Proposal Information Template for:
Electronic Displays

DOCKET
11-AAER-1
DATE SEP 30 2011
RECD. OCT 03 2011

Submitted to:
California Energy Commission
In consideration for the 2011 Rulemaking Proceeding on Appliance Efficiency Regulations,
Docket number 11-AAER-1

Prepared for:
Pacific Gas and Electric Company
San Diego Gas & Electric
Southern California Edison
Southern California Gas Company

Prepared by:
Bijit Kundu, Energy Solutions

Last Modified: September 30, 2011

Proposal Information Template – Electronic Displays

2011 Appliance Efficiency Standards

Prepared for: Pacific Gas and Electric Company, San Diego Gas & Electric, Southern California Edison, Southern California Gas Company

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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 Regulations,, §§ 1601 – 1608) This report specifically covers Electronic Displays.

Background

Electronic displays are used in both residential and commercial applications. The market for displays has shifted towards slim, sleek liquid crystal display (LCD) display screens and away from bulky cathode ray tube (CRT) monitors. Successive generations of LCDs have improved their energy efficiency through improvements to the LCD screen and its backlight, power supplies and control hardware and software. While some LCD backlights are cold cathode fluorescent (CCFL), newer LCD models are incorporating LED backlights Improvements to other components such as display enhancement films, reflectors, and diffusers reduce light losses and ensure a maximum directional light output towards the viewer. Because of the variety of components that contribute to efficiency, there remains a large range in LCD monitor efficiency.

While monitors are becoming increasingly efficient, consumer preferences are shifting towards increasingly larger screen sizes, which consume more energy than their smaller counterparts.

The term "Display" is meant to include a wide variety of electronics with a display screen, including computer monitors, digital picture frames, and professional displays (displays > 30") (Energy Star 2008b). The term "display" is NOT meant to include products marketed or sold as consumer televisions.

The existing market conditions are favorable for setting a cost-effective Title 20 efficiency standard for electronic displays. Tier 1 requirements of the current ENERGY STAR Version 5.1 Displays specification have been in effect since November 2009, and market share for ENERGY STAR qualified monitors has been increasing steadily since the adoption of the specification. The current 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 LED monitors. As of September 2010, there were over 1700 qualified displays, representing all screen sizes and over 40 brands. Due to rapid uptake of the current specification and the high market penetration of ENERGY STAR qualified displays in the market, the Environmental Protection Agency (EPA) launched the revision of the current specification in December 2010, only 13 months from the previous effective date. The current specification revision process is expected to become effective in late 2012.

Figure 1 below outlines the key components with respect to display technologies. Most of the features and functionalities outlined in this slide affect the power consumption of a display to some degree (Energy Star 2011).

Figure 1. Display Product Complexity

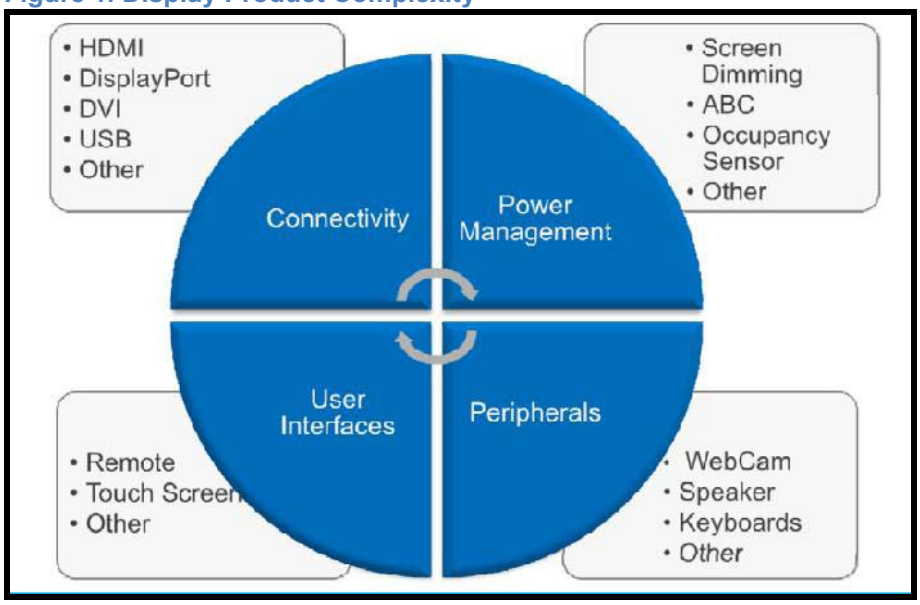
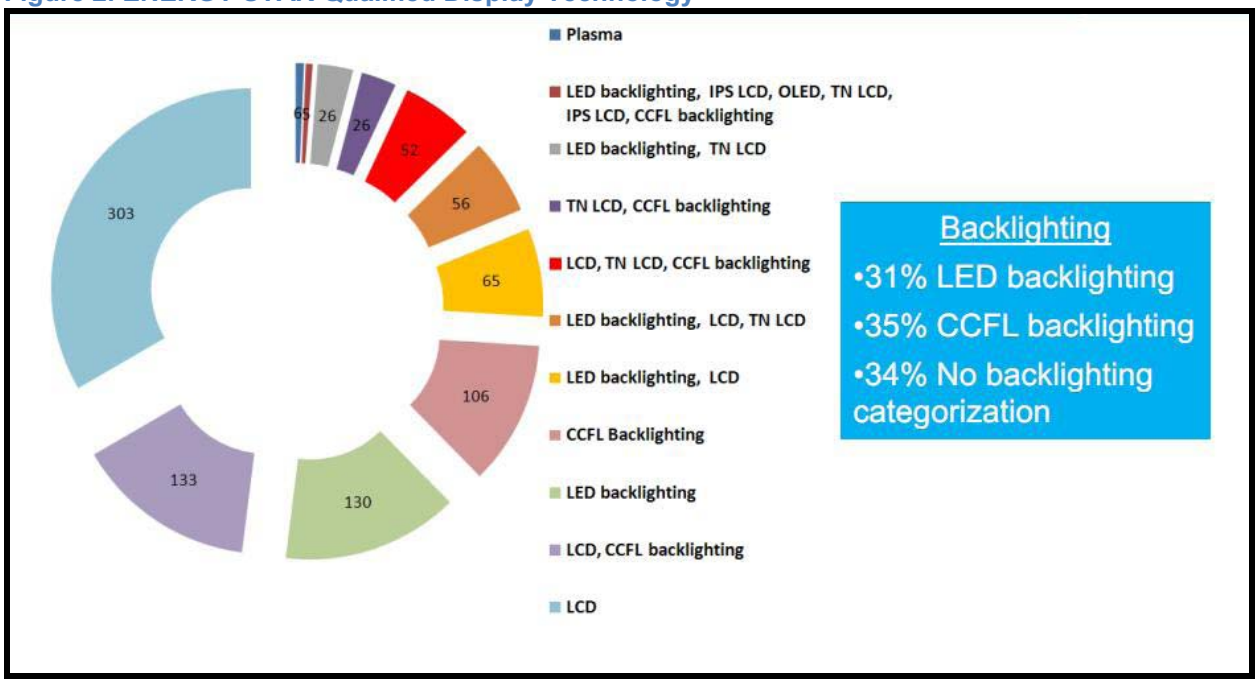


Figure 2 below highlights the diversity of backlight technology used in ENERGY STAR qualified displays. As previously noted, backlighting is one of the major contributors to the power draw of a display (Energy Star 2011).

Figure 2. ENERGY STAR Qualified Display Technology



Based on an extensive analysis of market trends and energy consumption data, we recommend that the Commission adopt a maximum active[1] and sleep mode power consumption levels that exceed the current ENERGY STAR Version 5.1 maximum active mode power requirements by 40% (i.e., 40% more stringent than current ENERGY STAR levels). As noted above, by the time a Title 20 standard would become effective, version 5.1 would no longer be current, as it will be replaced by a more stringent version 6.

The analysis of this report focuses primarily on computer monitors,[2] but we also recommend that the Commission include signage displays[3] and digital picture frames[4] in the scope. References to electronic displays in this report are intended to include computer monitors, digital picture frames, and professional displays.We plan to update market and sales data in the completed CASE report. There are a number of commercially-available display market surveys available for purchase.

[1] "Active" mode and "On" mode are used interchangeably throughout this report.
[2] A complete CASE report will expand upon the computer monitor analysis to include signage displays and digital picture frames.
[3] Signage Displays: An electronic device with a display screen that is marketed as signage for typical use in locations such as retail and department stores, fast food restaurants, museums, hotels, outdoor venues, airports, conference rooms and education markets.
[4] Digital Picture Frame: An electronic device whose primary function is to display digital images, but it may contain additional functionality such as a programmable timer, occupancy sensor, audio, video, bluetooth, wireless capability, etc.

Overview

<table>
<tr><td>Description of Standards Proposal</td><td>Effective January 1, 2014 (assuming this rule is completed in 2012) all electronic displays shall not exceed the maximum active mode and sleep mode power consumption levels (in Watts) in the figure below. ENERGY STAR is in the process of updating their specification and test procedure, and they have indicated that the updated power limits will be based only on screen area and not on screen resolution as noted below.[5] Updated proposed Title 20 levels based only on screen area will be outlined in the completed CASE report.

<table>
<tr><th colspan="2">Product Type</th><th colspan="2">Power Requirements</th></tr>
<tr><td>Diagonal Screen Size, d (inches)</td><td>Screen Resolution, r (megapixels)</td><td>Active Mode (W)</td><td>Sleep Mode (W)</td></tr>
<tr><td>< 30</td><td>≤ 1.1</td><td>3.6r + 0.03A + 1.8</td><td>≤ 2.0</td></tr>
<tr><td>< 30</td><td>> 1.1</td><td>5.4r + 0.03A + 1.8</td><td>≤ 2.0</td></tr>
<tr><td>30 ≤ d ≤ 60</td><td>Any</td><td>0.162A + 4.8</td><td>≤ 2.0</td></tr>
</table>
A = viewable screen area rounded to the nearest 0.1 square inch.

In addition to power requirements, power supply efficiency requirements, luminance, automatic brightness control allowances, and power management enablement requirements should be considered for a future standard.</td></tr>
<tr><td>California Stock and Sales</td><td>The estimated current California stock is 28 million electronic displays. Estimated annual sales are 6.9 million units. Roughly 82% of these sales (5.7 million units) are “baseline” units (i.e., those that currently do not meet the proposed standard levels). An estimated 18% (1.2 million units) of monitor sales currently meet our proposed “Title 20 standards” level today and this should significantly increase between now and the proposed effective date.

Given rapid developments of this marketplace, we plan to update market and sales data in the completed CASE report. There are a number of commercially-available display market surveys available for purchase.</td></tr>
</table>

[5] ENERGY STAR has done an exhaustive analysis suggesting that it is reasonable to remove screen resolution as a factor in the power consumption limits. This ENERGY STAR data and conclusions can be found at: ENERGY STAR 2011 reference in the References section.

Energy Savings and Demand Reduction	The average per unit energy savings from the proposed standard is estimated to be 39 kWh/yr. For first-year sales, energy savings are estimated to be 268 GWh/yr and the coincident peak demand reduction is 41 MW. After the entire stock turnover, energy savings would be 1339 GWh/yr and coincident peak demand reduction would be 205 MW.
Economic Analysis	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. As we collect additional data and information, they will be incorporated into 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). 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.
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 Version 5 specification that has been effective for over two years should help to minimize any acceptance issues. ENERGY STAR is updating its performance level for 2012. We are currently awaiting the 2010 Unit Shipment Data Report published annual by EPA. EPA has indicated that this report should be published by September 2011. All the major display vendors have qualified products with ENERGY STAR; therefore, we recommend that a proposed Title 20 standard utilize the same definitions as the current ENERGY STAR specification. Based on the number of currently qualified products, we expect a higher market share percentage for ENERGY STAR Version 5. In an effort to harmonize the test procedures for displays with televisions in the current specification revision process, EPA is proposing the adoption of the International Electrical Commission (IEC) standard IEC 62087, Ed. 3.0: Methods of Measurement for the Power Consumption of Audio, Video and Related Equipment for testing displays of all diagonal sizes. This industry accepted test procedure is currently referenced as the test procedure to measure the power of active mode for ENERGY STAR televisions as well.

Federal Preemption or other Regulatory or Legislative Considerations	There are no known interactions with other existing laws for this standard. Currently, there are no federal energy conservation standards regarding electronic displays. Based on information published at the U.S. Office of Information and Regulatory Affairs – Office of Management and Budget, the U.S. Department of Energy (DOE) may consider establishing future standards for computer equipment, which may include computer monitors.[6] However, if DOE decides to move forward with a rulemaking to cover products described here, the earliest effective date would be 2018.

Methodology and Modeling used in the Development of the proposal
We developed savings estimates using the best readily available data from a number of sources. Given ongoing developments in the marketplace, we are planning to update these estimates upon obtaining new data, particularly for energy usage data from ENERGY STAR 6.0, and costs of compliance to meet TEC levels. 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 qualified product 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 the data set (dated August 15, 2011) to estimate baseline energy consumption characteristics and savings from the proposed recommendation. The completed CASE report will incorporate any updates based on the most recently published qualified product list.

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 used 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 3 shows the specification levels for ENERGY STAR qualified displays. Tier 1 became effective on October 30, 2009. Due to increased market penetration of ENERGY STAR displays (estimated to be over 90% in 2010), a revision process is currently underway and a new draft specification is expected to be finalized in early 2012, with an effective target date of late 2012.

[6] Based on information published at the U.S. Office of Information and Regulatory Affairs – Office of Management and Budget. URL: http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201104&RIN=1904-AC33. Accessed on September 13, 2011.

Figure 3. Key Product Criteria for ENERGY STAR Displays

Tier 1 Requirements for ENERGY STAR Qualified Displays			
Display Category	**On Mode**	**Sleep Mode**	**Off Mode**
Diagonal Screen Size < 30 inches Resolution <= 1.1 MP Effective October 30, 2009	Po = 6*(MP) + 0.05*(A) + 3	<= 2 watts	<= 1 watt
Diagonal Screen Size < 30 inches Resolution > 1.1 MP Effective October 30, 2009	Po = 9*(MP) + 0.05*(A) + 3		
Diagonal Screen Size 30–60 inches All Resolutions. Effective January 30, 2010	Po = 0.27*(A) + 8		

Notes:
Po is expressed in watts and rounded up to the nearest whole number
MP is the number of megapixels in decimal form
A is the Viewable Screen Area (in square inches)

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

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

		Operating Hours (Hours/yr)		
	Assumed Sales Distribution	Active	Sleep	Off
Residential	33%	1865	875	6020
Commercial	67%	3081	4336	1343
Weighted Operating Hours		**2680**	**3194**	**2886**

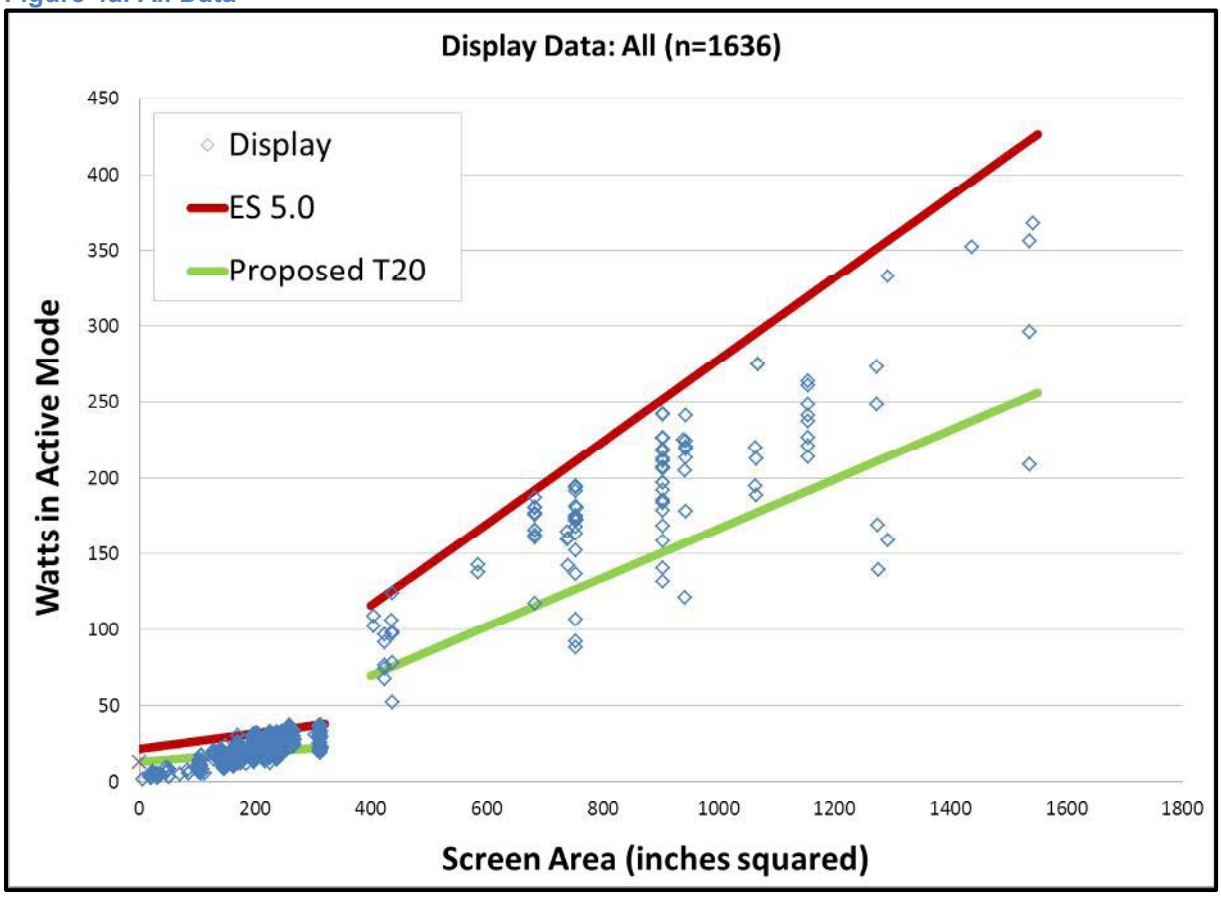
Based on the results discussed in the next section, we recommend a Title 20 standard level that is 40% more stringent than the current ENERGY STAR Version 5 Specification level (e.g., the maximum allowed active mode power level will be 40% less than the current ENERGY STAR specification). It is first important to define the key terminology we use throughout the remainder of this report. In order to assess potential energy implications of a proposed standard, we have established the following two monitor categories:

- Baseline Units: includes all displays that are currently available on the market (meet current ENERGY STAR levels).
- Title 20 Standards Unit: includes currently available displays that would pass our recommended specification levels.

Data, Analysis, and Results

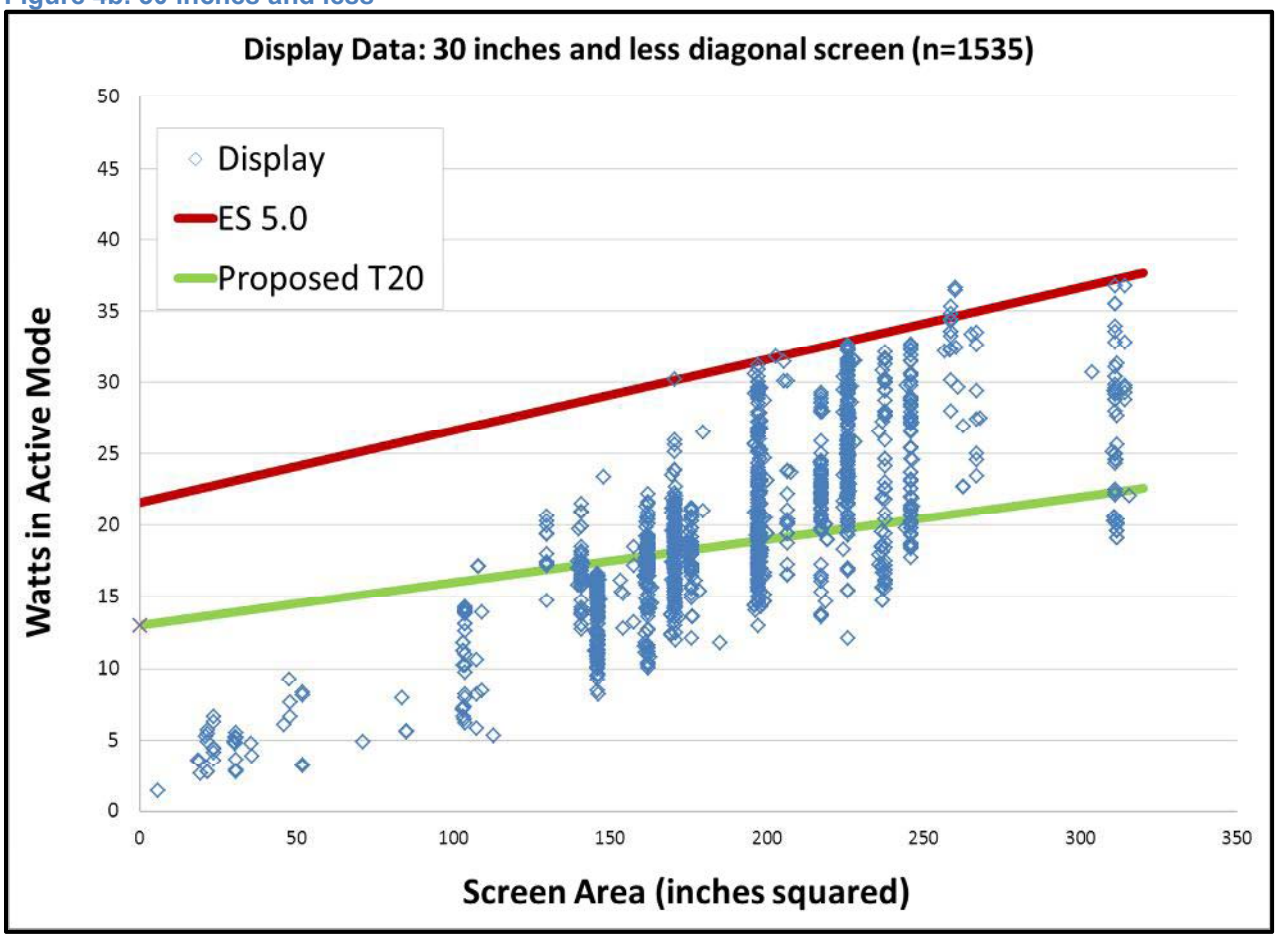
Figures 4a through 4c illustrate the 1636 displays on the August 15, 2011 ENERGY STAR qualified product list with the current Version 5.0 ENERGY STAR and the proposed T20 levels. Please note that the ENERGY STAR and proposed Title 20 levels represented on these charts do not reflect the standard for all displays. They represent the standard lines for displays with a 2.07 megapixels. These displays are the most represented in the ENERGY STAR dataset (45%). The actual requirements are dependent on both screen resolution and diagonal screen size—thus, the maximum level increases with increased megapixels, and vice versa.

Figure 4a. All Data[7]



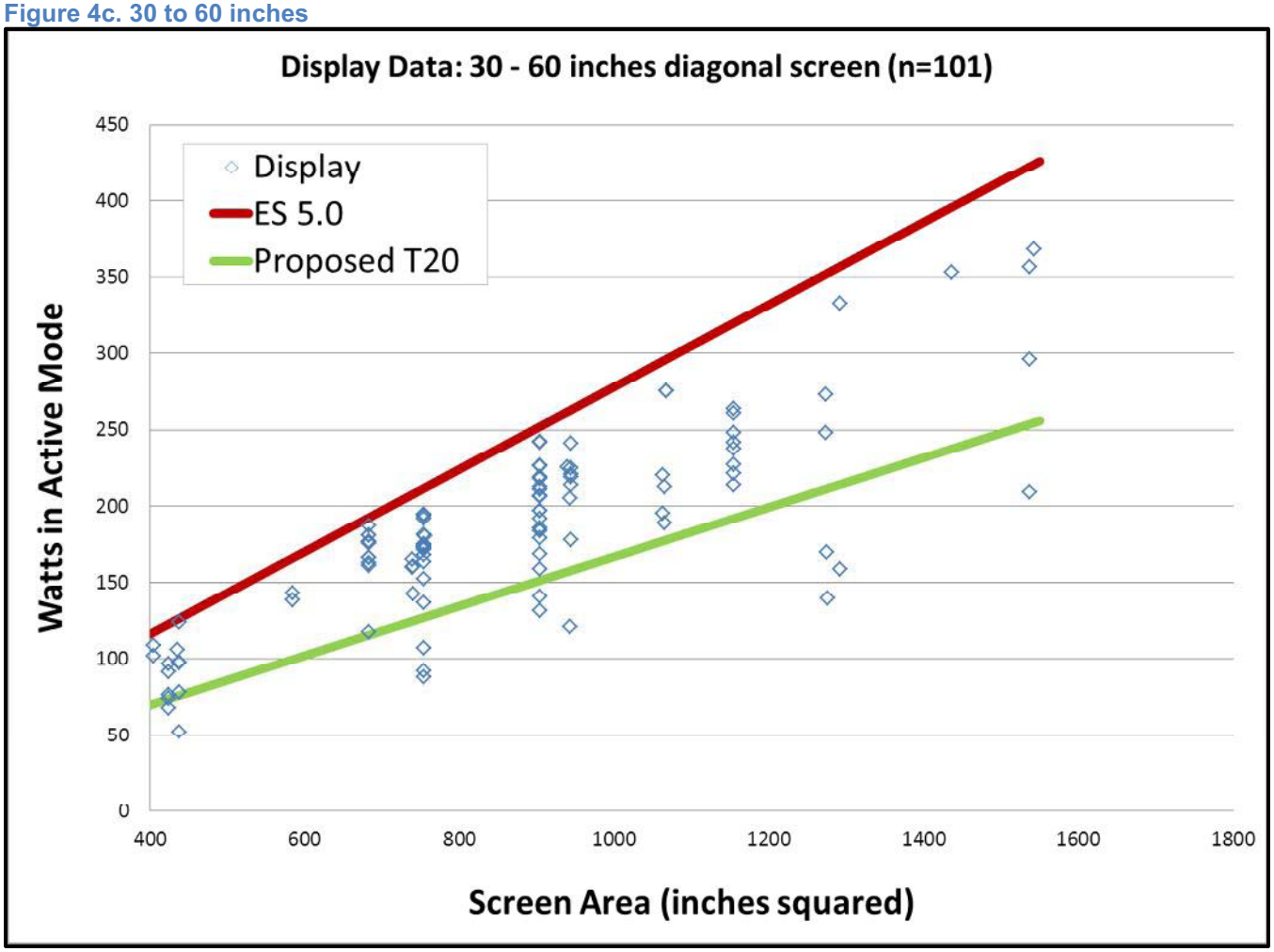
[7] Lines are shown for 2.07 megapixel displays.

Figure 4b. 30 inches and less[8]



[8] Lines are shown for 2.07 megapixel displays. Some display models shown exceed the ENERGY STAR requirement in this chart. This is because they have a higher megapixel and a subsequently higher level.

Figure 4c. 30 to 60 inches



We use the average power draw values and our assumed duty cycles (Table 1) to estimate the weighted annual energy consumption for average display based in the current market and for the average display that would meet our proposed Title 20 levels. The results are shown in Figure 5 below. The current market average unit energy consumption is 124 kWh/yr compared to 85 kWh/yr for the average for a unit that meets the Title 20 proposed standard resulting in a 39 kWh/yr savings per monitor.

Figure 5: Annual Energy Consumption and Savings by Mode

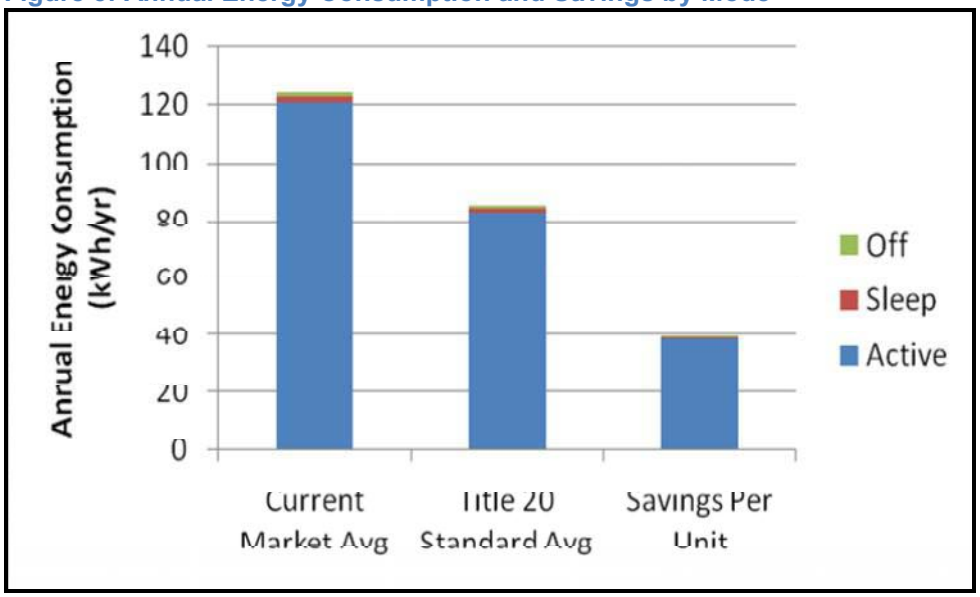


Table 2 displays current estimates for the California stock and annual sales. The estimated current California stock is 28 million computer displays. Estimated annual sales are 6.9 million units. Roughly 82% of these sales today (5.7 million units) are "baseline" units and 17% (1.2 million units) meet the proposed "Title 20 standards option" levels.

The estimated annual energy consumption of the computer monitor stock in California is 3,468 GWh/yr. This is approximately 1% of California's total electricity consumption. The coincident peak demand is an estimated 532 MW.

Table 3 illustrates the estimated California statewide energy savings for our proposed Title 20 standard. The estimated annual savings for the first-year sales is 268 GWh/yr and the coincident peak demand reduction is 41 MW. After the entire stock turnover, annual energy savings are estimated to be 1339 GWh/yr with a coincident peak demand reduction of 205 MW.

Statewide Stock & Sales, Energy Use and Savings

Table 2. California Stock and Sales

	California Stock	California Annual Sales	
	Units (millions)	Units (millions)	Percent of forecasted sales
All Displays	28	6.9	100%
Baseline Models		5.7	83%
Title 20 Standards Models		1.2	17%

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. Annual sales are an estimate based on ENERGY STAR Unit Shipment Data (2010).

Table 3. Estimated California Statewide Energy Savings for Proposed Standards

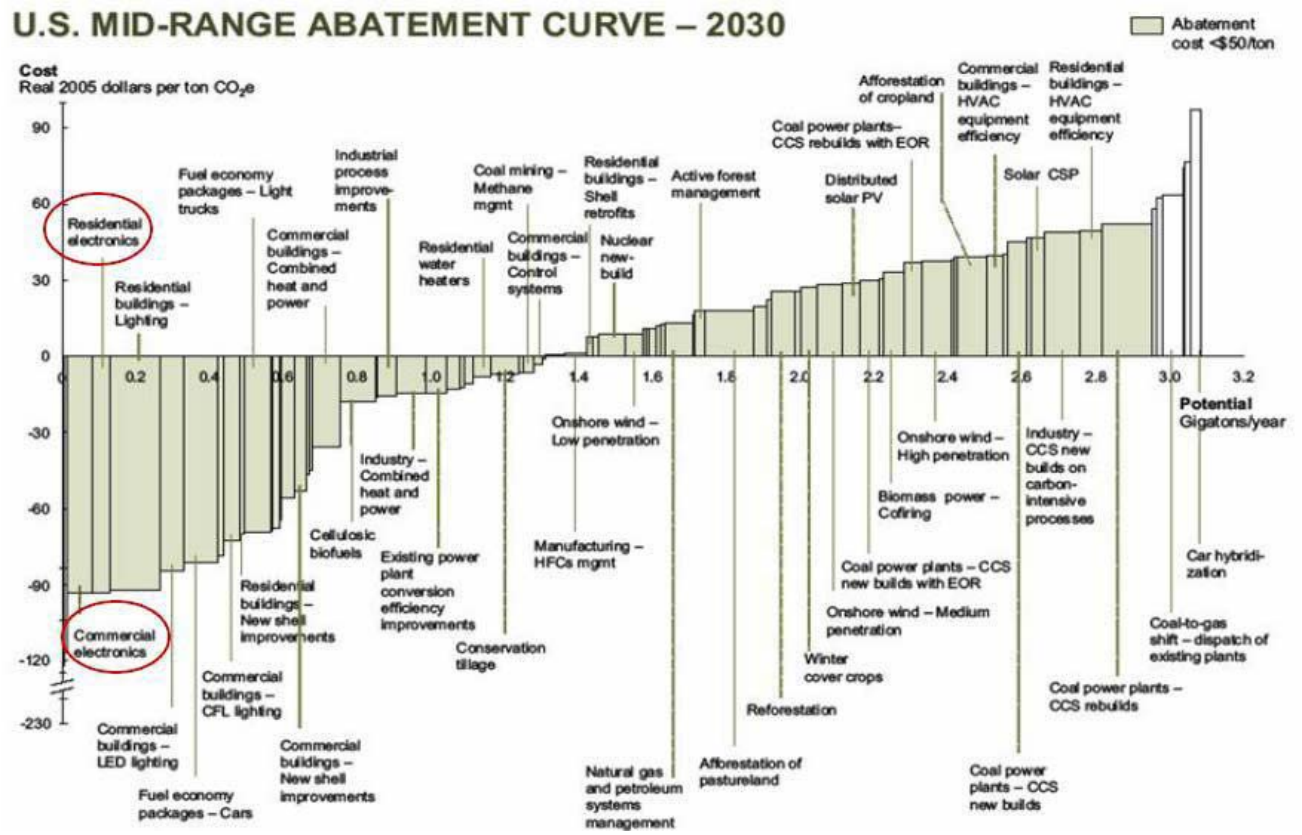
For First-Year Sales		For Entire Stock	
Coincident Peak Demand (MW)	Annual Energy Savings (GWh/yr)	Coincident Peak Demand (MW)	Annual Energy Savings (GWh/yr)
41	268	209	1,339

Note: Estimate based on weighted power draw values for all displays. 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 displays and "televisions" as a proxy for residential displays).

Our proposed Title 20 recommendation should be highly cost-effective. The present value lifetime avoided energy costs from the proposed standard are: $28 per monitor, $57 million for first-year sales, and $131 million after the entire stock turnover. 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.

Figure 5, shown below, is from a 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 electronic displays, California can leverage these opportunities as an important strategy for reaching its ambitious AB 32 greenhouse gas reduction goals (1990 levels by 2020).

Figure 5. Greenhouse Gas Abatement Curve



Proposed Standards and Recommendations

Effective January 1, 2014 (assuming this rule is completed in 2012), electronic displays shall not exceed the maximum power consumption levels in the Table X below:

Product Type		Power Requirements	
Diagonal Screen Size, *d* (inches)	Screen Resolution, *r* (megapixels)	Active Mode (W)	Sleep Mode (W)
< 30	≤ 1.1	$3.6r + 0.03A + 1.8$	≤ 2.0
< 30	> 1.1	$5.4r + 0.03A + 1.8$	≤ 2.0
$30 \leq d \leq 60$	Any	$0.162A + 4.8$	≤ 2.0

A = viewable screen area rounded to the nearest 0.1 square inch.

ENERGY STAR is in the process of updating their specification and test procedure, and they have initially indicated that the updated power limits will be based only on screen area and not on screen resolution as noted below.[9] Updated proposed Title 20 levels based on the most up to date ENERGY STAR proposal and data analysis will be outlined in the completed CASE report.

We recommend that the Commission adopt the key definitions and test procedures outlined in the Version 6.0 ENERGY STAR specification revision process now underway (expected final draft will be released early 2012 with an late 2012 effective date). In particular, we recommend the following elements be addressed:

- Test Method: EPA is proposing the adoption of the International Electrical Commission (IEC) standard IEC 62087, Ed. 2.0: Methods of Measurement for the Power Consumption of Audio, Video and Related Equipment with the dynamic broadcast test clip for testing displays of all diagonal sizes.

- Luminance: EPA initially proposed that partners test and ship products at a luminance value greater than or equal to 65% of the maximum luminance to qualify as ENERGY STAR, mirroring the ENERGY STAR Televisions specification.

- Automatic Brightness Control: EPA initially proposed testing conditions for ABC enabled by default that have been recommended by DOE for televisions to harmonize with the Version 6.0 draft specification for Televisions.

As data and information are collected and distributed by EPA on these issues during this specification revision process, they will be incorporated into 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).

[9] ENERGY STAR has done an exhaustive analysis suggesting that it is reasonable to remove screen resolution as a factor in the power consumption limits. This ENERGY STAR data and conclusions can be found at: ENERGY STAR 2011 reference in the References section.

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