TIAX (2006). "Greening of IT" scenario
Laptop PCs	21	6	2.5	NA	Cremer et al. (2003)
	15	3	2	NA	ADL (2002)
	25	NA	2	2	TIAX (2006)
	23	14	2	2	Foster and Calwell (2003)
Current Study Baseline	24	14	2	2	Active: Average of TIAX (2006) and Foster and Calwell (2003); standby and sleep: TIAX (2006)
Improved Case Scenario	15	10.5	1	1	TIAX (2006). "Greening of IT" scenario and 25% standby mode effieciency
Monitors	75.9	NA	2.3	0.6	Energy Solutions (2005) - CRT
	39.5	NA	1.6	1.2	Energy Solutions (2005) - Non-ES LCD
	30.0	NA	0.9	0.7	Energy Solutions (2005) - Tier 2 LCD
	21.2	NA	0.8	0.6	Energy Solutions (2005) - Tier 2+25%
	48.5	NA	1.6	0.7	Energy Solutions (2005) - Weighted Avg.
	45	NA	2	1	TIAX (2006)
Current Study Baseline	21.2	NA	0.8	0.6	Energy Solutions (2005) - Weighted Avg.
Improved Case Scenario	21.0	NA	0.8	0.6	Energy Solutions. Energy Star Tier 2+25%
Inkjet Printers	20	5	3	NA	Cremer et al. (2003)
	13	5	5	2	ENERGY STAR (2006) - Conventional unit
	13	5	NA	2	ENERGY STAR (2006) - ES Qualified unit
	13	5	NA	2	TIAX (2006)
Current Study Baseline	13	5	NA	2	TIAX (2006) and ENERGY STAR (2006)
Improved Case Scenario	10	3	NA	1	TIAX (2006). "Greening of IT" scenario
Laser Printers	150	20	3	NA	Cremer et al. (2003)
	173	87.5	10.5	NA	ADL (2002)
Current Study Baseline	161	54	7	NA	Average of Cremer et al (2003) and ADL (2002)
Improved Case Scenario	129	43	5	NA	Assume 20% efficiency improvement
Scanners	16	5	2	NA	Cremer et al. (2003)
	36	24	NA	0	ENERGY STAR (2006) - Conventional unit
	36	24	12	0	ENERGY STAR (2006) - ES Qualified unit
Current Study Baseline	36	24	12	0	ENERGY STAR (2006) - Average based on 75% ES saturation.
Improved Case Scenario	36	24	12	0	No change
Copiers	200	40	2	0	Cremer et al. (2003)
	400	85	20	0	ADL (2002)
Current Study Baseline	300	62.5	11	0	Average of Cremer et al (2003) and ADL (2002)
Improved Case Scenario	200	40	2	0	Cremer et al (2003)
Fax machines	NA	13	3.5	NA	Cremer et al (2003)
	350	30	NA	NA	ENERGY STAR (2006) - Conventional unit
	350	30	15	NA	ENERGY STAR (2006) - ES Qualified unit
Current Study Baseline	350	30	9	NA	Average of studies
Improved Case Scenario	350	30	3.5	NA	ENERGY STAR (2006) and Cremer et al. (2003)
Multi-Function Devices	16	11	N/A	8	ENERGY STAR (2006) - Conventional unit
	16.5	11.0	11.0	8.0	ENERGY STAR (2006) - ES Qualified unit
	19.0	11.0	7.0	7.0	TIAX (2006)
Current Study Baseline	19	11	7	7	TIAX (2006)
Improved Case Scenario	18	7	1	1	TIAX (2006). "Greening of IT" scenario
Broadband Devices	6.0	NA	NA	NA	TIAX (2006)
	12	NA	NA	NA	Cremer et al. (2003)
Current Study Baseline	9	NA	NA	NA	TIAX (2006) and Cremer et al. (2003)
Improved Case Scenario	2	NA	NA	NA	TIAX (2006). "Greening of IT" scenario
Home Router	6	NA	NA	NA	TIAX (2006)
Current Study Baseline	6	NA	NA	NA	TIAX (2006)
Improved Case Scenario	2	0.5	NA	NA	TIAX (2006). "Greening of IT" scenario
VoIP	6	NA	4	NA	TIAX (2006)
Current Study Baseline	6	NA	4	NA	TIAX (2006)
Improved Case Scenario	3	NA	1	NA	TIAX (2006). "Greening of IT" scenario

Appendix Table 4. Small Office Equipment - First-Year Annual Energy Savings with Improved Case Scenario – 100% Sales Penetration of New Shipments to PG&E Mass Market (million kWh/yr)

	2006	2007	2008	2009	2010
Desktop PCs	55.3	57.0	57.8	58.7	61.2
Laptop PCs	29.9	31.5	32.3	33.1	34.7
Monitors	5.2	5.4	5.5	5.5	5.8
Inkjet Printers	1.8	1.8	1.7	1.7	1.6
Laser Printers	0.4	0.4	0.4	0.4	0.4
Scanners	0.8	0.7	0.7	0.6	0.5
Copiers	1.5	1.3	1.3	1.0	1.0
Fax machines	3.6	3.6	3.1	3.1	2.6
Multi-Function Devices	8.8	8.8	8.8	8.8	9.3
Broadband Devices	17.8	20.8	23.9	27.6	31.9
Home Router	2.1	2.1	2.5	2.9	3.3
VoIP	4.9	4.9	4.9	4.9	4.9
Total	**132.1**	**138.2**	**142.8**	**148.3**	**157.2**

Appendix B: Television

Appendix Table 5. Television Stock in PG&E Territory - RASS Survey (Early 2003)

	PG&E Households		Total TVs		Combined Total
Number of TVs	**<= 36 in.**	**> 36 in.**	**<= 36 in.**	**> 36 in.**	
NONE	407,100	3,455,400	0	0	0
ONE	1,469,200	706,900	1,469,200	706,900	2,176,100
TWO	1,433,800	60,100	2,867,600	120,200	2,987,800
THREE OR MORE	923,400	11,100	2,954,880	35,520	2,990,400
NO RESPONSE	17,500	17,500			
Totals	4,251,000	4,251,000	7,291,680	862,620	**8,154,300**
			Average TV per PGE household (2003)		**1.9**

Source: CEC (2004) PG&E residential survey occurred in late 2002 and early 2003. All data is weighted based on 9,647 survey responses, representing a 4,251,000 Household Population in PG&E territory.
Note: Assumes 3.2 average for "three or more" response

Appendix Table 6. Television Power Measurements - Report Summaries

		Austrialian Greenhouse Office (1)					CNET (2)				
		Low	**High**	**Mean**	**Median**	**Sample (n)**	**Low**	**High**	**Mean**	**Median**	**Sample (n)**
Active Mode (W)	CRT	45	200	79	NA	113	87	189	134	125	3
	LCD	24	134	56		41	44	214	108	110	6
	Plasma	65	305	150		27	229	434	339	359	6
	Projection	94	223	157		30	172	276	223	227	6
Standby Mode (W)	CRT	0.5	50.0	4.1	NA	50	2.5	5.2	3.7	3.5	3
	LCD	6.0	18.5	2.9		35	3.9	11.8	10.3	8.4	6
	Plasma	0.7	4.4	2.4		21	13.2	37.0	19.5	16.5	6
	Projection	0.4	45.0	7.7		32	3.1	39.8	16.4	10.6	6

		NRDC / Ecos (3)					EPA / LBNL (4)				
		Low	**High**	**Mean**	**Median**	**Sample (n)**	**Low**	**High**	**Mean**	**Median**	**Sample (n)**
Active Mode (W)	CRT	41	167	96	87	8	108	132	120	NA	
	LCD	42	198	104	89	5	96	117	106		
	Plasma	257	451	338	322	4	265	324	294		
	Projection	156	193	174	170	7	155	189	172		
Standby Mode (W)	CRT	NA					3.9	4.1	4.0	NA	
	LCD						9.0	9.5	9.2		
	Plasma						20.7	21.8	21.2		
	Projection						18.7	19.7	19.2		

Notes: 1) Source: AGO (2004e); 2) Source: CNET 2005; 3) Source: NRDC/Ecos (2005b); 4) Source: EPA (2006). Derived from Lawrence Berkeley National Lab analysis presented within report. "Projection" is used as a proxy for "DLP". The report presents annualized electricity consumption estimates (kWh/yr). These power consumption values are calculated from the LBNL estimates using an assumed 5.5 hrs/day active mode duty cycle for the "low" value a 4.5 hrs/day for the "high" value. The report states that values are derived from various sources, but does not state how values are calculated. NA = Not Available

Appendix Table 7. Televisions - Baseline and Improved Case Power Consumption Values

		Sample Size (n)	Low (W)	High (W)	Baseline Mean (W)	Improved Case (W)
Active Mode	CRT	125	41	200	**82**	**61**
	LCD	53	24	214	**68**	**51**
	Plasma	38	65	451	**204**	**153**
	Projection	44	94	276	**169**	**127**
Standby Mode	CRT	54	0.5	50.0	**3.0**	**1.0**
	LCD	42	3.9	18.5	**3.0**	**1.0**
	Plasma	28	0.7	37.0	**3.0**	**1.0**
	Projection	39	0.4	45.0	**3.0**	**1.0**

Source: Weighted active mode baseline based power measurements from four reports - AGO (2004e); EPA (2006); NRDC/Ecos (2005b); and CNET (2005). 3 watt standby baseline mean based on CEC standard.

Note: Improved case is 25% more efficient in active mode compared to baseline. 1 watt standby mode is based on ENERGY STAR specification.

Appendix Table 8. Televisions – First-Year Annual Energy Savings with Improved Case Scenario, by Various Sales Penetration to PG&E Mass Market (million kWh/yr)

Sales Penetration	Display	2006	2007	2008	2009
5%	CRT	1.2	1.0	0.6	0.5
	LCD	0.6	1.0	1.3	1.6
	Plasma	0.5	0.7	0.9	1.0
	Projection	0.4	0.4	0.5	0.6
	Total	**2.7**	**3.0**	**3.3**	**3.6**
25%	CRT	6.1	4.8	3.1	2.3
	LCD	3.2	4.9	6.4	8.0
	Plasma	2.4	3.4	4.4	4.8
	Projection	2.0	2.2	2.6	2.8
	Total	**13.7**	**15.2**	**16.6**	**17.9**
50%	CRT	12.1	9.6	6.2	4.6
	LCD	6.5	9.7	12.9	15.9
	Plasma	4.7	6.7	8.8	9.6
	Projection	4.1	4.5	5.2	5.7
	Total	**27.4**	**30.5**	**33.2**	**35.9**
100%	CRT	24.3	19.2	12.5	9.3
	LCD	13.0	19.4	25.8	31.9
	Plasma	9.4	13.5	17.7	19.2
	Projection	8.1	8.9	10.5	11.4
	Total	**54.8**	**61.0**	**66.4**	**71.7**

Appendix C: Set-Top Boxes

Appendix Table 9. Set-Top Box Shipments to PG&E Mass Market, 2005 - 2010

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Digital cable box	348,480	354,200	358,600	357,280	349,800	350,100	0.5%
Digital satellite reciever	459,800	435,600	410,080	400,400	374,000	355,200	-3.8%
Digital video recorders*	286,880	282,200	328,900	375,600	400,400	469,100	10%
IPTV	11,000	25,500	50,600	83,600	154,000	297,900	108%
Total	1,106,160	1,097,500	1,148,180	1,216,880	1,278,200	1,472,300	6%

*Stand alone DVRs only (e.g., TiVo).

Source: IDC (2005c) for digital cable box, digital satellite reciever, and IPTV. iSuppli (2005) for digital video recorders.

Appendix Table 10. Set-Top Boxes Power Measurements - Report Summaries

		Austrialian Greenhouse Office (1)				LBNL (2)			
		Low	High	Mean	Sample (n)	Low	High	Mean	Sample (n)
Active Mode (W)	Analog cable box	NA				5.4	23.4	11.9	42
	Digital cable box	6.9	35.3	15.4	28	20.5	25.2	23.0	4
	Digital satellite reciever					9.1	21.2	16.9	30
	Digital TV adapter	10.0	35.3	17.4	13	NA			
	Digital video recorders	NA				NA			
	IPTV	NA				NA			
Standby Mode (W)	Analog cable box	NA				2.4	18.0	10.5	42
	Digital cable box	NA	20.1	7.9	26	19.7	24.7	22.3	4
	Digital satellite reciever					8.8	18.8	16.2	30
	Digital TV adapter	1.9	21.5	7.5	12	NA			
	Digital video recorders	NA				NA			
	IPTV	NA				NA			

		NRDC / Ecos (3)				Rainer et al. (4)			
		Low	High	Mean	Sample (n)	Low	High	Mean	Sample (n)
Active Mode (W)	Analog cable box	NA				NA		12	NA
	Digital cable box	10.9	21.4	16.3	14	NA		23	
	HD Digitial cable	*25.3*	*29.5*	*27.4*	*2*	NA		NA	
	Digital satellite reciever	8.0	34.0	12.2	6	NA		17	
	HD Satellite reciever	*14.5*	*23.0*	*19.5*	*3*	NA		NA	
	Digital TV adapter	NA				NA		17	
	Digital video recorders	17.2	47.4	31.1	6	NA		NA	
	IPTV	NA				NA		15	
Standby Mode (W)	Analog cable box	NA				NA		10	NA
	Digital cable box	10.2	20.4	15.6	14	NA		22	
	HD Digitial cable	*24.9*	*28.0*	*26.5*	*2*	NA		NA	
	Digital satellite reciever	8.0	34.0	12.1	6	NA		16	
	HD Satellite reciever	*14.0*	*21.0*	*18.3*	*3*	NA		NA	
	Digital TV adapter	NA				NA		8	
	Digital video recorders	16.9	44.3	29.9	6	NA		NA	
	IPTV	NA				NA		14	

Notes: 1) Source: AGO (2004c); 2) Source: Rosen et al. (2001); 3) Source: NRDC/Ecos (2005a); 4) Source: Rainer et al. (2005); NA = Not Available.

Appendix Table 11. Set-Top Boxes - Power Consumption Baseline and Improved Case Values

		Sample Size (n)	Low (W)	High (W)	Baseline Mean (W)	Improved Case (W)
Active Mode	Analog cable box	42	5	23	**12**	**8.0**
	Digital cable box	20	11	35	**19**	**9.2**
	Digital satellite reciever	53	7	34	**16**	**10.2**
	Digital TV adapter	13	6	10	**17**	**8.0**
	Digital video recorders	6	17	47	**31**	**20.8**
	IPTV	NA	NA		**15**	**12.0**
Standby Mode	Analog cable box	42	2.4	18.0	**11**	**8.0**
	Digital cable box	20	10.9	35.3	**18**	**3.0**
	Digital satellite reciever	52	8.0	23.0	**14**	**3.0**
	Digital TV adapter	12	1.9	21.5	**8**	**3.0**
	Digital video recorders	6	16.9	44.3	**30**	**19.7**
	IPTV	NA	NA		**14**	**11.2**

Sources: Baseline - AGO (2004); Rosen et al. (2001); NRDC/Ecos (2005a); Rainer et al (2005).
Note: Improved case assumptions are based on EU Code of Conduct specifications for cable boxes (7W active standby, 3W passive standby) and satellite recievers (8W,3W). For active standby mode power, we assume an additional power consumption allowance for an internal hard disk drive (2.2W), bringing the total to 9.2W for cable and 10.2W for satellite. For DVRs, the device with the second lowest tested power draw was used. Since limited testing data is available on IPTV, we assume a 20% efficiency improment.
Note: The Improved Case scenario assumes the utilization of a true low power mode. Therefore, mode descriptions would more appropriately read "Active Standby Mode" instead of "Active Mode" and "Passive Standby Mode" instead of "Standby Mode"

Appendix Table 12. Set-Top Boxes – First-Year Annual Energy Savings with Improved Case Scenario, by Various Sales Penetration to PG&E Mass Market (million kWh/yr)

Sales Penetration	Display	2006	2007	2008	2009
5%	Digital cable box	2.2	2.2	2.2	2.1
	Digital satellite reciever	1.9	1.8	1.7	1.6
	Digital video recorders	1.3	1.5	1.7	1.8
	IPTV	0.0	0.1	0.1	0.2
	Total	**5.3**	**5.5**	**5.7**	**5.7**
25%	Digital cable box	10.9	11.0	11.0	10.7
	Digital satellite reciever	9.4	8.9	8.6	8.1
	Digital video recorders	6.3	7.4	8.4	9.0
	IPTV	0.2	0.3	0.5	1.0
	Total	**26.7**	**27.5**	**28.5**	**28.7**
50%	Digital cable box	21.7	22.0	21.9	21.5
	Digital satellite reciever	18.8	17.7	17.3	16.2
	Digital video recorders	12.6	14.7	16.8	17.9
	IPTV	0.3	0.6	1.0	1.9
	Total	**53.5**	**55.1**	**57.1**	**57.4**
100%	Digital cable box	43.4	44.0	43.8	42.9
	Digital satellite reciever	37.6	35.4	34.6	32.3
	Digital video recorders	25.3	29.4	33.6	35.8
	IPTV	0.6	1.3	2.1	3.8
	Total	**107.0**	**110.1**	**114.1**	**114.9**

Appendix D: Home Entertainment Systems

Appendix Table 13. Home Entertainment Systems – Duty Cycle Definitions

Off Mode
The unit is plugged in and the power switch is in the "off" position.

Passive Standby Off
When a product or appliance is not performing its main function but it is ready to be switched on (in most cases with a remote control) or is performing some secondary function (e.g. has a display or clock).

Active Standby Mode
Active standby is when the appliance on but not performing its main function. For example, the DVD or CD is on but not playing a disc.

Play (On) Mode
The device performing its main function.

Source: AGO (2004f)

Appendix Table 14. U.S. and International Energy Efficiency Standards and Specifications for Component Stereo

Country / Organization	Off Mode	Passive Standby	Play (On) Mode	Voluntary	Mandatory	Effective Date
US EPA - ENERGY STAR	none	≤ 1 watts	none	✓		2004
California Energy Commission	none	≤ 3 watts	none		✓	2006
Australian Greenhouse Office	≤ 1 watts ≤ 0.3 watts	≤ 4 watts ≤ 1 watts	none		✓	2006 2012
EU Negotiated Agreement	none	≤ 8 watts ≤ 1 watts	none		✓	until 12/31/06 after 12/31/06
EU - Group for Energy Efficient Appliances (GEEA)	none	≤ 1 watts	none	✓		2004
Nordic Swan	Must Have Off Switch	≤ 1 watts	≤ 40 watts	✓		after 3/19/2003

Sources: AGO (2004b) and Energy Star (2006).

Appendix Table 15. U.S. and International Energy Efficiency Standards and Specifications for Compact Stereo

Country / Organization	Off Mode	Passive Standby	Play (On) Mode	Voluntary	Mandatory	Effective Date
US EPA - ENERGY STAR	NA	≤ 1 watts	NA	✓		2004
California Energy Commission	NA	≤ 3 watts	NA		✓	2006
Australian Greenhouse Office	≤ 1 watts ≤ 0.3 watts	≤ 4 watts ≤ 1 watts	NA		✓	2006 2012
EU Negotiated Agreement	NA	≤ 8 watts ≤ 1 watts	NA		✓	until 12/31/06 after 12/31/06
EU - Group for Energy Efficient Appliances (GEEA)	NA	≤ 1 watts	NA	✓		2004
Nordic Swan	Must Have Off Switch	≤ 1 watts	≤ 40 watts	✓		after 3/19/2003

Sources: Australian Greenhouse Office (2004) and ENERGY STAR - Home Audio Products (2006).
NA: Not Applicable

Appendix Table 16. U.S. and International Energy Efficiency Standards and Specifications for Portable Stereo

Country / Organization	Off Mode	Passive Standby	Play (On) Mode	Voluntary	Mandatory	Effective Date
US EPA - ENERGY STAR	NA	≤ 1 watts	NA	✓		2004
California Energy Commission	NA	≤ 3 watts	NA		✓	2006
Australian Greenhouse Office	≤ 1 watts ≤ 0.3 watts	≤ 4 watts ≤ 1 watts	NA		✓	2006 2012
EU - Group for Energy Efficient Appliances (GEEA)	≤ 0.5 watts	≤ 1 watts	NA	✓		2004

Sources: Australian Greenhouse Office (2004) and ENERGY STAR - Home Audio (2006).
NA: Not Applicable

Appendix Table 17. Home Entertainment Equipment - Baseline and Improved Case Power Consumption for Representative Devices

		Play (W)	Active standby (W)	Passive standby (W)	Off (W)
DVDs (1,2,3)	Low	14.1	6.9	0.0	NA
	High	17.7	16.6	5.7	NA
	Current Study Baseline	15.9	13.8	2.2	NA
	Improved case	14.1	10.4	1.0	NA
Home theater (4,5)	Low	20.5	18.5	0.0	0.0
	High	56.4	54.4	15.6	1.0
	Current Study Baseline	38.4	36.4	2.5	0.1
	Improved case	29.5	27.5	1.0	0.0
Component Stereo (4,5)	Low	13.5	11.4	0.0	0.0
	High	103.0	100.7	15.0	1.6
	Current Study Baseline	41.0	39.0	1.7	1.6
	Improved case	27.0	25.0	1.0	0.0
Compact Stereo (5,6)	Low	7.3	6.1	0.03	NA
	High	49.8	47.8	25.2	NA
	Current Study Baseline	22.3	17.4	4.1	NA
	Improved case	14.7	11.8	1.0	NA
Portable Stereo (5,6)	Low	4.1	2.1	1.0	NA
	High	17.4	15.4	6.5	NA
	Current Study Baseline	6.5	5.4	2.0	NA
	Improved case	5.5	3.7	1.0	NA

Notes: Baseline sources - (1) Source: Energy Star (2006); (2) Source: ACEEE (2006); (3) Source: AGO (2003a); (4) Source: AGO (2004b); (5) Source: Rosen (1999); (6) Source: AGO (2004f). Improved case assumes the following: Passive standby mode power consumption equals the Energy Star specification. Active standby and play modes power consumption is the average of the low case and study baseline.

Appendix Table 18. Home Entertainment Equipment - System Power Measurements - Report Summaries

		Australian Greenhouse Office (1)				LBNL (2)			
		Low	High	Mean	Sample (n)	Low	High	Mean	Sample (n)
Play (On) Mode (W)	DVD players	NA				14.1	NA	17.0	18
	Home Theater	NA				NA			
	Component Stereo	NA				25.8	73.6	45	70
	Compact Stereo	NA				7.3	41	22.3	19
	Portable Stereo	NA				1.7	13	6.5	22
Active Standby Mode (W)	DVD players	6.9	16.6	9.9	32	12.6	NA	13.0	18
	Home Theater	18.5	54.4	36.4	32	NA			
	Component Stereo	11.4	100.7	39	54	13.0	73.6	42.9	70
	Compact Stereo	6.1	47.8	17.4	39	6.7	38.8	20.3	19
	Portable Stereo	2.1	15.4	5.4	38	0.5	11.8	4.9	22
Passive Standby Mode (W)	DVD players	0.00	5.7	1.7	32	0.9	NA	4.1	18
	Home Theater	0.04	15.6	2.5	32	NA			
	Component Stereo	0.02	15	1.7	54	0.0	15.4	3.0	70
	Compact Stereo	0.03	25.2	4.1	39	0.5	27.5	9.8	19
	Portable Stereo	1	6.5	2	38	0.5	5.5	1.8	22

1) Source: AGO (2004b). 2) Source: Rosen et al. (1999). NA = Not Available

Appendix Table 19. Home Entertainment Equipment Shipments - First-Year Annual Energy Savings with Improved Case Scenario, by Various Sales Penetration to PG&E Mass Market (million kWh/yr)

Sales Penetration	Display	2006	2007	2008	2009
5%	DVD players	0.5	0.4	0.4	0.4
	Home Theater	0.3	0.3	0.3	0.3
	Component Stereo	0.2	0.2	0.2	0.2
	Compact Stereo	0.6	0.6	0.5	0.5
	Portable Stereo	0.1	0.1	0.1	0.1
	Total	**1.6**	**1.5**	**1.5**	**1.4**
25%	DVD players	2.3	2.0	1.9	2.0
	Home Theater	1.5	1.4	1.3	1.3
	Component Stereo	0.9	0.9	0.8	0.8
	Compact Stereo	3.0	2.9	2.7	2.6
	Portable Stereo	0.5	0.5	0.4	0.4
	Total	**8.2**	**7.7**	**7.3**	**7.1**
50%	DVD players	4.6	4.1	3.9	4.1
	Home Theater	3.0	2.8	2.7	2.6
	Component Stereo	1.8	1.7	1.6	1.5
	Compact Stereo	6.1	5.8	5.5	5.2
	Portable Stereo	1.0	0.9	0.9	0.8
	Total	**16.4**	**15.3**	**14.6**	**14.2**
100%	DVD players	9.1	8.2	7.8	8.2
	Home Theater	6.0	5.7	5.4	5.1
	Component Stereo	3.6	3.4	3.2	3.0
	Compact Stereo	12.1	11.5	10.9	10.4
	Portable Stereo	1.9	1.9	1.8	1.7
	Total	**32.7**	**30.6**	**29.1**	**28.4**

Appendix E: Personal Electronics Chargers

Appendix Table 20. Personal Electronic Chargers - Shipment and Stock Sources and Assumptions

Device	Shipment Sources / Assumptions	Stock Sources / Assumptions
Cell phones	Trend based on Kanellos (2006). We assume a decreasing shipment growth each year with increased penetration (7% in 2004, down to 3% in 2010).	CEC (2004) for initial 2003 stock. Add annual shipments for growth trend. Assume 1 out of every 2 phones is retired each year.
Cordless phones	Ecos et al (2004) for shipments. Assume -2% CAGR due to increased cell phone market share.	Calwell and Reeder (2002) for initial 2003 stock. Add annual shipments for growth trend. Assume 1 out of every 7 phones is retired each year.
Laptop PCs	Growth trend based on TIAX (2006).	CEC (2004) for initial 2003 stock. Growth trend based on TIAX (2006). Assume 1 out of each 5 laptop is retired each year.
Digital camera	Terdiman (2005) for 2005 shipments and growth trend. Assume 16% growth in 2005, declining to 8% in 2010.	Ecos et al. (2004) for initial 2003 stock. Terdiman (2005) for growth trend. Assume 1 out of every 4 cameras is retired each year.
Portable audio	Growth trend based on iSuppli (2006). Assume 100% growth in 2005, declining to 5% in 2010.	Ecos et al. (2004) for initial 2003 stock. iSuppli (2006) for growth trend. Assume 1 out of every 2 portable audio devices is retired each year.
PDA's	Gartner (2005) for 2005 sales and CAGR.	Estimated based on Gartner (2005) shipment projection. Assume 1 out of every 4 PDAs is retired each year.
Rechargeable batteries	Shipments based on annual difference of stock growth.	Assume 10% household saturation and 3% growth.
Personal hygine	Shipments based on annual difference of stock growth.	Assume 15% household saturation and 3% growth.
Other	3% of total to capture miscelaneous items	3% of total to capture miscelaneous items

Appendix Table 21. Personal Electronic Chargers – Forecasted First-Year Annual Energy Consumption for New Shipments to PG&E Mass Market, 2005-2010 (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Cell phones	49	54	58	62	65	65	6%
Cordless phones	10	10	10	9	9	9	-2%
Laptop PCs	9	10	10	11	11	11	4%
Digital camera	16	18	20	22	24	26	10%
Portable audio	30	35	40	42	45	45	9%
PDA's	3	3	3	3	4	4	5%
Rechargeable batteries	0	0	0	0	0	0	3%
Personal hygine	0	0	0	0	0	0	3%
Other / Misc.	4	4	4	4	5	5	6%
Total Annual Shipments	**120**	**134**	**146**	**154**	**162**	**164**	**6%**
% of PGE Mass Market	**0.5%**	**0.5%**	**0.6%**	**0.6%**	**0.6%**	**0.6%**	

Note: Calculated based on baseline electricity consumption and complete PG&E Mass Market stock.

Appendix Table 22. Personal Electronic Chargers – Forecasted First-Year Annual Energy Consumption for Complete PG&E Mass Market Stock, 2005-2010 (million kWh/yr)

	2005	2006	2007	2008	2009	2010	CAGR (05-10)
Cell phones	78	88	98	107	115	122	9%
Cordless phones	69	69	69	69	68	68	0%
Laptop PCs	25	29	32	35	37	39	9%
Digital camera	23	35	46	57	66	76	27%
Portable audio	37	59	79	94	107	116	26%
PDA's	4	7	8	10	11	12	22%
Rechargeable batteries	6	6	6	6	7	7	3%
Personal hygine	9	9	9	10	10	10	3%
Other / Misc.	8	9	10	12	13	14	12%
Total	**260**	**311**	**359**	**399**	**434**	**463**	**12%**
% of PGE Mass Market	**1.0%**	**1.2%**	**1.4%**	**1.5%**	**1.6%**	**1.7%**	

Note: Calculated based on baseline electricity consumption and projected shipments to PGE territory.