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NRDC comments on CEC's proposed computer and monitor standards

Additional submitted attachment is included below.

NRDC

NATURAL RESOURCES DEFENSE COUNCIL

NRDC Comments on CEC Proposed Regulations for Computers and Computer Monitors

2016 Appliance Efficiency Rulemaking
Docket Number 16-AAER-2

October 24, 2016

Submitted by:
Pierre Delforge, Natural Resources Defense Council

On behalf of the Natural Resources Defense Council and our more than 380,000 members and online activists in California, we respectfully submit these comments on the California Energy Commission's (CEC) Appliance Efficiency Proposed Regulations on Computers and Computer Monitors.

We strongly support CEC's initiative to develop energy efficiency standards for computers and displays. Computers and displays are responsible for roughly 3 percent of total electricity consumption in California. Realizing cost-effective energy savings in plug-in equipment, which represent approximately two thirds of building electricity use in California[1], is a critical strategy to help achieve the state's clean energy and carbon reduction goals.

CEC's proposed standards have the potential to reduce computer and display energy consumption by one third after stock turnover, saving 2.3 billion kilowatt-hours of electricity annually, equivalent to the consumption of all the households in the city of San Jose. This would also put $370 million back in Californians' pocketbooks from avoided electricity bills, and reduce carbon pollution by 730,000 tons CO2 annually.

CEC's proposal goes in the right direction toward establishing cost-effective, performance-based energy efficiency standards for computer and monitors. **However, NRDC cannot support CEC's proposal as it currently stands because the extended compliance timelines and overly generous allowances and exemptions pose a high risk that projected energy savings and environmental, health, and financial benefits from the standards will not materialize.**

NRDC is confident CEC can address our concerns through limited and reasonable changes to CEC's proposal. We do not challenge the core components of the standards, such as categorization framework

and base allowances. The compliance timeline is unnecessarily long but we think it could still work and achieve the desired savings if the risk of major loopholes were minimized. We believe it is critical for CEC to take the following steps to reduce the risk of losing much of the expected savings through major loopholes due to the combination of extended timelines and overly generous allowances and exemptions.

1. **Limit adders/exemptions:** Reduce the risk of major loopholes by eliminating or adjusting unwarranted padding of allowances and exemptions criteria for tier 2 (2021), based on actual power requirements, as detailed further down and summarized at the end of these comments.
2. **Set up an off-ramp for allowance and exemption with clear thresholds:** Set clear expectations, e.g. in the adoption resolution, that CEC will monitor the market and take action as necessary to preserve projected energy savings from the unexpected market growth of features that are uncommon today but could result in a major loss of savings if they became widespread.

I. Limit Adders/Exemptions - Computers

1. NRDC and its partners demonstrated that CEC's proposed computer standards are technically feasible and cost-effective today. The 4.5-year tier 2 timeline is unnecessarily long and creates a high risk of growing loopholes in the standards, which could cause the loss of much of the expected energy savings

NRDC, the California investor-owned utilities (IOUs) and their consultants, and industry partners such as Aggios, Power Integrations and Rohm Semiconductor, have demonstrated through two prototypes, a tear-down project, and in-depth research and analysis that CEC's proposed tier 2 standards are technically feasible and cost-effective today, using commonly available off-the-shelf components.

The first prototype demonstrated in April 2015, reduced idle power by 54 percent and 61 percent on two desktop computers through fine-tuning of the motherboard, operating system configuration changes, and an inexpensive power supply upgrade. [2]

The second prototype demonstrated in April 2016, cut idle power in half on a higher performance desktop, and featured a commercial-grade prototype of a two-stage power supply that achieves high efficiency at very low load, developed by Power Integrations and Rohm Semiconductor-Powervation. This was achieved with no compromise on performance and user convenience, and at no significant additional cost. [3,4]

[2] http://docketpublic.energy.ca.gov/PublicDocuments/14-AAER-02/TN204796_20150531T235158_Vojin_Zivojnovic_Comments_14AAER2_Desktop_Computer_Optimization.pdf
[3] http://docketpublic.energy.ca.gov/PublicDocuments/14-AAER-02/TN211230_20160425T101319_Aggios_Comments_AGGIOS_Title_20_Workshop_2016_04_26.pdf
[4] http://docketpublic.energy.ca.gov/PublicDocuments/14-AAER-02/TN211597_20160523T081334_Power_Integrations_Comments_On_the_Rulemaking_on_New_Energy_Eff.pdf

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NRDC and Aggios also performed a comparative tear-down of two All-in-One computers, and found that one of these computers used half the energy of the other in short idle mode, and a third in long-idle mode, demonstrating the feasibility of achieving CEC's tier 2 standards with 2014 technology. [5]

The 4.5-year tier 2 timeline creates a high risk of growing loopholes in the standards, which could cause a significant loss in expected energy savings. As the standards are currently written, some machines are exempted or given a large allowance because they have premium or emerging features. While these features may be rare in today's market, and the initial implementation often draws a little extra power, they could be commonplace, or even ubiquitous, four years from now when the second stage of the standard goes into effect, and no longer require any extra power. Continuing to give them an overly generous allowance has the potential to drastically reduce the standard's benefits, and is a point of serious concern.

For example, enhanced performance displays, both for monitors and for the integrated monitors of all-in-one desktops and notebooks, are given an extra allowance of up to 75 percent in tier 1 and 60 percent in tier 2. While only a small number of models on the market today achieve this level of image quality, display technology has historically been trending toward steady increases in resolution, contrast and color gamut, while drawing the same or less power. By the 2021 tier 2 effective date, what is defined today as "enhanced performance" will likely will likely be common or even standard, and require little or no extra power (60 percent is already overly generous today), which will effectively relax the standard by up to 60 percent for many monitors, creating a potentially large loophole in the standards which would wipe out much of the expected savings.

While tier 1 allowances for such features may also be unnecessary, the risk is more limited due to the shorter timeline. We recommend CEC focus on limiting the risk of loophole in tier 2 as this tier is most critical to realize the majority of savings.

1. USB 2.0/3.1 Ports and Headers

CEC proposes the following expandability allowances (Table V-1):

USB 2.0 or less	5
USB 3.0 or 3.1 Gen 1	10
USB 3.1 Gen 2	15
USB ports that can provide 100 or more watts of power	100
USB ports that can provide between 60 and up to 100 watts of power	60
USB ports that can provide between 30 and up to 60 watts of power	30
Unconnected USB 2.0 motherboard header	10 per header
Unconnected USB 3.0 or 3.1 Gen 1 motherboard header	20 per header

This is not aligned with the power values in the USB technical standard:

[5] http://docketpublic.energy.ca.gov/PublicDocuments/14-AAER-02/TN211601_20160523T103613_Pierre_Delforge_Comments_AggiosNRDC_AllInOne_Computer_Idle_Powe.pdf

Table 7-7: USB 2.0 Technical Specification[6]

7.3.2 Bus Timing/Electrical Characteristics

Table 7-7. DC Electrical Characteristics

Parameter	Symbol	Conditions	Min.	Max.	Units
Supply Voltage:					
High-power Port	VBUS	Note 2, Section 7.2.1	4.75	5.25	V
Low-power Port	VBUS	Note 2, Section 7.2.1	4.40	5.25	V
Supply Current:					
High-power Hub Port (out)	ICCPRT	Section 7.2.1	500		mA
Low-power Hub Port (out)	ICCUPT	Section 7.2.1	100		mA
High-power Function (in)	ICCHPF	Section 7.2.1		500	mA
Low-power Function (in)	ICCLPF	Section 7.2.1		100	mA

500 mA at 5 V means the maximum power that can be delivered by a USB 2.0 port is 2.5 W, which is half that proposed in CEC's proposed standards. We see no reason why CEC standards should give a higher allowance than can be technically provided, the intent of the expandability score is to represent the maximum power that can be delivered by each interface.

Table 11-2: USB 3.1 Technical Specification[7]

11.4.5 VBUS Electrical Characteristics

Table 11-2. DC Electrical Characteristics

Parameter	Symbol	Conditions	Min.	Max.	Units
Supply Voltage:					
Port (downstream connector)	VBUS		4.45	5.25	V
Port (upstream connector)	VBUS		4.0		V
Supply Current:					
High-power Hub Port (out)	ICCPRT		900		mA
Low-power Hub Port (out)	ICCUPT		150		mA
High-power Peripheral Device (in)	ICCHPF			900	mA

900 mA at 5 V means the maximum power that can be delivered by a USB 3.1 port is 4.5 W, which is less than half that proposed in CEC's proposed standards.

[6] http://www.usb.org/developers/docs/usb20_docs/, USB_20.pdf, Section 7.3.2 , Table 7-7
[7] http://www.usb.org/developers/docs/, USB_3_1_r1.0.pdf, Section 11.4.5 , Table 11-2

In summary, CEC's proposal is more than twice as high as the power specifications in the technical USB standard for USB 2.0 and USB 3.x SuperSpeed:

	CEC	USB Tech Standard
USB 2.0	5 W	2.5 W
USB 3.1	10 W	4.5 W

Given that desktop computers can have 10 to 15 such ports, this adds up to between 30 and 50 watts in extra, unwarranted allowance, a significant amount that can move many computers to a higher category.

To illustrate the impacts of this overly generous USB allowance, two of three sample desktops below would move to a higher category, getting 20 to 30 kWh (tier 1) or 10 to 15 kWh (tier 2) or unwarranted allowance.

Lenovo ThinkCenter M83	HP EliteDesk 705 SFF	Alienware Aurora R5
220 (**Cat 1**) ➔ 255 (**Cat 2**)	257 (Cat 2) ➔ 290 (=)	410 (**Cat 2**) ➔ 460 (**Cat 3**)

We recommend aligning CEC's expandability scores for USB 2.0 and 3.1 ports with the USB technical standard as referenced in Tables 7-7 and 11-2, and the scores for unconnected USB headers accordingly to 5 and 10 watts.

2. High Expandability Exemption

CEC proposes to exempt certain computers from annual energy consumption requirements. One of the criteria for exemption is the presence of a graphics processing unit (GPU) with a frame buffer bandwidth of **400 GB/s** (Jan 1, 2019), and **600 GB/s** (Jan 1, 2021).

The problem is that these values will likely be common in the computer market by 2019 and 2021. AMD and NVIDIA'S product roadmaps show planned introductions of top-end GPUs that exceed both thresholds by 2017, two years before tier 1 and 4 years before tier 2. These new architectures are likely to be common across enthusiast platforms by 2019, and perhaps across most product lines by 2021.

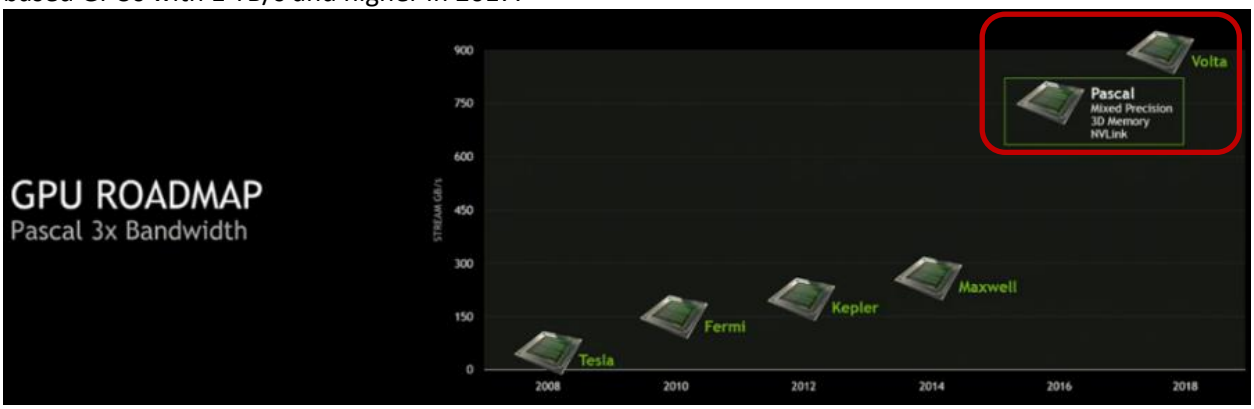
AMD already released a GPU with 512 GB/s in 2015, and is planning to release GPUs with 1 TB/s in 2018.[8]

[8] http://wccftech.com/amd-greenland-gpu-hbm2-14nm-2016/

AMD Graphics Architectures

WCCFTech	Year	Product	GPU	Process	Transistors In Billions	Performance	Memory	Bandwidth
Southern Islands	2012	HD 7970 Ghz	Tahiti	28nm	4.3	4.1 TFLOPS	3GB GDDR5	264GB/s
Volcanic Islands	2013	R9 290X	Hawaii	28nm	6.2	5.6 TFLOPS	4GB GDDR5	320GB/s
Caribbean Islands	2015	R9 Fury X	Fiji	28nm	8.9	8.6 TFLOPS	4GB HBM1	512GB/s
POLARIS	2016	RX 480	Polaris 10	14nm	5.7	5.2 TFLOPS	8GB GDDR5	256 GB/s
VEGA	2017	TBA	Vega 10	14nm	12-15	12 TFLOPS	16GB HBM2	512 GB/s
VEGA	2018	TBA	Vega 20	7nm	-	-	32GB HBM2	1 TB/s
NAVI	2019	TBA	Navi 10	7nm	-	-	Nextgen Memory	-

NVIDIA is planning to launch its "Pascal" GPU architecture with up to 1 TB/s in 2016, and its "Volta"-based GPUs with 1 TB/s and higher in 2017. [9,10]



NRDC is not opposed to the principle of exemptions when they are meant to provide some flexibility for the very first versions of new technologies, which may not yet have been successfully optimized for energy efficiency in idle mode, and are in very low volumes and therefore have limited impacts on savings. However, the roadmap information published by GPU manufacturers shows that **new GPU technologies will exceed the proposed thresholds as soon as 2017**, and will most likely have moved to mass-adoption in the enthusiast segment by 2019.

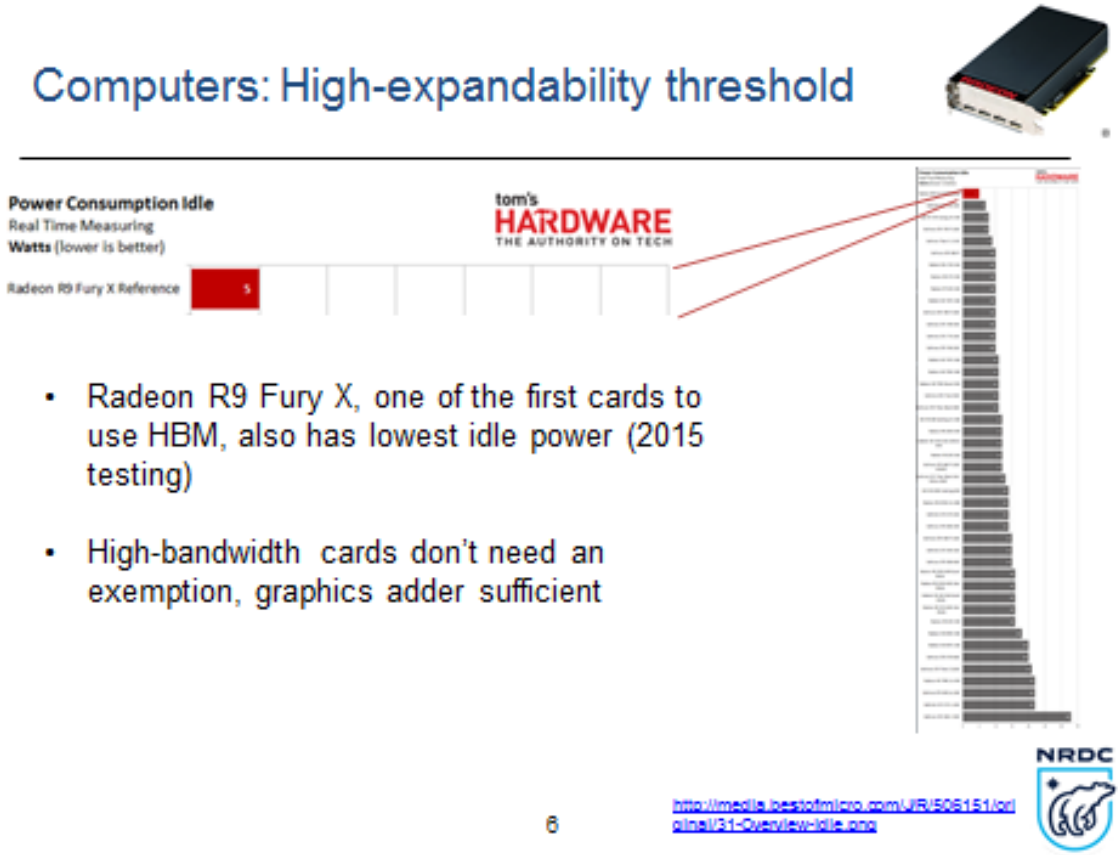
In addition, power data from the AMD R9 Fury X, the GPU that has the highest frame buffer bandwidth on the market currently, is also the most efficient of high-end GPUs currently on the market. **Therefore there is no evidence that discrete GPUs with high frame buffer bandwidth need an exemption**, on the contrary the only power data currently available shows that they can achieve standards levels with the discrete graphics adder.

[9] http://wccftech.com/nvidia-pascal-volta-gpu-leaked-2017-2018/
[10] http://videocardz.com/55218/nvidia-unveils-roadmap-for-2015-2018

Low-cost HBM technology makes the prospect of widespread high-bandwidth memory adoption by tier 2 and potentially even tier 1 more likely: cost has been the main factor of uncertainty around the speed of HBM adoption. But Samsung recently announced low-cost HBM memory that could accelerate HBM adoption across mainstream computers starting in 2019.[11]

The inclusion of integrated graphics in the exemption criteria makes the risk of loophole even higher. By including integrated graphics in the scope of the exemption, CEC risks making this loophole larger, as it could then apply to all computers on the market, vs. only those with discrete graphics. The lack of evidence on the need for an exemption discussed above applies to integrated graphics too. CEC's proposal already provides an adder for high-bandwidth memory, and these forms of memory tend to be more efficient than conventional types of memory, therefore the HBM adder is sufficient. **NRDC strongly recommends eliminating this exemption for both discrete and integrated graphics.**

Figure 1: Idle Power Draw of AMD Radeon R9 Fury X[12]



[11] http://www.extremetech.com/gaming/234333-hbm-everywhere-samsung-wants-hbm3-low-cost-options-to-blow-the-doors-off-the-memory-market

[12] http://media.bestofmicro.com/J/R/506151/original/31-Overview-Idle.png

Why this matters: overly generous exemptions threshold could result in exempting a large number of gaming computers, which are the highest-energy using segment of the market, with roughly 20 percent of all computer energy use.[13]

Frame buffer bandwidth is not the only criterion, high-expandability computers must also have a 600 W-rated power supply. **If the GPU bandwidth criterion became too weak, this would provide an incentive for manufacturers to oversize power supplies** to meet exemption criteria, potentially leading to lower efficiencies and higher energy use.

NRDC proposal: The AMD roadmap shows a doubling of frame buffer bandwidth each year over the past 3 years. While this pace will not necessarily be sustained, if continued it would lead to the top-end GPUs to have **2TB/s in 2019, 4TB/s in 2020, and 8 TB/s in 2021**.

Given the uncertainty in projecting this performance characteristic several years out, and the lack of evidence that these cards require an exemption and cannot achieve the standards with the normal graphics adder (market data suggests they can per the AMD Fury X GPU), **NRDC recommends the following exemption thresholds:**

Tier 1 (Jan.1, 2019)	1 TB/s, for GDDRx memory only
Tier 2 (Jan 1, 2021)	No exemption

NRDC agrees with ITI's proposal to align the tier 2 date for this GPU exemption with the tier 2 data for computer standards but only with the above revised exemption thresholds. Otherwise a one-year tier 2 delay with an inappropriate exemption would further increase this loophole in the standards.

3. 256-Bit Memory Interface and 4-channel memory

CEC's proposal would provide a 100-point expandability allowance to computers with CPU support for a 256-bit memory interface.

This is problematic for three reasons:

- First, the definition of memory interface is too vague and opens the door for unintended uses of this provision.
- Second, these thresholds will likely be achieved on many products in the near future given new technologies such as HBM, Wide I/O and HMC.
- Third, memory interface width and channels are unrelated to expendability and should be managed through an adder if at all, rather than through an expandability allowance.

Definition of memory interface: There are several potential memory interfaces that can be supported by CPUs. These include RAM memory as well as CPU- and GPU-integrated cache memories. CEC could

[13] Mills N. and Mills E., "Taming the energy use of gaming computers", LBNL, 2015, http://rd.springer.com/article/10.1007%2Fs12053-015-9371-1

clarify the definition to only cover system memory, not CPU- and GPU-integrated cache memories, but we recommend eliminating this provision instead as discussed further down.

256-bit threshold: There are several emerging memory technologies that will easily exceed the 256-bit threshold.

In terms of RAM memory, HBM2 (high-bandwidth memory 2), the next generation memory technology that will hit the market in 2017, will achieve 256-bit by default. This threshold will therefore be met in 2017, and will be common by 2019.

Forthcoming integrated GPUs from AMD are likely to include HBM2 memory and so if the CPU/integrated GPU memory interface is included within the scope of the allowance then many products with AMD integrated GPUs will be allowed the extra 100 points, irrespective of performance. Intel includes eDRAM alongside some of its higher end integrated GPUs which could have 256-bit memory interfaces going forward.

GPUs already achieve memory interface widths of up to 4096 bits.

GPU Memory Math					
	AMD Radeon R9 290X	NVIDIA GeForce GTX 980 Ti	AMD Radeon R9 Fury X	Samsung's 4-Stack HBM2 based on 8 Gb DRAMs	Theoretical GDDR5X 256-bit sub-system
Total Capacity	4 GB	6 GB	4 GB	16 GB	8 GB
Bandwidth Per Pin	5 Gb/s	7 Gb/s	1 Gb/s	2 Gb/s	10 Gb/s
Number of Chips/Stacks	16	12	4	4	8
Bandwidth Per Chip/Stack	20 GB/s	28 GB/s	128 GB/s	256 GB/s	40 GB/s
Effective Bus Width	512-bit	384-bit	4096-bit	4096-bit	256-bit
Total Bandwidth	320 GB/s	336 GB/s	512 GB/s	1 TB/s	320 GB/s
Estimated DRAM Power Consumption	30W	31.5W	14.6W	n/a	20W

While GPUs typically have higher memory interface width than CPUs, the technology exists and is likely to rapidly percolate to CPUs, particularly for CPUs with on-board HBM memory like AMD's APUs.

Other new memory technologies such as Wide I/O and hybrid memory cube (HMC) also have wide bus interfaces, [14] and Intel is preparing to release their Optane (3D Xpoint) memory/storage devices to market in the very near future. Data transfer rates of these products will be many times faster than

[14] http://www.extremetech.com/computing/197720-beyond-ddr4-understand-the-differences-between-wide-io-hbm-and-hybrid-memory-cube

conventional solid-state drives. Details of the memory interface for Optane products are not available but given the data transfer rates they may have memory interfaces at 256-bits or greater.

Some of these new memory technologies are already growing in the market (HBM), others are likely to enter in 2017 and potentially become much more common by 2019 and standard by 2021, making this 256-bit threshold very common.

Lastly, **memory interface width has nothing to do with expandability**, and already receives an adder through the HBM adder. While the commission proposal includes language to avoid "double-dipping," this language does not cover the memory interface.

NRDC proposal: Given that memory interface does not correlate with expandability, **we recommend that CEC eliminate the expandability allowance for 256-bit and 4-channel memory, and rely solely on the HBM adder instead.**

4. Integrated Display Adder for Integrated Desktop Computers and Notebooks

The enhanced performance display adders for integrated displays are too high per our comments on monitors. They should be adjusted consistently with our recommendation for monitors.

5. "Other" Secondary Storage Adder

CEC's proposal provides various allowances for various types of secondary storage depending on the storage type. NRDC supports the IOUs analysis and recommendation docketed on May 23, 2016 that the allowance for 3.5-inch drives should be 12 kWh, or at most 17, instead of 26.[15] But the biggest risk of loophole is the open-ended "Other" allowance of 26 kWh, given to any type of secondary storage that doesn't meet existing storage types.

Intel's upcoming "Optane" storage devices could for example be considered Other. While we don't know the power consumption of these devices, it will most likely be much lower, and the setting of an appropriate allowance, if necessary, would be better managed through CEC's petition process rather than give a very large allowance that is not based on any power data for any specific technology.

NRDC proposal: Ideally 12 kWh for 3.5-inch and 0.5 kWh for "Other" secondary storage. 17 and 1 kWh would be reasonable compromises.

[15] http://docketpublic.energy.ca.gov/PublicDocuments/14-AAER-02/TN211614_20160523T163525_California_Investor_Owned_Utilities_Comments_California_Investo.pdf

II. Limit Adders/Exemptions - Monitors

1. Gaming monitors

CEC's proposed standard would give adders of **30% to 35% (tier 1)** and **20% to 35% (tier 2)** for monitors that can adjust their refresh rate to match that of the GPU, providing for smoother display of gaming action scenes.

This adder is unwarranted for the following reasons:

1. **The test method doesn't exercise the variable refresh rate functionality**. The test method specifies the use of a test computer with fixed refresh rate. There is no processing to do by the monitor to adjust the refresh rate and therefore no reason for the monitor to draw more power than a standard monitor in a world of silicon-level power scaling.

2. **A majority of gaming monitors currently on the market already complies with no adder.** NRDC analyzed the ENERGY STAR version 6 qualified products list (QPL), cross-referencing with lists of monitors that support FreeSync and Gsync technologies. ENERGY STAR v6 had over 90 percent penetration rate by July 2016 and is therefore representative of the entire market. We found that **73% of Gsync and 57% FreeSync monitors on the market today already comply with CEC proposed levels with no adder**. This demonstrates that gaming monitors need no adder today, and certainly not 2.5 years and 4 years after standards adoption.

NRDC recommends eliminating the gaming monitor adder for both Tier 1 and Tier 2. But given the shorter timeline, we could accept a reduced 10% adder for Tier 1 as a reasonable compromise.

2. Enhanced Performance Displays (EPD) Adder

CEC's proposal would give adders ranging from 20 to 75% to enhanced-performance displays.

While there are few such displays currently on the market, NRDC's analysis shows that **63% of sRGB**, and **48% of Adobe-RGB ENERGY-STAR v6**-qualified EPDs already achieve CEC's tier 2 levels today (with proposed adders), and **100% of ENERGY STAR v7-qualified Adobe-RGB EPDs** pass CEC tier2. This gives a strong indication that in 4.5 years from now, most or all would qualify without any power optimizations.

CEC proposed adders are much higher than ENERGY STAR v7: According to analysis by the Northwest Energy Efficiency Alliance (NEEA), the ENERGY STAR v7 adders of 15% and 65% are applied after subtracting the resolution component of TEC, whereas CEC's proposal applies to total system power. Applying the ENERGY STAR adders using CEC's approach would result in adders of roughly **9%** for sRGB (vs. **30%** tier 1 and **20%** tier 2 for CEC), and **37%** for Adobe-RGB (vs. **75%** tier 1 and **60%** tier 2 for CEC), less than half the values proposed by CEC.

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ENERGY STAR v7 EPD adders:

Table 2: Calculation of Energy Allowance for Enhanced Performance Displays

Color Gamut Criteria	E_{EP} (kWh) *Where:* ▪ E_{TEC_MAX} *is the Maximum TEC requirement in kWh; and* ▪ *r is screen resolution in megapixels*
Color Gamut support is 32.9% of CIE LUV or greater.	$0.15 \times (E_{TEC_{MAX}} - 6.13 \times r)$
Color Gamut support is 38.4% of CIE LUV or greater.	$0.65 \times (E_{TEC\_MAX} - 6.13 \times r)$

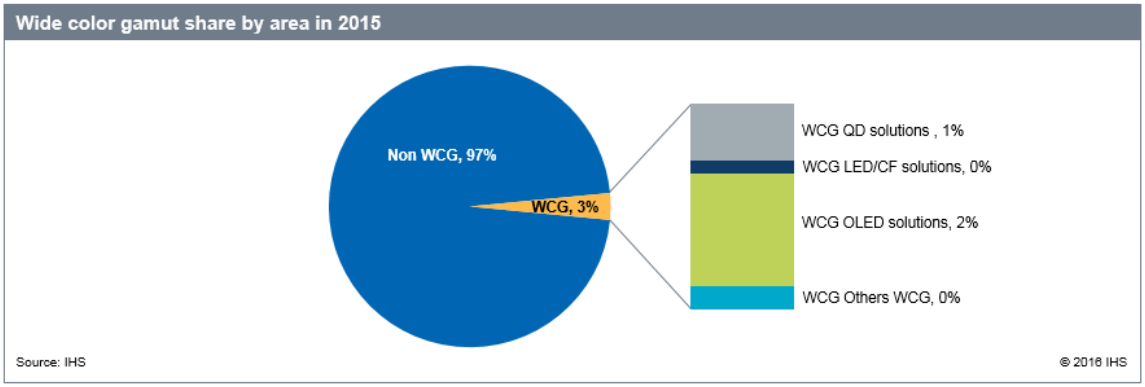
Note: A model supporting greater than 99% of the sRGB color space translates to 32.9% of CIE LUV and a model supporting greater than 99% of Adobe RGB translates to 38.4% of CIE LUV.

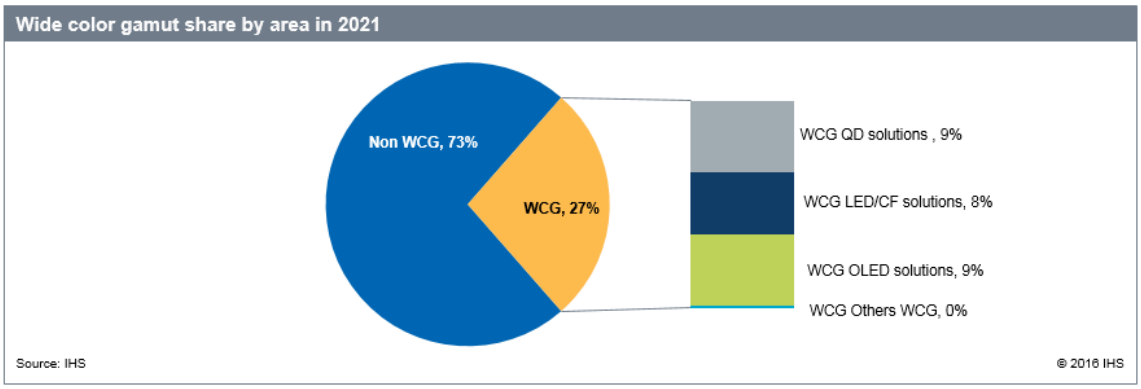
EPDs are likely to become much more common: Display technology has historically evolved toward higher qualify (resolution, color gamut, contrast), while using the same or less energy. As technology evolves, the EPD criteria are become relatively easier to achieve and we can expect EPDs to become more common, while using less energy. The currently proposed adders constitute a very large potential loophole in the standards.

NEEA market research has revealed the following publicly posted wide color gamut (WCG) research summary by IHS[16]:

> *According to the IHS Wide Color Gamut Market Tracker, aside from OLED and quantum dot (QD), technologies like light-emitting diode (LED)—LED packages and color filters—have been improved by panel makers. LED solutions are still deemed the most competitive wide color gamut technology in terms of production cost. LED TVs have failed to attract the attention of consumers in the past, probably because of high prices and low interest in color reproduction. Nowadays, however, phosphors with high purity and high performance are being applied to mass-produced products, and considerable improvements have been made in terms of color reproduction. Therefore, there has been growing adoption of LED solutions in the mid-range TV, monitor, and notebook PC market where price competition is especially fierce.*
>
> *Furthermore, along with wide color gamut solutions, high dynamic range (HDR) technology began to be used as a selling point in the TV market in 2015, receiving favorable responses from consumers. The growing attention to new technologies like HDR will also likely contribute to the expansion of the wide color gamut display market.*
>
> *Simply put, driven by three factors—improved understanding among consumers, enhanced technologies such as OLED and QD, and marketing campaigns focusing on premium displays—the wide color gamut display market is forecast to grow steadily. The share of wide color gamut displays hovered around 3% in 2015, but* ***it is projected to be 27% of the total display market in 2021****. Wide color gamut technology will become a key requirement in the high-end display market.*

[16] http://blog.ihs.com/wide-color-gamut-technology-emerging-as-a-key-requirement-for-high-end-displays





Research by NEEA shows that the three monitors #1, 2, 18 in Tables 1 and 2 below cost less than $450—compared to $100-150 price range for volume LCD monitors—and two of them offer 99% of the Adobe RGB color space. There is still a significant price gap between WCG and volume displays, but WCG prices have fallen well below the four figure price tags for yesterday's professional displays with WCG and are approaching the price range which would allow them to go mainstream.

Table 1 – Sample EPD Monitors from 144HzMonitors.com[17]

Category	ID	Model	Price	Diagonal	Type	85º Contrast	Resolution	Mega-pixels	Gamut	ESTAR Power (w)	EPD	VHPD
Entry-level Photo Editing Monitor	1	ASUS PA248Q	$300	24	IPS		1920x1200	2.3	100% sRGB	19.9	X	
Budget Wide Gamut Display	2	ASUS PA249Q	$400	24	AH-IPS	60	1920x1200	2.3	99% Adobe RGB		X	
Gaming and Graphic Design Monitor	3	ASUS MG279Q	$500	27	IPS		2560x1440	3.7	100% sRGB		X	
	4	ASUS PB278Q	$380	27	IPS	89	2560x1440	3.7	100% sRGB	24.9	X	
UltraWide 1440p 10-bit IPS Monitor	5	LG 34UM95	$800	34	IPS		3440x1440	5	99% sRGB		X	
High-end 10-bit Color Accuracy Monitor	6	ASUS PA279Q	$750	27	AH-IPS		2560x1440	3.7	99% Adobe RGB		X	
	7	Samsung S32D850T	$400	32			2560x1440	3.7	100% sRGB		X	
	8	BenQ BL3200PT	$500	32	IPS		2560x1440	3.7	100% sRGB		X	
	9	NEC PA272W	$900	27	AH-IPS		2560x1440	3.7	99.3% Adobe RGB		X	
Best 4K Photo and Video Editing Monitors	10	BenQ BL3201PH	$800	32	IPS	60	3840x2160	8.3	100% sRGB	38.1	X	
	11	BenQ BL2711U	$600	27	IPS		3840x2160	8.3	100% sRGB		X	
Professional True 10-bit Monitors for Photography	12	HP DreamColor Z27;	$1,200	27	AH-IPS		2560x1440	3.7	100% Adobe RGB		X	
	13	Eizo ColorEdge CX27	$1,400	27	IPS		2560x1440	3.7	99% Adobe RGB		X	
	14	NEC PA322UHD	$3,000	32	IPS		3840x2160	8.3	99.2% Adobe RGB			X
17:9 True 10-bit 4K Monitor	15	LG 31MU97	$900	31	IPS		4096x2160	8.9	99.5% Adobe RGB			X

Table 2 – Adobe-RGB EPD Monitors from ENERGY STAR v7 Qualified Product List

OEM	ID	Model	Price	Diagonal	Type	85º Contrast	Resolution	Mega-pixels	Gamut	ESTAR Power (w)	EPD II	VHPD
ASUS	16	PA329Q, PA329QR, PA329QE, PA329Q-P	$1,200	32	VA LCD	60	3840 x 2160	8.3	99% Adobe RGB	47.49	X	X
DELL	17	UP3216Q	$1,400	31.5	PLS LCD	66	3840 x 2160	8.3	99% Adobe RGB	44.21	X	X
DELL	18	P2415Q	$400	23.8	IPS LCD	60	3840 x 2160	8.3	99% Adobe RGB	29.5	X	X
PHILIPS	19	328P6VJEB	$900	31.5	P-Line		3840 x 2160	8.3	99% Adobe RGB	42.17	X	X
DELL	20	UP3017	$1,000	29.7	IPS LCD	112	2560 x 1600	4.1	99% Adobe RGB	37.81	X	
HP	21	Z30i IPS Display	$1,100	29.8	IPS LCD	70	2560 x 1600	4.1	99% Adobe RGB	36.3	X	
DELL	22	UP2716D	$600	27	IPS LCD	94	2560 x 1440	3.7	99% Adobe RGB	27.99	X	
AOC	23	E2798SH		27	TN LCD		1920 x 1080	2.1	99% Adobe RGB	18.03	X	
AOC	24	E2280SWDN	$100	21.5	TN LCD		1920 x 1080	2.1	99% Adobe RGB	15.24	X	
AOC	25	E2280SWN		21.5	TN LCD		1920 x 1080	2.1	99% Adobe RGB	14.06	X	

NRDC proposal: In the tier 2 timeframe, we think it is really important to give no adder to sRGB EPDs, and a much more limited adder to Adobe-RGB EPDs. In the tier 1 timeframe, we are open to adders more in line with ENERGY STAR v7 adders as proposed below:

	EPD with 32.9% of CIELUV(sRGB)	EPD with 38.4% of CIELUV (Adobe RGB)
Tier 1	10%	50%
Tier 2	0%	25%

[17] http://www.144hzmonitors.com/best-photo-editing-monitor-2016/, research by NEEA. Price rounded to nearest $100 based on Amazon or other online retailer listing. Could not confirm that all monitors above met the EPD contrast ratio requirement; although, few ENERGY STAR models fail to meet the requirement.

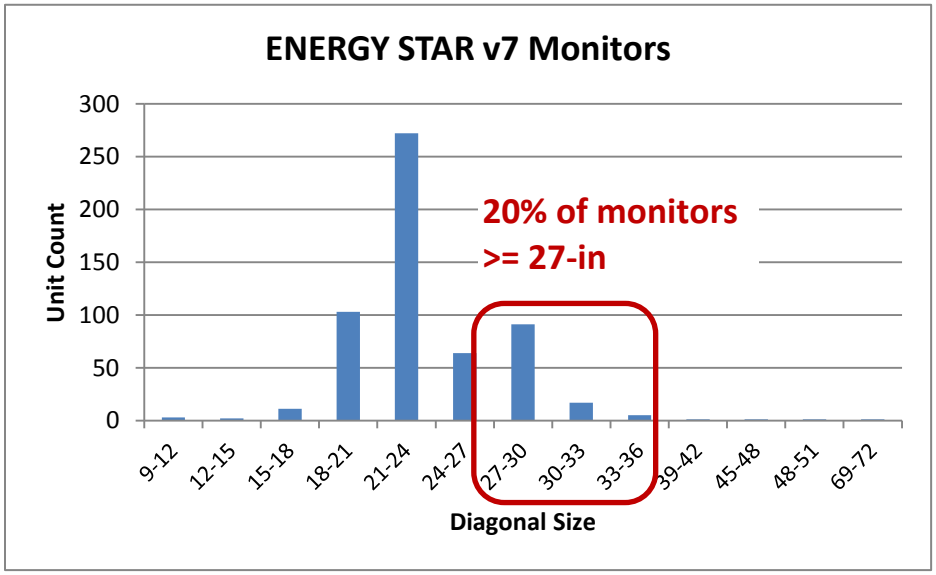
3. Very High Performance Monitors Exemption

CEC's proposal would exempt monitors that meet all of the following criteria:

1. Diagonal size greater than 27-in
2. Resolution greater than 3840x2160 pixels or 8.2 MP (4K)
3. Color space greater than 99% Adobe-RGB or DCI-P3

NRDC is not opposed to an exemption for the truly very high-performance products, but the proposed criteria are not a very high-bar and will likely cover a significant share of the market by 2019 and 2021:

1. Diagonal size greater than 27-in: 20 percent of ENERGY STAR v7-qualified monitors already meet this requirement today



2. Resolution greater than 3840x2160 pixels or 8.2 MP: this is equivalent to 4K, which is rapidly becoming the new standard in the market and will be by 2019.[18] With just 3 more inches diagonal size, the 4k monitor in Tables 1 and 2 above—the Dell P2415Q—would qualify for this exemption, and at $350 it is priced for volume sales.
3. Color space greater than 99% Adobe-RGB or DCI-P3: as discussed in the previous section on EPDs, historical technology trends suggest this will no longer be a high bar by 2019, and definitely by 2021.[19] It is possible that low cost WCG twisted nematic (TN) displays popular with gamers for their wide color gamut will qualify for this exemption. Walmart offers a 22 inch, 2.1 megapixel TN. display with 99% Adobe RGB for $90 (Model E2280SWDN). TN displays have poor

[18] http://4k.com/news/4k-tv-market-to-reach-52-billion-in-revenues-by-2020-6655/
[19] See IHS post above

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off-angle viewing, so the application of the off-angle contrast requirement used in the definition of EPDs would mitigate the risk of low cost, volume TN displays qualifying for this exemption.[20]

In addition, monitors larger than 30-inch are already getting a very lenient limit equivalent to ENERGY STAR v6, rather than ENERGY STAR v7, they should be able to meet this limit easily. The proposed exemption is more justified for 27- to 30-inch monitors due to the higher stringency of proposed standards (ENERGY STAR v7-equivalent levels), and as a short-term measure (tier 1 only, not tier 2) to give manufacturers time to reengineer their products.

NRDC proposal: Limit the exemption to tier 1, eliminate it for tier 2. And add the following off-angle contrast requirement:

> *A contrast ratio of at least 60:1 measured at a horizontal viewing angle of at least 85º, with or without a screen cover glass*

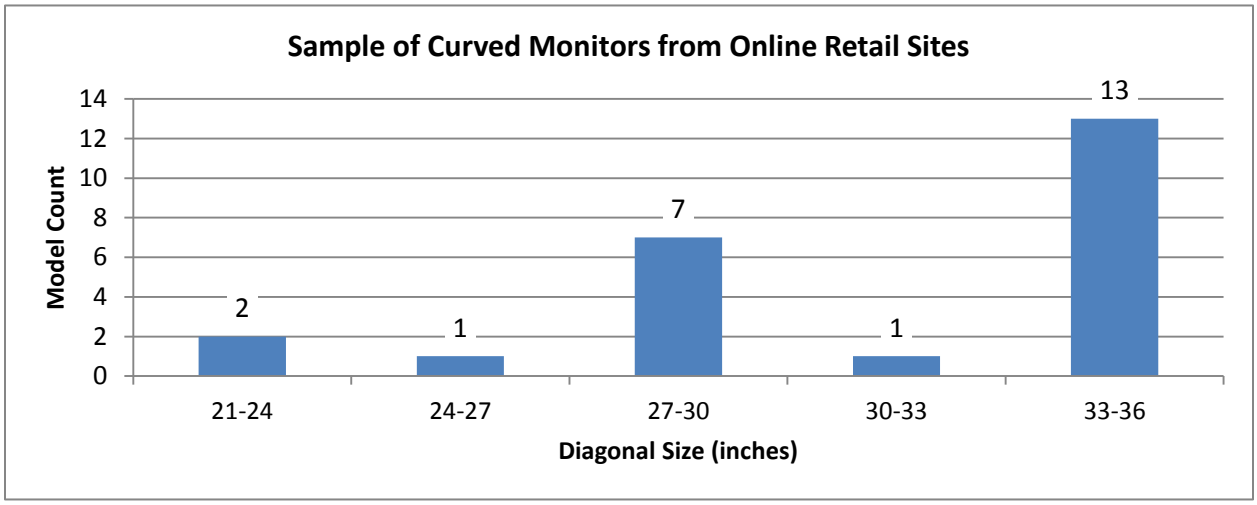
This would significant reduce the risk of too many monitors getting exempted.

While NRDC opposes a very high performance exemption in tier 2 as currently defined, if there must be one, it should be more selective than currently defined in order to limit the risk of savings loss. At a minimum the threshold should be raised to 30-inch diagonal size, and the contrast ratio and viewing angle requirements added for both Tier 1 and Tier 2.

4. Curved Monitors Adder

CEC's proposed standard would give adders of **30% (tier 1)** and **20% (tier 2)** for curved monitors.

Curved monitors could become relatively common for large size monitors: NRDC found 24 models on just two online retail sites (Amazon and BestBuy), half of them in the 33-36 inch size range, and another 30 percent of them in 27-30 inch size range.



[20] Based on analysis by NEEA.

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10 of these 24 models (42%) qualified for ENERGY STAR version 6, 8 of them (33%) could meet CEC proposed levels without an adder. If one third can already meet levels without an adder, we can expect that many more will by 2019 and 2021.

From a technology perspective, curved monitors are no less efficient than flat ones: they use a curved light guide plate which emits light perpendicular to its surface, just as a flat one does. The 8 existing curved monitors that meet CEC levels without an adder are a demonstration of their technical feasibility.

NRDC recommends CEC provides no adder for curved monitors in Tier 2, and potentially a reduced 10% adder for Tier 1 although current data suggests this is not necessary.

5. Touch Screen Capability Adder

CEC's proposal would give monitors with touch screen capability an additional 1 watt allowance per mode in on, sleep, and off modes.

NRDC is not opposed to this allowance in modes where the touch functionality is enabled, but there is no reason to give it to off and sleep modes if the functionality is not enabled in those modes.

NRDC proposal: apply the 1 W extra allowance only to modes where touch functions are available.

6. Cumulative Adders (Adder Stacking)

CEC proposed that no more than one adder can be applied per unit. Industry requested that adders can be cumulated across certain categories. While NRDC supports this proposal in principle, it only works in practice if adders are right-sized. When adders are higher than warranted (as they currently are in CEC's proposal per these comments), or become higher than warranted over time as manufacturers optimize the energy efficiency of emerging features, then **a monitor could end up with a power allowance of 3x** (1.75 for EPD * 1.30 for gaming * 1.30 for curved + 1 watt for touch) which is far higher than is actually required for these monitors.

NRDC proposal: NRDC would agree with cumulative adders only if they were right-sized, and mostly sunset for tier 2, as recommended in these comments.

7. Testing of Exempted Products

In the October 10, 2016 public meeting, industry proposed that "Exempted Computer Monitors should not be required to test and report power consumption information (no value add)".

NRDC strongly disagrees: testing and reporting power draw is important to enable CEC to monitor the market, evaluate if the exemptions are still needed, and adjust the standards as needed. It helps provide valuable comprehensive market information as well as with enforcement.

If the exemptions only apply to a very small portion of the market as intended, this should not constitute a significant burden for industry, and the policy benefits clearly outweigh the small burden on industry.

III. Allowance and Exemption Off-Ramp

NRDC recommends that CEC set up a clear process to monitor the market and take action as necessary to preserve projected energy savings from potential loopholes.

Scope: Give that it is impossible to predict which loopholes may develop, the scope of the process should be kept broad in order to give CEC flexibility to apply it as needed. It should apply in particular to:

- Tier 1 and tier 2: tier 1 will be in effect until 2021, which is enough time for the market share of certain features to grow significantly and warrant reducing or eliminating an adder before tier 2.
- All adders, expandability allowances, and exemptions, whether given to rare features, or to common features such as computer memory and integrated display. ENERGY STAR v2.0 for servers is an example where memory allowances rapidly became several-fold higher than warranted and resulted in system-level energy allowances that were roughly twice as high as the average server consumed. Keeping common features in scope will allow CEC address this type of situation.

Adders and exemptions in scope

Computers	**Monitors**
Adders	**Adders**
All adders in Table V-8	All adders in Table V-5
	Touch screen capability
Exemptions	**Exemptions**
High-expandability computers	Very high performance monitor
Workstations	
Expandability allowance	
All interface types listed in Table V-1	

Market Monitoring: The market share of specific features of computers and monitors is not publicly available information and NRDC is not aware that such detailed information can even be obtained from industry analysts. Instead we recommend that CEC use product model information from its registration database as a proxy for market share. While model information may be different from sales, it is a commonly used proxy for policy purposes, such as by the ENERGY STAR program.

Trigger: For uncommon/emerging features, we recommend CEC sets the trigger threshold for opening a rulemaking at 20 percent of models registered in the database over the last 6 months. It is important to react early because of the rapid pace of evolution of the computer market, and the 18 to 24-month expected time lag between opening a rulemaking and the rule going into effect.

For common features that get adders, such as integrated displays and memory, if 75 percent of models registered in the database over the last 6 months pass without the adder or with a significantly reduced adder, CEC should reopen a rulemaking to assess the adder.

IV. NRDC RECOMMENDED CHANGES TO EXPRESSED TERMS

We provide below redline edits to the commission's draft expressed terms:

Computers

"High expandability computer" means a computer with any of the following:

(1) An expandability score of more than 690;

(2) If the computer is manufactured before January 1, 2020, a power supply of 600 watts or greater and a discrete ~~or integrated~~ graphics with a frame buffer bandwidth of ~~400 gigabytes per second (GB/s)~~ 1 terabytes per second (TB/s) or greater.~~; or~~

~~(3) If the computer is manufactured on or after January 1, 2020, a power supply of 600 watts or greater and a discrete or integrated graphics with frame buffer bandwidth of 600 gigabytes per second (GB/s) or greater.~~

Table V-1 - Interface Types and Scores for Expandability Score Calculation

Interface Type	*Interface Score*
USB 2.0 or less	~~5~~ 2.5
USB 3.0 or 3.1 Gen 1	~~10~~ 4.5
Unconnected USB 2.0 motherboard header	~~10~~ 5 per header
Unconnected USB 3.0 or 3.1 Gen 1 motherboard	~~20~~ 10 per header
…	
~~CPU Support for 4 channels of memory or a 256 bit or greater memory interface~~	~~100~~

Table V-8 – List of Potentially Applicable Adders

Function	*Desktop Computer, Mobile Gaming System, and Thin Client Adder (kWh/yr)*	*Notebook Computers and Portable All-In-One Adder (kWh/yr)*
Storage device other than primary storage device	3.5-inch Drive: ~~26~~ 12 2.5-inch Drive: 4.5 Solid-State Drive (SSD): 0.5 Solid-State Hybrid Drive (SSHD): 1.0 Other: ~~26~~ 0.5 per storage	

	device	
Integrated Display Where: "d" is the diagonal measurement of the display in inches "r" is the megapixel resolution of the display "A" is the viewable screen area in square inches EP=0 for displays that are not enhanced performance displays	For d≤20: (8.76*0.35*(1+EP)* [(4.2*r)+5.7])*0.8 For 20<d<23: (8.76*0.35*(1+EP)* [(4.2*r)+(0.02*A)+2.2])*0.8 For 23≤d<25: (8.76*0.35*(1+EP)* [(4.2*r)+(0.04*A)-2.4])*0.8 For 25≤d: (8.76*0.35*(1+EP)* [(4.2*r)+(0.07*A)-10.2])*0.8 Resolutions greater than 6 megapixels shall use 6 for r. On or after July 1, 2019: EP=~~0.3~~ 0.1 for displays with a color gamut support of 32.9% of CIELUV or greater (99% or more of defined sRGB colors); and EP=~~0.75~~ 0.5 for displays with a color gamut support of 38.4% of CIELUV or greater (99% or more of defined Adobe RGB colors). On or after January 1, 2021: EP=~~0.2~~ 0 for displays with a color gamut support of 32.9% of CIELUV or greater (99% or more of defined sRGB colors); and EP=~~0.6~~ 0.25 for displays with a color gamut support of 38.4% of CIELUV or greater (99% or more of defined Adobe RGB colors).	

Monitors

Table V-5 - List of Potentially Applicable Adders

Computer Monitor Type	*Models manufactured on or after July 1, 2019, and before January 1, 2021*	*Models manufactured on or after January 1, 2021*

Enhanced Performance Display with a color gamut support of 32.9% of CIELUV or greater (99% or more of defined sRGB colors)	~~1.30~~ 1.10	~~1.20~~
Enhanced Performance Display with a color gamut support of 38.4% of CIELUV or greater (99% or more of defined Adobe-RGB colors)	~~1.75~~ 1.50	~~1.60~~ 1.25
Gaming Monitors ~~without incremental hardware-based assistance~~	~~1.30~~ 1.1	~~1.20~~
~~Gaming Monitors with incremental hardware-based assistance~~	~~1.35~~	~~1.35~~
Curved Monitor	~~1.30~~ 1.10	~~1.20~~

(4) **Computer monitors**. Computer monitors manufactured on or after July 1, 2019, shall comply with all of the following:

(A) Comply with the maximum on-mode standards in Table V-4.

(B) Comply with at least one of the following requirements:

1. Consume less than or equal to 0.7 watt in sleep mode and less than or equal to 0.5 watt in off mode;

or

2. Consume less than or equal to 1.2 watts in sleep mode and off mode power combined.

(C) Be shipped with a screen luminance less than or equal to 200 cd/m2 ± 35 percent. A manufacturer may ship with additional features enabled, even if they were turned off in testing.

(D) Computer monitors with touch screen capability are allowed an additional 1 watt allowance per mode in ~~on, sleep, and off~~ modes where the touch functionality is enabled.

"**Very high performance monitors**" means a computer monitor that meets all of the following criteria:

(1) Has a diagonal screen size of between 27 and 30 inches ~~or greater~~;
(2) Has a resolution equal to or greater than either 3840x2160 pixels or 8.2 Megapixels; and

(3) Has a color space greater than 99 percent of defined AdobeRGB color or greater than 99 percent of Digital Cinema Initiative (DCI)-P3 colors;
(4) Has a contrast ratio of at least 60:1 measured at a horizontal viewing angle of at least 85º, with or without a screen cover glass.

1605.3 (v) (4) (F) **EXCEPTIONS to Section 1605.3(v)(4)**: The following computer monitors are not required to comply with Section 1605.3(v)(4) but shall comply with the test procedures in Section 1604(v)(4), the certification requirements in Section 1606, and the marking requirements in Section 1607:

1. KVMs.
2. KMMs.
3. Computer monitors that are classified for use as medical devices by the United States Food and Drug Administration.
4. Very high performance monitors before January 1, 2021.

We appreciate the opportunity to provide this input to the CEC, and thank CEC for its careful consideration of our comments.

Respectfully submitted,

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