Proposal Information Template for:
Computer Monitors and other Video Displays

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Proposal Information Template – Computer Monitors and other Video Displays

2008 Appliance Efficiency Standards

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January 30, 2008

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Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, Cal. Code Regs, §§ 1601 – 1608). This report specifically covers computer monitors and other video displays.

Background

The existing market conditions are favorable for implementing a cost-effective Title 20 efficiency standard for computer monitors. The current Energy Star specification addresses total energy usage (i.e., all operating modes are covered: active, sleep, and off), and has successfully increased the market share of more efficient monitors. The current Energy Star specification levels have been effective since January 1, 2006, and there are now over 1300 qualified monitors, representing all screen sizes and over 40 brands. The increased market share of more efficient monitors has led Energy Star to start a specification revision process that is expected to become effective in April 2009.

There is also a trend towards an increased amount of monitors that are at least 25% more efficient than the Energy Star levels. The percentage of qualified Energy Star monitors that "go beyond" Energy Star levels by 25% or more has increased from 42% to 52% over the last two years. Furthermore, all the top monitor companies (in addition to many lesser-known companies) currently make models that surpass Energy Star by at least 25%. This is prevalent for all screen sizes, as well.

Based on an extensive analysis of market trends and energy consumption data, we recommend that the Commission adopt a maximum active mode[1] consumption levels that surpass the current Energy Star specification levels by 25% (i.e., 25% more efficient than Energy Star). We also recommend adopting a maximum 2W standard for sleep mode and

[1] "Active" mode and "On" mode are used interchangeably throughout this report.

1W for off mode (equal to current Energy Star levels). This report provides the justifications and potential energy savings for this recommendation.

This report focuses primarily on computer monitors, but we also recommend that the Commission consider performance standards for a product category commonly referred to as "signage and professional displays". This category primarily consists of non-consumer, electronic/programmable displays that are at least 30 inches in diagonal screen size. This segment is rapidly growing with increased usage of signs in airports, hotels, restaurants, retail stores and other professional applications. A leading market research firm, iSuppli, estimates that worldwide shipments will increase over 440% from 2007 to 2011, or 5 million to 22 million units (Energy Star 2008b). We also recommend that the Commission consider performance standards for digital photo frames—another growing product segment. Energy Star is currently collecting data on both categories to inform its stakeholder revision process. We will provide specific recommendations for these products in subsequent versions of this report template, future CASE reports, and/or at public CEC hearings.[2]

Overview

<table>
<tr><td>Description of Standards Proposal</td><td>Effective November 1, 2009 (assuming this rule is completed in 2008), Computer Monitors shall not exceed the maximum On, Sleep, and Off Mode power consumption levels in the figure below.
<table>
<tr><th colspan="3">Maximum Allowable Power Consumption</th></tr>
<tr><td>On Mode</td><td>Sleep Mode</td><td>Off Mode</td></tr>
<tr><td>If X < 1 megapixel, then Y = 17 watts

If X ≥ 1 then Y = 21X</td><td>≤ 2 watts</td><td>≤ 1 watts</td></tr>
<tr><td colspan="3">Y is expressed in watts and rounded up to the nearest whole number and X is the number of megapixels in decimal form (e.g., 1,920,000 pixels = 1.92 megapixels)</td></tr>
</table>
This is a technology-neutral performance standard that allows higher-resolution monitors to use more power in active mode.

We also recommend that the standard address the rapidly growing professional display and digital photo frame market.[3]</td></tr>
<tr><td>California Stock and Sales</td><td>The estimated current California stock is 28 million computer monitors. Estimated annual sales are 7.2 million units. Roughly 79% of these sales (5.7 million units) are "baseline" units (i.e., those that currently do not meet the proposed standard levels). An estimated 21% (1.5 million units) of monitor sales currently meet our proposed "Title 20 standards option" level today, and this should significantly increase between now and the proposed effective date. See Table 2 for details.</td></tr>
</table>

[2] PG&E has also provided recommendations for an expanded Title 20 television standard under a separate report. Consideration should be taken for any potential harmonization between a future TV and monitor standard since there exists some product overlap.

[3] The market and energy analysis presented in this report focuses primarily on computer monitors. Future versions and/or a complete PG&E CASE report will expand upon the computer monitor analysis to also include professional signage and digital photo frames.

Energy Savings and Demand Reduction	The average per unit energy savings from the proposed standard is estimated to be 42.6 kWh/yr (see Figure 8). For first-year sales, energy savings are estimated to be 242 GWh/yr and the coincident peak demand reduction is 36 MW. After the entire stock turnover, energy savings would be 968 GWh/yr and coincident peak demand reduction would be 142 MW (see Table 4).
Economic Analysis	The present value lifecycle benefits from the proposed standard are: $22 per monitor, $57 million for first year sales, and $185 million after the entire stock turnover (see table 5). An initial analysis of the market indicates that there is no incremental cost to the consumer for monitors that meet our proposed levels, making this measure highly cost-effective (see Figure 8). In addition, McKinsey & Company (2007) performed a cost-benefit analysis of various options for reducing greenhouse gas emissions, and reported that increasing the efficiency of residential and commercial electronics has a negative marginal cost, and represents the most cost-effective strategy of all options analyzed (see Figure 9).
Non-Energy Benefits	Our proposal will reduce greenhouse gas emissions at the power generation source, helping California to meet its AB 32 goals (1990 levels by 2020).
Environmental Impacts	We are not aware of any adverse environmental impacts that will be created by the proposed standard.
Acceptance Issues	The existing Energy Star specification that has been effective for over two years should help to minimize any acceptance issues. Energy Star is updating its performance level for 2009. With model weighted and shipment weighted market share exceeding 50% and 20% in 2007, respectively, it is clear that the Energy Star update must reach beyond the current Energy Star plus 25% for its 2009 levels. All the major monitor vendors have certified monitors with Energy Star; therefore, we recommend that a proposed Title 20 standard utilize the same definitions and test procedure as the current Energy Star specification. In addition, utility-sponsored rebate programs are aiming to shift the market towards monitors that meet our proposal levels, and will help to lay the foundation for adopting a Title 20 requirement with minimal acceptance issues (Pacific Gas and Electric and Southern California Edison are currently offering rebates to retailers that sell “ultra-efficient” monitors (i.e., those that exceed Energy Star by 25% or more).

AB 1109 (California Lighting Efficiency and Toxics Reduction Act) [if applicable]	Not applicable.
Federal Preemption or other Regulatory or Legislative Considerations	Monitors are not a federally preempted product. They will be added to the Federal ENERGY GUIDE labeling program in late 2009.

Methodology
In an effort to assess the most accurate and up-to-date market trends and energy characteristics of computer monitors, we relied primarily on the following sources:

1. **Energy Star monitor lists:** Energy Star releases a qualified monitor list approximately every 1-2 months and it includes the following attributes for each monitor: brand, model number, screen size, resolution, and power draw in each operating mode (active, sleep, and off). We analyzed 16 historical data sets (dating back to late 2005) to estimate baseline energy consumption characteristics and savings from the proposed recommendation.

2. **Consumer Electronics Association commissioned study:** The CEA commissioned TIAX to prepare a report assessing the energy consumption by consumer electronics in U.S. residences (Roth and McKenney, 2007). We use this report as a basis for residential usage patterns (e.g., annual hours of usage in each operating mode) and estimated stock values.

Various other sources were utilized and are referenced accordingly throughout this report.

Figure 1 shows the specification levels for Energy Star qualified monitors. Tier 1 became effective on January 1, 2005, and was replaced by the more stringent Tier 2 levels on January 1, 2006. The Energy Star monitor specification has been very successful, and accounts for roughly 40% of EPA's Energy Star voluntary product labeling greenhouse gas savings achieved to date (Energy Star 2008b). Due to increased market penetration of Energy Star monitors (estimated to be 35% in 2006), a revision process is currently underway and a new draft specification is expected to be released in March 2008, with an effective target date of April 2009 (Energy Star 2008b).

Figure 1. Key Product Criteria for Energy Star Qualified Monitors

Key Product Criteria for ENERGY STAR Qualified Monitors			
	Maximum Allowable Power Consumption:		
	On Mode	Sleep Mode	Off Mode
Tier 1 (Effective 1/1/05)	Y = 38X + 30.	< 4 watts	< 2 watts
Tier 2 (Effective 1/1/06)	If X < 1 megapixel, then Y = 23; if X > 1 megapixel, then Y = 28X.	< 2 watts	< 1 watt
Y is expressed in watts and rounded up to the nearest whole number and X is the number of megapixels in decimal form			

Source: Energy Star (2008a).

Figure 2 shows the Energy Star monitors by screen size for historical qualifying lists between September 2005 and December 2007. The most recent December 31, 2007 list has 1334 qualifying monitors representing various screen sizes and over 40 brands.[4] There has been a general trend toward increased screen size over the last two years, with 19 inch monitors being the most represented monitor size, followed by 17 inches.

Figure 2. Energy Star Monitors by Screen Size for Historical Qualifying Lists

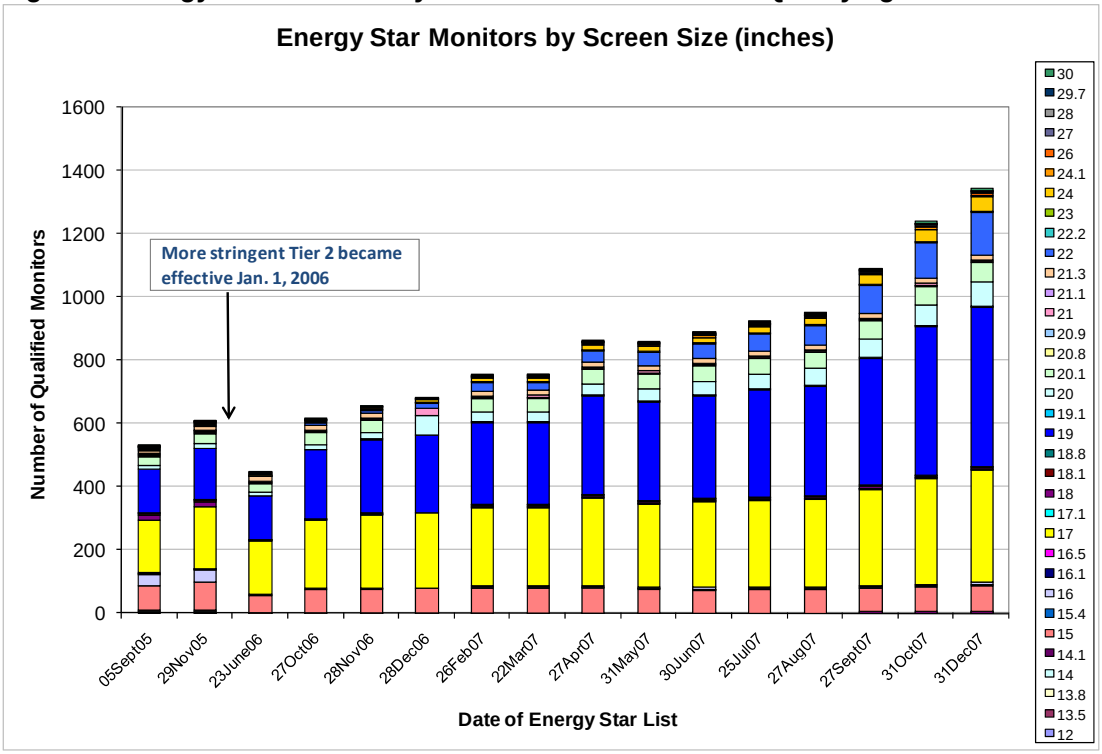


Table 1 shows the assumed duty cycle (annual hours of operation by mode) used for this analysis. We used two different duty cycles for monitors used in residential and those used

[4] Note, the list includes all Energy Star qualified models submitted to EPA, including models that are not available in the U.S. and models that may no longer be available on the market.

in commercial applications to account for the fact that active mode usage is greater in a commercial office environment.

Table 1. Monitor Duty Cycle Used for Analysis (Annual Hours of Operation by Mode)

	Estimated Distribution	Active mode	Standby (Sleep) mode	Off mode
Residential	38%	1865	875	6020
Commercial	62%	3278	4175	1305

Sources: Roth and McKenney (2007) for residential duty cycle; commercial derived from Roberson et al (2004); estimated distribution for residential and commercial monitors from Chase et al (2005, Table 9).

Based on the results discussed in the next section, we recommend a Title 20 standard level that is 25% more stringent than the current Tier 2 Energy Specification level (e.g., the maximum allowed active mode power level is 25% less than the current Energy Star specification). It is first important to define the key terminology we use throughout the remainder of this report. In order to assess potential energy and cost implications of a proposed standard, we have established the following two monitor categories:

- **Baseline Units**: includes all monitors that would not pass our proposed specification levels.

- **Title 20 Standards Option**: includes all monitors that would pass our recommended specification levels. For simplicity, we sometimes refer to this level as "Tier 2+25%".

Analysis and Results

Figure 3 illustrates the current Energy Star specification level as well as our proposed Title 20 level. All the 1334 monitors on the December 31, 2007 Energy Star list are plotted on the chart, and of those, 52% would meet the proposed Title 20 level. These results indicate that a majority of the Energy Star qualified monitors on the market already meet our proposed levels.

Figure 4 shows the number of monitors available from the top ten monitor vendors that would meet our proposed Title 20 levels. All of the top monitor companies currently make models that surpass Energy Star by at least 25%. Of the approximately 700 monitors that meet our proposed level, about half are made by the top ten monitor vendors and the other half are made by lesser-known or smaller companies. This strengthens the assumption that most monitor vendors can meet our proposal levels with minimal acceptance issues.

Figure 3. Energy Star and Proposed Title 20 Levels

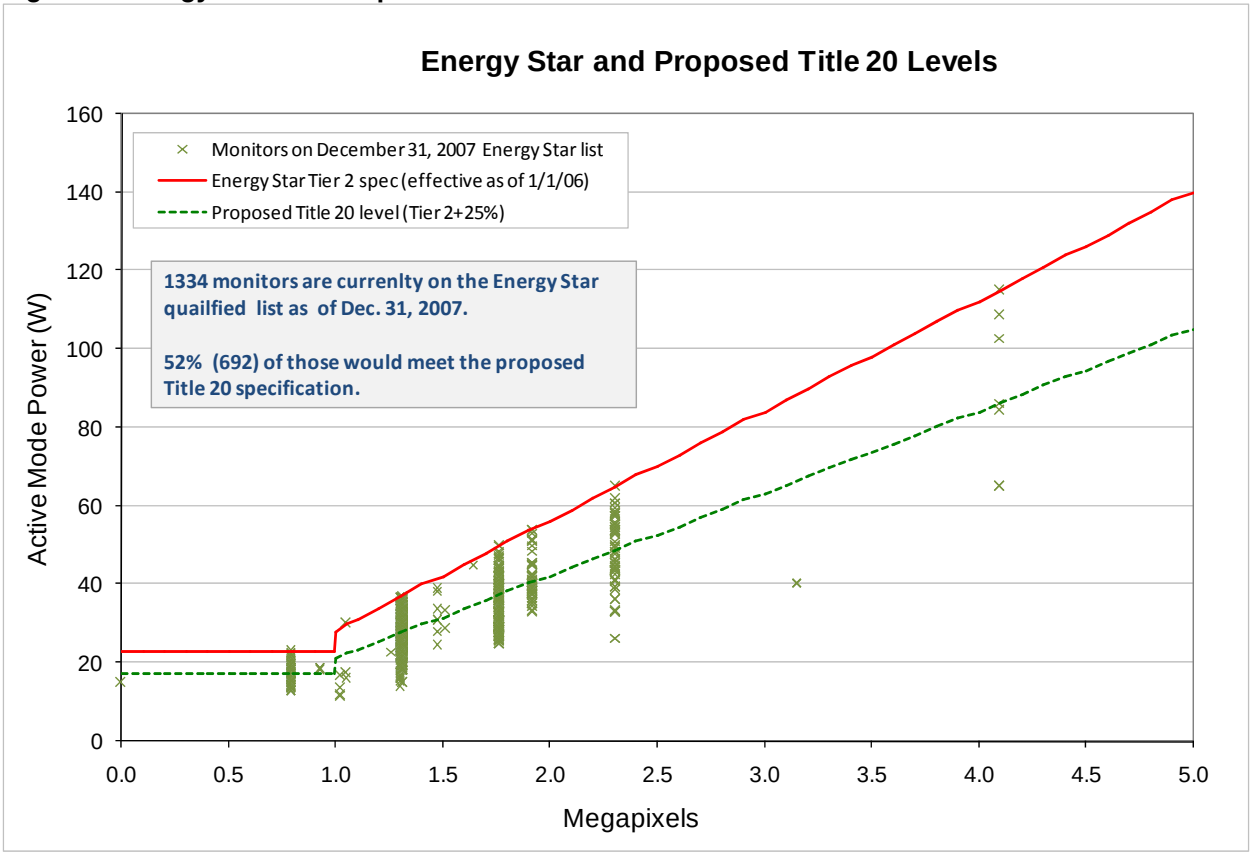
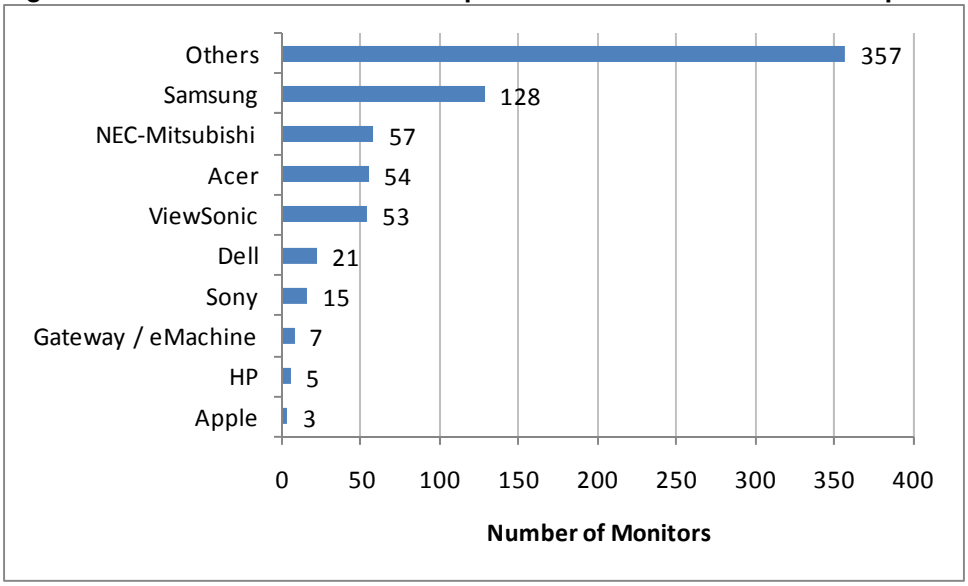


Figure 4. Monitors Available from Top Ten U.S. Vendors that Meet Proposed Title 20 Standard Level

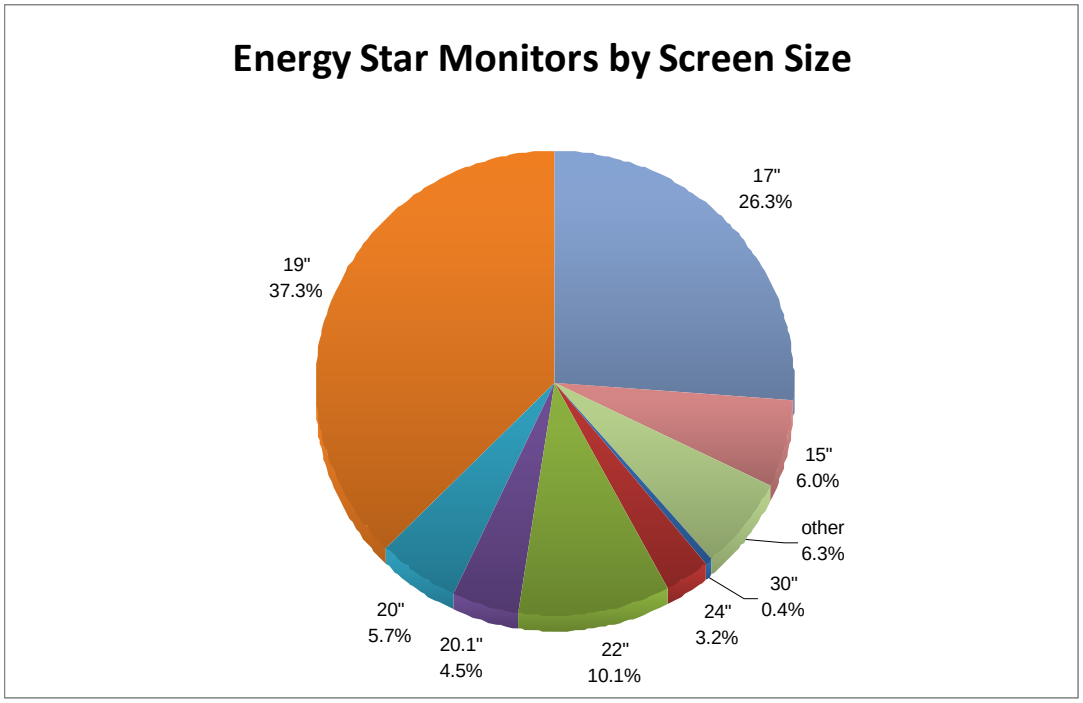


Note: Values are from the December 31, 2007 Energy Star monitor list. Some monitors may be discontinued and no longer available on the market.

Figure 5 displays the Energy Star monitors by screen size for the latest December 31, 2007 monitor list. The 19-inch monitors are the most represented (37% of all monitors), followed

by 17-inch (26%) and 22-inch (10%) monitors. These values are used later to estimate sales-weighted power draw averages.[5]

Figure 5. Energy Star Monitors by Screen Size



Note: Source data from December 31, 2007 Energy Star monitor list (Energy Star 2008a); 1334 total monitors.

Figure 6 shows how the prevalence of monitors exceeding Energy Star levels has significantly increased over the last year and a half. For example, 42% of the monitors on the June 2006 list were at least 25% beyond the current Energy Star levels (i.e., they would meet our proposed Title 20 level). By December 2007, the percentage increased to 52% of the monitors. This trend is occurring for higher efficiency levels as well, as indicated by the lines that surpass Energy Star levels by 35% and 40%.

[5] We currently do not have access to enough data to develop statistically significant sales-weighted or stock-weighted averages, so we use the values in Figure 4 as a useful proxy.

Figure 6. Percentage of Monitors that Go Beyond Energy Star Active Mode Level

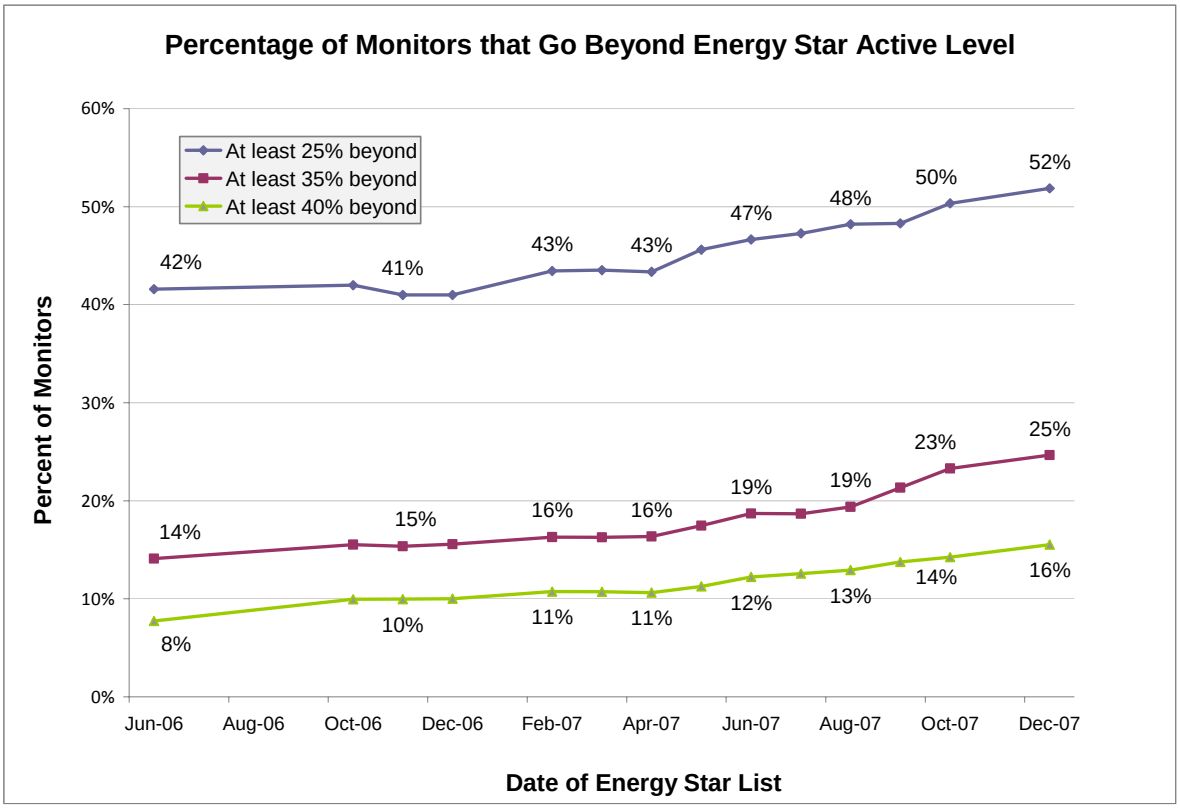
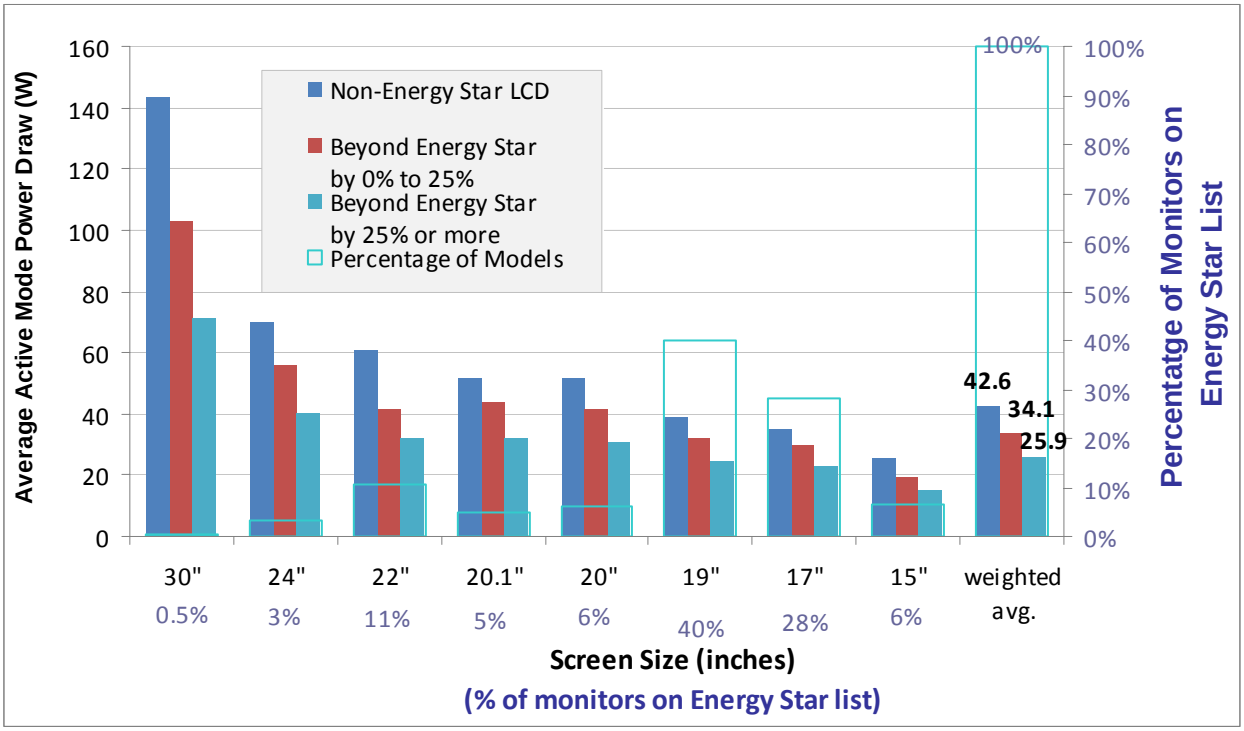


Figure 7 displays the average active mode power draw for three different monitor categories: 1) non-Energy Star LCDs, 2) Energy Star monitors that exceed the specification levels by only 0% to 25% and 3) monitors that exceed the Energy Star levels by 25% or more. The first two categories would not meet our proposed Title 20 levels and the third category would. The calculated weighted average for each category is shown, and is based on the relative percentage of monitors on the Energy Star list. The weighted averages for the respective three categories are: 42.6W, 34.1W, and 25.9W. The monitors that meet our proposed specification draw roughly 40% and 25% less power, respectively, compared to non-Energy Star monitors and the least-efficient Energy Star monitors. A similar analysis was done for sleep mode, and off mode and those results are shown in Appendix Tables 8 and 9.

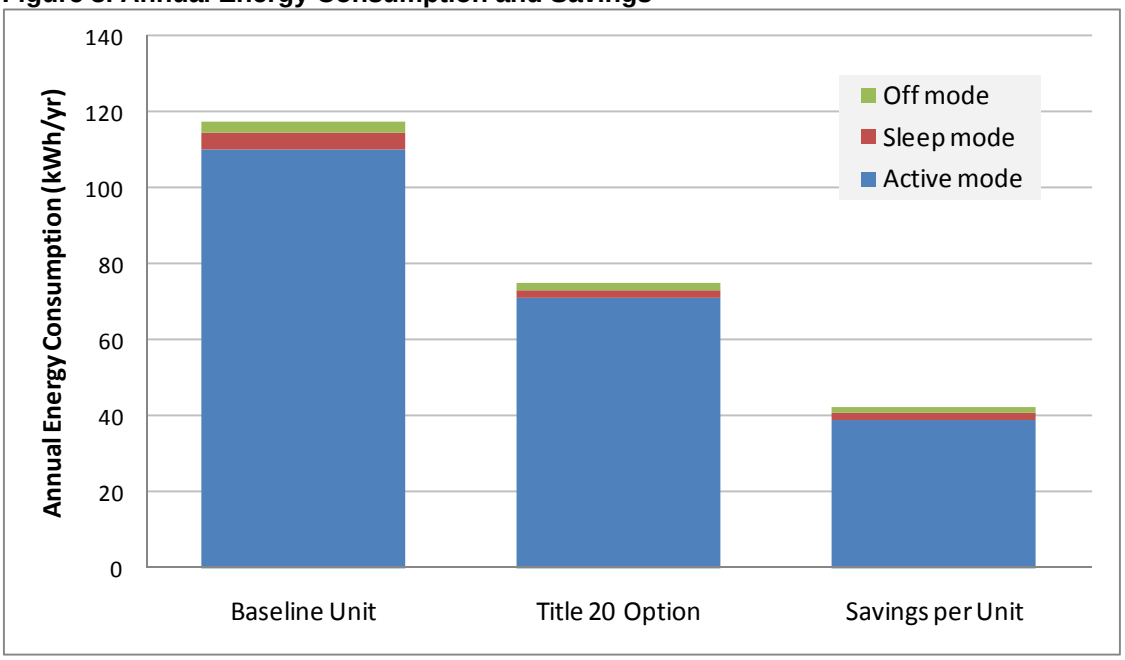
Figure 7. Average Active Mode Power Draw for Monitors



Note: Solid bars represent average active mode power and are plotted using the left-vertical axis. The semi-transparent bars indicate the scaled percentage of monitors on the 12/31/07 Energy Star list and are plotted using the right-vertical axis (for simplicity, we include only the top eight monitor screen sizes, and thus the percentages listed in this figure are scaled slightly higher than the pie chart in Figure 5).

We use the average power draw values (shown in Figure 7 and Appendix Tables 6, 7, and 8) and our assumed duty cycles (Table 1) to estimate the weighted annual energy consumption for the "baseline" monitors and for the monitors that would meet our proposed Title 20 levels. The results are shown in Figure 8 below. The "baseline" unit energy consumption is 117.8 kWh/yr, compared to 75.2 kWh/r for the Title 20 option, resulting in a 42.6 kWh/yr savings per monitor.

Figure 8. Annual Energy Consumption and Savings



Note: See appendix Tables 7, 8, and 9 for detailed power draw sources for each mode. Values are a weighted average for monitors used in residential and commercial applications. Appendix Table 10 shows exact values.

Table 2 displays current estimates for the California stock and annual sales. The estimated current California stock is 28 million computer monitors. Estimated annual sales are 7.2 million units. Roughly 79% of these sales today (5.7 million units) are "baseline" units and 21% (1.05 million units) meet the proposed "Title 20 standards option" levels.

The estimated annual energy consumption of the computer monitor stock in California is 3,052 GWh/yr. This is approximately 1% of California's total electricity consumption. The coincident peak demand is an estimated 448 MW (see Table 3).

Table 2. California Stock and Sales

	California Stock	California Annual Sales	
	Units (millions)	Units (millions)	Percent of forecasted sales
All Monitors	28	7.2	100%
For future savings analysis:			
Baseline units	N/A	5.7	79%
Title 20 standards option	N/A	1.5	21%

Note: California stock derived from U.S. residential value in Roth and McKeeney (2007) and assumes California has 12% of U.S. stock based on population. Value for all monitors (residential and commercial) is then calculated by assuming 38% of stock is residential (from Chase et al, 2005). Annual sales are an estimate for 2010 based on Chase et al (2005). See appendix Table 6 for percent of forecasted sales sources.

Table 3. California Stock Energy Consumption and Coincident Peak Demand

	For Entire Stock	
	Coincident Peak Demand (MW)	Annual Energy Consumption (GWh/yr)
All Monitors	448	3052

Note: Estimate based on weighted power draw values for "All Monitors" in appendix Tables 6-8. Coincident peak demand is calculated by using a 0.78 load factor (developed using load factors in Brown and Koomey (2002): used "office equipment" as a proxy for commercial monitors and "televisions" as a proxy for residential monitors).

Table 4 illustrates the estimated California statewide energy savings for our proposed Title 20 standard. The estimated annual savings for the first-year sales is 242 GWh/yr and the coincident peak demand reduction is 36 MW. After the entire stock turnover, annual energy savings are estimated to be 968 GWh/yr with a coincident peak demand reduction of 142MW.

Table 4. Estimated California Energy Savings for Proposed Title 20 Standards Option

For First-Year Sales		After Entire Stock Turnover	
Coincident Peak Demand Reduction (MW)	Annual Energy Savings (GWh/yr)	Coincident Peak Demand Reduction (MW)	Annual Energy Savings (GWh/yr)
36	242	142	968

Note: Assumes a 4-year useful life for stock turnover estimates based on an assessment of multiple sources (see Chase et al 2005, pg. 45 Appendix J). See Table 3 note for load factor assumption.

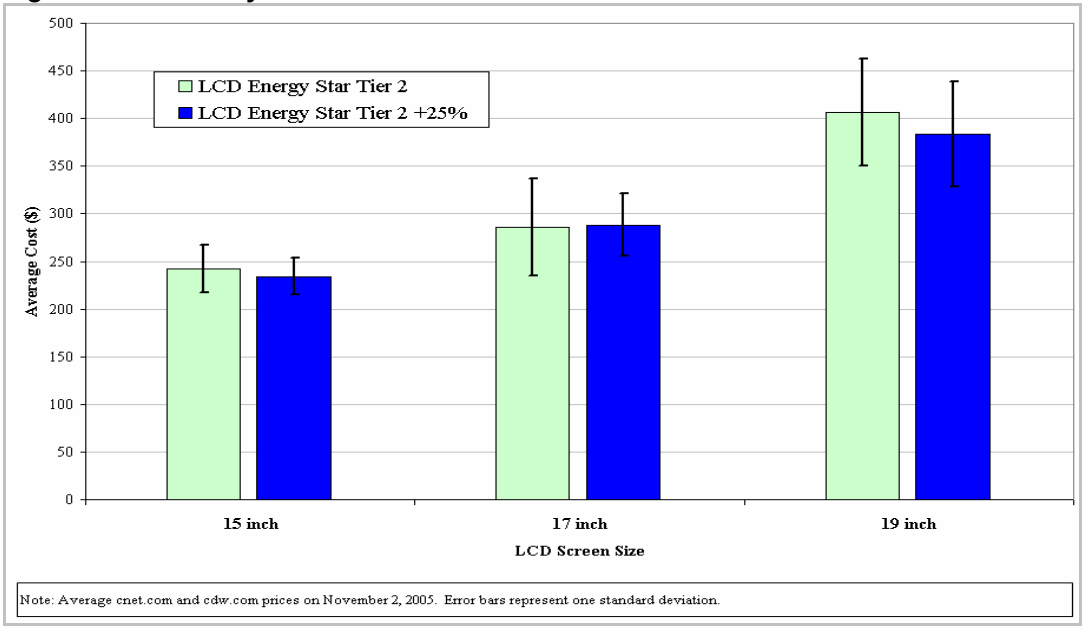
Our proposed Title 20 recommendation should be highly cost-effective. The present value lifecycle benefits from the proposed standard are: $22 per monitor, $57 million for first-year sales, and $185 million after the entire stock turnover (see table 5). An initial analysis of the market indicates that there is no incremental cost to the consumer for monitors that meet our proposed levels; however, additional research is warranted to support these findings (see Figure 9).

Table 5. Lifecycle Benefits from Energy Savings for Standards Option

Per Unit ($)	For First Year Sales ($M)	After Stock Turnover ($M)
$22	$57	$185

Note: Calculated using the CEC's average statewide present value statewide energy rates that assume a 3% discount rate (CEC 2004).

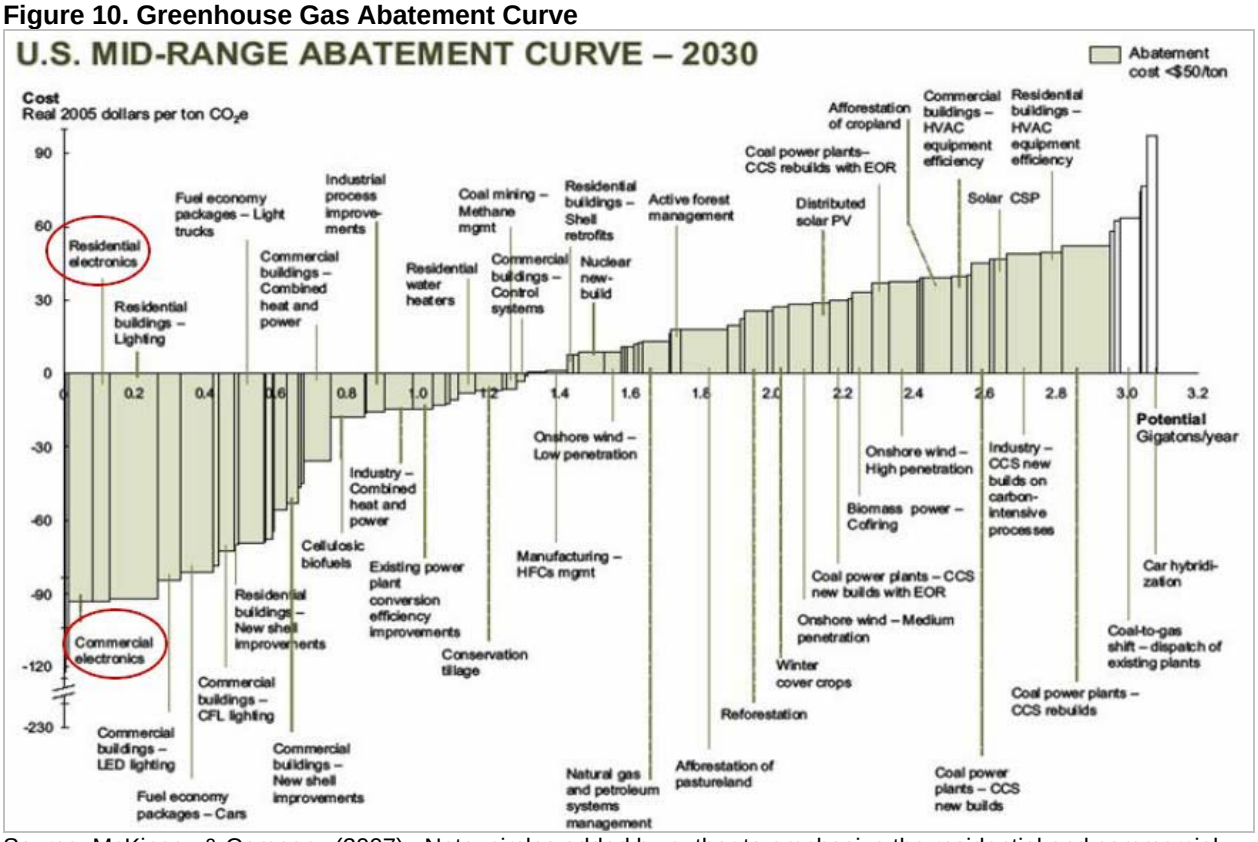
Figure 9. Cost Analysis



Source: Chase et al (2005)

Figure 10, shown below, is from a recent December 2007 McKinsey & Company report depicting a cost-benefit analysis for reducing greenhouse gas emissions. Their analysis indicates that increasing the efficiency of residential and commercial electronics represents a significant opportunity (shown by the width of the bars), and is also the most cost-effective strategy (shown by the negative marginal cost on the y-axis). By setting a Title 20 efficiency standard for computer monitors, California can leverage these opportunities as an important strategy for reaching its ambitious AB 32 greenhouse gas reduction goals (1990 levels by 2020).

Figure 10. Greenhouse Gas Abatement Curve



Source: McKinsey & Company (2007). Note: circles added by author to emphasize the residential and commercial electronics categories.

Recommendations

Effective November 1, 2009 (assuming this rule is completed in 2008), Computer Monitors shall not exceed the maximum power consumption levels in the Table 6 below.

Table 6. Recommended Title 20 Levels for Computer Monitors

Maximum Allowable Power Consumption		
On Mode	Sleep Mode	Off Mode
If X < 1 megapixel, then Y = 17 watts If X ≥ 1 then Y = 21X	≤ 2 watts	≤ 1 watts
Y is expressed in watts and rounded up to the nearest whole number and X is the number of megapixels in decimal form (e.g., 1,920,000 pixels = 1.92 megapixels)		

We recommend that the Commission adopt the key definitions and test procedures outlined in the current Version 4.1 Energy Star computer monitor specification. In addition, and in an effort to harmonize terms and testing procedures as much as possible with Energy Star, consideration should be given to any relevant changes that Energy Star makes during is

specification revision process now underway (expected draft will be released March 2008 with an April 2009 effective date).

We also recommend that a standard address the rapidly growing professional display and digital photo frame market. We will provide specific recommendations for these products in subsequent versions of this report template, future CASE reports, and/or at public CEC hearings (and will also update savings values based on those recommendations). [6]

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[6] PG&E has also provided recommendations for an expanded Title 20 television standard under a separate report. Consideration should be taken for any potential harmonization between a future TV and monitor standard since there exists some product overlap.

Appendices

Table 7. Weighted Active Mode Power Assumption

	Active Mode Power (W)	Estimated Energy Star Saturation	Estimated distribution within Energy Star	Estimated Market Share	Weighted Active Mode Power (W)	
					All monitors	**Baseline vs. Title 20 option**
Baseline Units					37.2	**40.2**
Non-Energy Star LCDs	42.6	60%	n/a	60%		
Beyond Energy Star by 0% to 25%	34.1	40%	48%	19%		
Title 20 Standards Option (Beyond ES by 25% or more)	25.9		52%	21%		**25.9**

Notes: Active Mode Power based on December 31, 2007 Energy Star monitor list (Energy Star 2008a) and is weighted based on screen size representation. Estimated Energy Star Saturation is an estimate for when Title 20 standard could become effective in 2010 and is based on Energy Star (2008b) documents saying that market share was approximately 35% at end of 2006. Estimated distribution within Energy Star is based on analysis of December 31, 2007 monitor list (see Figure 6). Estimated Market Share is then calculated based on these previous estimates.

Table 8. Weighted Sleep Mode Power Assumption

	Sleep Mode Power (W)	Estimated Energy Star Saturation	Estimated distribution within Energy Star	Estimated Market Share	Weighted Sleep Mode Power (W)	
					All monitors	**Baseline vs. Title 20 option**
Baseline Units					1.3	**1.5**
Non-Energy Star LCDs	1.6	60%	n/a	60%		
Beyond Energy Star by 0% to 25%	0.9	40%	48%	19%		
Title 20 Standards Option (Beyond ES by 25% or more)	0.8		52%	21%		**0.8**

Notes: Sleep Mode Power based on December 31, 2007 Energy Star monitor list (Energy Star 2008a) and is weighted based on screen size representation. Estimated Energy Star Saturation is an estimate for when Title 20 standard could become effective in 2010 and is based on Energy Star (2008b) documents saying that market share was approximately 35% at end of 2006. Estimated distribution within Energy Star is based on analysis of December 31, 2007 monitor list (see Figure 6). Estimated Market Share is then calculated based on these previous estimates.

Table 9. Weighted Off Mode Power Assumption

	Off Mode Power (W)	Estimated Energy Star Saturation	Estimated distribution within Energy Star	Estimated Market Share	Weighted Off Mode Power (W)	
					All monitors	**Baseline vs. Title 20 option**
Baseline Units					1.0	**1.1**
Non-Energy Star LCDs	1.6	60%	n/a	60%		
Beyond Energy Star by 0% to 25%	0.9	40%	48%	19%		
Title 20 Standards Option (Beyond ES by 25% or more)	0.8		52%	21%		**0.6**

Notes: Off Mode Power based on December 31, 2007 Energy Star monitor list (Energy Star 2008a) and is weighted based on screen size representation. Estimated Energy Star Saturation is an estimate for when Title 20 standard could become effective in 2010 and is based on Energy Star (2008b) documents saying that market share was approximately 35% at end of 2006. Estimated distribution within Energy Star is based on analysis of December 31, 2007 monitor list (see Figure 6). Estimated Market Share is then calculated based on these previous estimates.

Table 10. Energy Consumption Assumptions for Baseline Units and Title 20 Recommendation

		Energy Consumption (kWh/yr)			
	Estimated Distribution	Active mode	Sleep mode	Off mode	Unit Electricty Consumption
Baseline Unit					
Residential	38%	75.0	1.3	6.4	82.7
Commercial	62%	131.8	6.1	1.4	139.3
Weighted	100%	110.2	4.3	3.3	117.8
Title 20 Option					
Residential	38%	48.3	0.7	3.6	52.7
Commercial	62%	85.0	3.3	0.8	89.1
Weighted	100%	71.0	2.3	1.9	75.2
Savings per Unit					
Residential	38%	26.7	0.6	2.8	30.0
Commercial	62%	46.9	2.8	0.6	50.2
Weighted	100%	39.2	1.9	1.4	42.6

Notes: Values based on December 31, 2007 Energy Star monitor list. Power levels are weighted based on screen size prevalence.