Natural Resources Defense Council
Appliance Standards Awareness Project
American Council for an Energy-Efficient Economy
Consumer Federation of America
Consumers Union
Northeast Energy Efficiency Partnerships
Northwest Energy Efficiency Alliance

October 2, 2014

Ms. Brenda Edwards
U.S. Department of Energy
Building Technologies Program
Mailstop EE-2J
1000 Independence Avenue SW
Washington, DC 20585-0121

RE: Docket Number EERE-2014-BT-STD-0025 (RIN # 1904-AD04): Framework Document for Computer and Battery Backup Systems

Dear Ms. Edwards:

On July 17, 2014, the U.S. Department of Energy (the Department or DOE) released its framework document for computer and battery backup systems (Framework Document). 79 Fed. Reg. 41656. The Natural Resources Defense Council (NRDC), Appliance Standards Awareness Project (ASAP), American Council for an Energy-Efficient Economy (ACEEE), Consumer Federation of America, Consumers Union, Northeast Energy Efficiency Partnerships (NEEP), and Northwest Energy Efficiency Alliance (NEEA) respectfully submit these comments in response to the Department's Framework Document.

Introduction

We support the Department's decision to initiate the energy conservation standards setting process for computers and battery backup systems (computer systems). As the Department outlines in the Framework Document, energy consumption estimates associated with this product category are very significant and consumption levels vary. Desktop and laptop computer energy consumption in U.S. households is estimated to be around 21 TWh annually,[1] computer server energy consumption could be as high as 32.1 TWh annually,[2] and the Department estimates in the Framework Document that residential consumption for uninterruptible power supplies (UPS) for 2013 was 3.5 TWh. DOE's total estimated power usage of computer systems roughly equals the electricity produced by 20 coal-fired 500-megawatt power plants, costing Americans $5 billion in utility bills annually. Based on EPA's greenhouse gas calculator, producing the electricity to power computer systems results in 39 million

[1] Energy Consumption of Consumer Electronics in US Homes in 2013. Fraunhofer USA, Final Report to the Consumer Electronics Association. June 2014.
[2] Koomey, Jonathan. Growth in Data Center Electricity Use 2005-2010. Analytics Press. 2011.

tons of carbon pollution annually.[3] The Department's initial analysis also highlights the variations in consumption, particularly for desktop computers, where consumption of studied models ranged from around 35 to 210 kWh annually. This rulemaking is an important energy savings opportunity that will reduce electricity bills for American consumers and businesses, and will help avoid the carbon and toxic pollution associated with the building of new power plants. We explain in our comments why we believe that the energy consumption and savings potential are actually substantially higher than estimated by DOE.

Energy conservation standards for computers also provide an opportunity to support what has historically been a very robust and effective ENERGY STAR program for computers. Computers were among the first products addressed by the ENERGY STAR program and the U.S. Environmental Protection Agency (EPA) has successfully worked with industry and energy efficiency advocates to set efficiency levels that encourage the development, deployment, and market adoption of efficient technologies. But, as the Department's initial analysis suggests, inefficient models exist in this product category that the ENERGY STAR program is not able to address. The implementation of conservation standards in combination with ENERGY STAR would provide a framework whereby efficiency innovation continues to be encouraged while the least efficient products are removed from the market. This approach has been demonstrated to great effect in California, through the implementation of minimum efficiency standards for televisions.

Additionally, this year the European Union implemented its first conservation standards for computers, with a second tier scheduled to take effect in 2016. California is also expected to adopt conservation standards for computers in 2015. We expect that the analysis and observed market reaction to both of these efforts will provide the Department with valuable information as this rulemaking proceeds.
We look forward to working with the Department and other stakeholders on this rulemaking. The comments below are intended to assist the Department in developing the broadest possible understanding of this product category as it prepares to move forward with its analysis.

Summary

DOE may be underestimating the energy consumption of computers in the United States by a factor of at least two - We urge DOE to revise its estimates of computer stock energy consumption of 16 TWh/year for desktop computers and 4.9 TWh/year for portable computers. These estimates may significantly under-represent the energy consumption of computers in the US by a factor of two or even higher, for three main reasons: 1) DOE used estimates from the 2014 Fraunhofer report,[4] which considers residential sector computers only. It does not include consumer type computers used in the commercial sector, which we believe are also covered products from a regulatory perspective; 2) The ENERGY STAR test procedure underestimates the real-world energy consumption of computers, by up to 30 percent for notebooks; 3) The duty cycle used in the ENERGY STAR v6.0 specification may underrepresent computer on-mode time. Revising these estimates may reveal a significantly higher energy savings opportunity and provide an economic justification for deeper savings.

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[3] Per EPA's greenhouse gas equivalencies calculator: http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

[4] Energy Consumption of Consumer Electronics in US Homes in 2013. Fraunhofer USA, Final Report to the Consumer Electronics Association. June 2014.

Definitions - We propose adjustments to DOE's proposed definitions to ensure that the scope of the regulation is clear and remains relevant for the period over which standards are intended to affect the market. This is important for two reasons: 1) Computers share many functional characteristics with other electronic products, which could make them difficult to differentiate; 2) Electronic products and technology are evolving rapidly, as illustrated by the recent market adoption of new form factors like "all-in-one" and "two-in-one" computers, as well as emerging voice and gesture recognition user input mechanisms. It is critical that (where possible) product definitions can anticipate and capture new form factors within their scope.

Scope - computer servers: Instead of limiting the scope of computer servers to those that can be powered using 120 Volts (V) input or a standard wall plug receptacle (which could be interpreted as not including 240 V receptacles commonly used by appliances such as dryers, electric ranges, and electric vehicle supply equipment), we recommend that DOE defines the scope as "computer servers that can be powered using residential power circuits, such as 120 Volts and 240 Volts".

Scope – UPS: We believe that the scope for consumer UPS should match that of computers and servers, e.g. UPSs intended to be used for servers that are found to be in scope, should also be considered in scope.

Computer test procedure – The vast majority of computer energy as defined by IEC 62623 is measured using idle modes that are not representative of typical operating conditions of computers and do not appropriately reflect their energy consumption and savings potential. DOE should modify the IEC 63623 Ed. 1.0 test procedure to include a "real-world idle" mode that better reflects the operating conditions that computers typically spend the most time and energy in.

Computer mode weightings - The mode weightings used by ENERGY STAR Computers v6.0 are based on limited and outdated studies that may not appropriately represent how computers are actually used by typical users. We urge DOE to assess the need to develop a revised mode weighting based on an evaluation of the full body of available literature and to perform new studies that can complement and supplement available data as necessary.

Computer server test procedure, use of idle state - We encourage DOE to include an active mode test for computer servers, in addition to its proposed idle mode test. As with computers, we believe that the test procedure should cover modes that are typical of operating conditions.

Categorization criteria for computers – The ENERGY STAR v5.2 categorization structure for computers is outdated and inconsistent, and not appropriate for federal standards expected to go into effect in 2021. We urge DOE to adopt a categorization structure based on a single performance metric like ENEGY STAR v6.0, rather than a categorization structure based on multiple technical characteristics like v5.2.

Computer graphics categorization structure - We recommend that DOE revises the approach for graphics, moving from a category-based approach to a progressive allowance approach, and that it applies this approach to both integrated and discrete graphics. The seven discrete graphics categories used in ENERGY STAR v6.0 based on IEC 62623 were well suited to the market when they were defined by ECMA-383 in 2010. However they need to be reexamined in the light that DOE standards will go into effect in 2021 at the earliest, 11 years after the creation of this categorization structure. Performance characteristics of discrete graphics have already evolved considerably since 2010 and are expected to continue to do so, likely rendering this categorization structure obsolete by 2021.

Computer product classes - Conventional and integrated desktop computers should be separated into distinct categories. They have different consumer utilities, and standards that are appropriate for one form factor are not appropriate for the other.

Technology options for computer efficiency - DOE has identified 12 technology options that can be used to improve computer efficiency. We add another six options. This plethora of technology options offers manufacturers a high degree of choice and flexibility to make computers more efficient in a cost effective manner.

Detailed Comments

Additional Comment on 1.2.1 Energy Consumption of Computers

We urge DOE to revise its estimates of computer stock energy consumption of 16 TWh/year for desktop computers and 4.9 TWh/year for portable computers. These estimates may significantly under-represent the energy consumption of computers in the US by a factor of two or even higher, for three main reasons:

1. **Fraunhofer numbers are for the residential sector only, they do not include consumer computers used in the commercial sector.**

Per our April 15, 2014, comments on DOE's Proposed Determination of Computer and Battery Backup Systems as a Covered Consumer Product, in the absence of a clear and lasting distinction between computers used in residential and commercial settings, DOE must conclude that all computers are of the same type from a regulatory perspective, and therefore covered by the standards, irrespective of whether they are marketed to, or operated in, commercial settings.

There are more personal computers used in the commercial sector than in the residential sector. Hamm and Greene 2008 puts the ratio at 59% for commercial and 41% for residential. The 2014 Fraunhofer study only included residential computers. DOE should include all consumer computers in its energy consumption estimates, which would more than double its current estimate.

2. **The ENERGY STAR test procedure underestimates the real-world energy consumption of computers, by up to 30 percent for notebooks.**

Per NRDC's response[5] to the California Energy Commission's Invitation to Participate, the IEC 62623 Ed. 1.0 test procedure and the ENERGY STAR v6.0 approach to estimating a computer's typical energy consumption (TEC) uses idle mode (a weighted average of short and long idle) as a proxy for active mode power. The computer is not tested in active mode. It is tested in idle mode, displaying the desktop, with no applications open. These testing conditions do not represent typical use of a computer: typical computer users likely spend very little time every day in this condition, they typically have windows open and applications running in the background, even when they are not actively using the computer.

While this proxy worked sufficiently well in computers until a few years ago, progress in power scalability in modern computers has increased the difference between idle and active power, and

[5] http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Consumer_Electronics_12-AAER-2A/NRDC_Response_to_CEC_Invitation_to_Participate_with_Excel_Spreadsheets_2013-05-09_TN-70852.pdf

this trend is expected to continue as improvements in real-time power management enables computers to better scale power to processing needs. NRDC's anecdotal testing suggests that a notebook's daily active energy use (including all active and idle time during a day's use) can be 20% to 50% higher than IEC 62623's idle condition.

NRDC's anecdotal evidence is currently being complemented by an ongoing project funded by the California Investor-Owned Utilities (CA IOUs) which is expected to be completed in Fall 2014. The purpose of this project is to measure the difference between IEC 62623 and typical "real-world idle" conditions on a sample of desktop and notebook computers.

There is another factor which potentially increases the difference between IEC 62623 and real-world computer energy consumption further: as computers age, their energy consumption may significantly increase due to a combination of factors, including 1) software bloating; 2) dust inside the computer and thermal paste degradation leading to less effective cooling and degraded thermal operating conditions; and 3) semiconductor degradation and increased leakage current over time. We are not aware of any existing research quantifying these effects, but there is clear anecdotal evidence that computers run hotter and fans run more often as computers age. While efficiency degradation is not unique to computers, it appears to be particularly significant with computers and should be investigated to determine if it is significant enough to warrant taking into account to determine computer energy consumption and savings potential.

We recommend that DOE works to correct the difference in computer energy consumption between IEC 62623 test conditions and the real world operating conditions by updating the IEC 62623 test procedure to better reflect real-world energy consumption, per our later comments on the test procedure. Additionally, a complementary approach could be pursued that estimates the difference in consumption of computers between the test procedure and the typical real-world use, and applies a correction factor when calculating stock energy consumption and savings. This may be a beneficial approach to account for aging-related energy increases that may be difficult to capture through a test procedure.

3. The duty cycle used in the ENERGY STAR v6.0 specification may underrepresent computer on-mode time.

The ENERGY STAR v6.0 duty cycle is based on estimates rather than a recent, metered study of a meaningful sample representative of computer use in the US. Survey responses are often not very accurate when it comes to estimating time spent using a particular device. The California Plug Load Research Center is expected to publish a study, based on metered data, showing a high percentage of computers with power management settings disabled. DOE should take into consideration this report and other recent metered usage data to inform its usage pattern assumptions, rather than rely on the ENERGY STAR v6.0 mode weightings.

Item 3-1 *DOE requests comment on the definition of a computer or alternate approaches that should be considered. Specifically, DOE requests suggestions of characteristics that may be used in the definition to distinguish general consumer electronics from computers.*

We propose adjustments to DOE's proposed definitions to ensure that the scope of the regulation is clear and remains relevant for the period over which standards are intended to affect the market. This is important for two reasons: 1) Computers share many functional characteristics with other electronic products, which could make them difficult to differentiate; 2) Electronic products and technology are also evolving rapidly, as illustrated by the recent market adoption of new form factors like “all-in-one” and “two-in-one” computers, as well as emerging voice and gesture recognition user input mechanisms.

DOE proposes to define a computer as a “consumer product powered by mains power with the primary function of performing logical operations and processing data”. Performing logical operations and processing data is a characteristic shared by all electronic devices, such as game consoles, smart TVs, etc. It could also be argued that performing logical operations and processing data is not the function of an electronic device, rather, it is the means by which electronic devices perform their primary function. DOE’s proposed definition may not sufficiently differentiate a computer from other electronic products. Instead, we suggest defining a computer as a “consumer product powered by mains power with the primary function of running software applications”. We believe that this would better differentiate computers from other electronic devices whose primary function may be to play games (game consoles), display video content (TVs, media players), etc.

DOE proposes to require that a computer includes user input devices. This could be problematic because manufacturers could claim that computers shipped without an input device would be out of the scope of this rulemaking, even if they are designed to be used with input devices. We propose to change this to “capable of using an input device”. We also recommend that input device be singular, because it is possible that a computer could be designed to be operated with a single user input device such as a natural user interface (voice or motion recognition). We recommend that DOE adds “natural user interface” to the list of examples to make it clear that user input devices can also consist of non-traditional devices.

Item 3-2 *DOE requests feedback and information on additional factors and criteria that could be used to distinguish clearly between computer servers and client computers, other than those based on point-of-sale or end-use.*

To differentiate personal computers from computer servers, we propose using the following criterion, similar to DOE’s language on page 15 of the Framework Document:

- Personal computers are computers intended for single-user simultaneous operation.
- Computer servers are computers designed to handle multiple simultaneous users and service requests sharing system resources.

Item 3-5 *DOE requests comment on the types of computers that should be excluded from the scope.*

DOE stated that it will consider limiting the scope to computer servers that can be powered using 120 Volts (V) input or a standard wall plug receptacle. While we support the principle of limiting the scope to servers that can be powered by residential power infrastructure, this could be interpreted as not including 240 V receptacles commonly used by appliances such as dryers, electric ranges, and electric vehicle supply equipment. The potential adoption of other emerging power technologies such as 24 V direct current should also be included. We recommend that DOE defines the scope as “computer servers that can be powered using residential power circuits, such as 120 Volts and 240 Volts”.

Item 3-8 *DOE requests feedback on the proposed scope for UPSs. In particular, whether or not industry believes a particular UPS type should be included within the scope.*

DOE is considering including consumer UPSs that are intended to protect desktop computers and related peripherals, and/or home entertainment devices such as TVs, set top boxes, digital video recorders (DVRs), Blu-ray and digital video disc (DVD) players. As such, DOE is considering identifying consumer type UPSs as those operated at 120 V AC on a standard wall plug receptacle as commented by NEMA and Schneider Electric.

We believe that the scope of consumer UPS should reflect the scope of computers and servers. That is, UPSs intended to be used for computers and servers that are found to be within the scope of this rulemaking, should also be considered within the scope of this rulemaking.

Item 4-1 *DOE requests comment on the use of IEC 62623 Ed. 1.0 as the basis for the development of the computers test method.*

The vast majority of computer energy as defined by IEC 62623 is measured using idle modes that are not representative of typical operating conditions of computers and do not appropriately reflect their energy consumption and savings potential. DOE should modify the IEC 63623 Ed. 1.0 test procedure to include a "real-world idle" mode that better reflects the operating conditions that computers typically spend the most time and energy in.

IEC 62623 uses short and long idle as a proxy for computer "on mode" energy consumption based on a metered study of 17 computers conducted in 2010 by the ECMA-383 workgroup[6]. The machines used for this study could have been anywhere from 0 to 3 years old at the time of the study. Technology has evolved significantly since 2007-2010, and computers have become better able to adjust power usage to processing requirements. Short and long idle are the sub-states of on mode where computers have the least work to do: there are no applications launched, no windows open, minimal graphics to display (only the desktop) and only minimal background processing taking place. Testing is performed out of the box, without any apps added to the computer startup procedure by the user, and no widgets added to the desktop.

Short and long idle are not representative of the typical daily operating conditions of computers in American homes and businesses. Computers typically spend negligible time on the desktop screen with no applications loaded, no windows open, and no applications even installed on the computer. Typical computers in use have many applications installed, some of them loaded in memory, windows open and accessories plugged in such as USB devices, second monitors, printers, etc. We call this typical operating state "real-world idle."

This real-world idle state is not an "active" state with heavy processing requirements; it is the state typical computers are in when either no one is actively using them, or users are performing tasks requiring only light processing such as using web browsers, word processors and other office productivity software.

Over the past several years, computer technology has become better able to adjust power use to processing requirements: in particular, CPUs and GPUs have implemented dynamic voltage and

[6]http://www.ecma-international.org/publications/standards/Ecma-383.htm

frequency scaling, power islands, graphics switching and other innovations to reduce power when little or no processing is required. We expect this trend to continue with the adoption by computers of real-time power management technology already used on mobile devices. This improved ability to scale power means that the difference between short and long idle, and real-world idle power, is increasing. For DOE computer standards to be effective, it is important that this difference be accounted for in the test procedure, standard levels setting, assessment of savings potential and determination of the economic justification of standards.

We encourage DOE to work with stakeholders to adjust the IEC 62623 test procedure to accurately reflect and effect computer energy consumption and efficiency potential.

Item 4-3 *DOE requests comment on the inclusion of ENERGY STAR Computers v6.0 mode weightings.*

The mode weightings used in ENERGY STAR Computers v6.0 are based on limited and outdated studies that may not appropriately represent how computers are used by average users.

DOE should adjust the ENERGY STAR Computers v6.0 mode weightings to more accurately reflect usage patterns in American homes and businesses. It is important that the duty cycle be representative of real computer usage in order to support reasonably accurate estimates of energy consumption, standard levels, energy savings potential, and economic justification. The ENERGY STAR Computer v6.0 duty cycle is based on two outdated studies: Microsoft 2008 and ECMA-383. In 2013, the CA IOUs submitted comments[7] as part of the standard setting process for computers in California identifying other studies[8] that show highly variable duty cycles, some as high as 94% for desktops in the commercial sector. We urge DOE to assess the need to develop a revised mode weighting based on an evaluation of the full body of literature, and to perform new studies to complement available data as necessary. Duty cycle studies should be based on:

1. Metered studies rather than surveys. Surveys can be unreliable and affected by user awareness, understanding, memory and values.
2. Recent data, in order to reflect current user behavior and technology.

Item 4-6 *DOE requests comment on the best approach to address network proxying: (a) using four levels of weightings for proxy functionality as specified in ENERGY STAR Computers v6.0 in addition to the conventional weightings; (b) using two levels of weightings, one for no network proxy functionality and the other for network proxy functionality; and, (c) using a single weighting for all computers.*

We are not aware of any metered duty cycle data supporting the ENERGY STAR Computers v6.0 weightings for network connectivity in low-power modes (referred to as network proxy). ENERGY STAR v6.0 is a voluntary program whose objective is to encourage leadership and innovation, with the advantage of being updated on a more regular basis than DOE standards. As such, ENERGY STAR uses mode weightings as an incentive for the market to adopt network proxy technology, which we support.

[7] http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Consumer_Electronics_12-AAER-2A /California_IOUs_Response_to_the_Invitation_to_Participate_for_Computers.pdf

[8] PG&E / Barr, Harty & Nero

However, as a mandatory and longer-lasting standard, DOE mode weightings should be based on metered data on the usage patterns of computers that feature network proxy. Inappropriate mode weightings could result in higher annual energy consumption (AEC) limits than warranted, and unnecessary energy waste, especially if and when network proxy achieves wide adoption in the market.

DOE should either perform a study to determine appropriate mode weightings for computers, or, in the absence of such data, apply conventional mode weightings to computers with network proxy.

Item 4-8 *DOE requests comment on the use of the idle state test from the ENERGY STAR Computer Servers v2.0 Test Method for computer servers as a base for the development of the computer servers test method.*

We encourage DOE to include an active mode test for computer servers, in addition to its proposed idle mode test. As with computers, we believe that the test procedure should cover modes that are typical of operating conditions.

Computer servers do spend a lot of their time in idle mode, while waiting for data processing requests. The average server utilization levels of x86 servers in data centers is around 12 percent[9], and many servers spend most of their time idle. Idle mode is therefore an important mode to include in the test procedure. However, the SPECpower_ssj2008 benchmark[10] shows that modern servers often feature power management capabilities that significantly reduce power use in idle mode relative to even light load levels such as 10% load. Idle mode is therefore not representative of server power consumption at low but non-zero load levels, and it does not require manufacturers to limit server power use at those levels.

We acknowledge the challenges identified by DOE regarding the use of the SPEC Server Efficiency Rating Tool (SERT), such as SERT being very recent, not being compatible across all computer servers and the lack of clarity on how to use it to derive an active state energy consumption value. We encourage DOE to seek solutions to these issues with interested stakeholders. One possible solution to the lack of clarity regarding the use of SERT output would be to define a duty cycle that is representative of typical server operating conditions, such as X% in idle, Y% at 10% load, etc.

Item 5-2 *DOE requests comment on the categorization criteria for the ENERGY STAR Computers v5.2 product categories.*

We urge DOE to adopt a categorization structure based on a single performance metric like ENERGY STAR v6.0, rather than a categorization structure based on multiple technical characteristics like v5.2.

The v5.2 categorization structure is outdated and inconsistent. It was developed in 2008. The computer market has evolved considerably since then and is now at a stage where v5.2 categories no longer adequately represent products available in the market. v5.2 categories are defined largely based on the number of processor cores and amount of memory. Technology has changed

[9] Alex Benik, *The Sorry State of Server Utilization and the Impending Post-Hypervisor Era*, Gigaom, November 30, 2013, https://gigaom.com/2013/11/30/the-sorry-state-of-server-utilization-and-the-impending-post-hypervisor-era/

[10] http://www.spec.org/power_ssj2008/

dramatically over the past few years relative to these two factors: dual- and quad-core processor machines with 4+GB of memory represented the high-end of the market in 2008 but are now mainstream. This trend is expected to continue for the foreseeable future.

There are very few products left on the market in category A, entry and mainstream products are increasingly migrating towards categories C and D, leading to a situation where two categories will cover most of the market. This does not allow for appropriate differentiation for performance-based standard setting. And this situation will worsen over the next few years as this migration toward higher categories continues.

In addition, as noted by DOE in the Framework Document, v5.2 categories overlap, creating ambiguities as to which category applies. v6.0 categories solve this problem by using a simple, performance-based metric, which avoids overlaps. Whether the ENERGY STAR v6.0 performance score is the right metric or not, we encourage DOE to follow the same principle and adopt a categorization structure based on a single performance metric rather than multiple technical criteria.

Additional comment on v5.2 Computer Product Classes

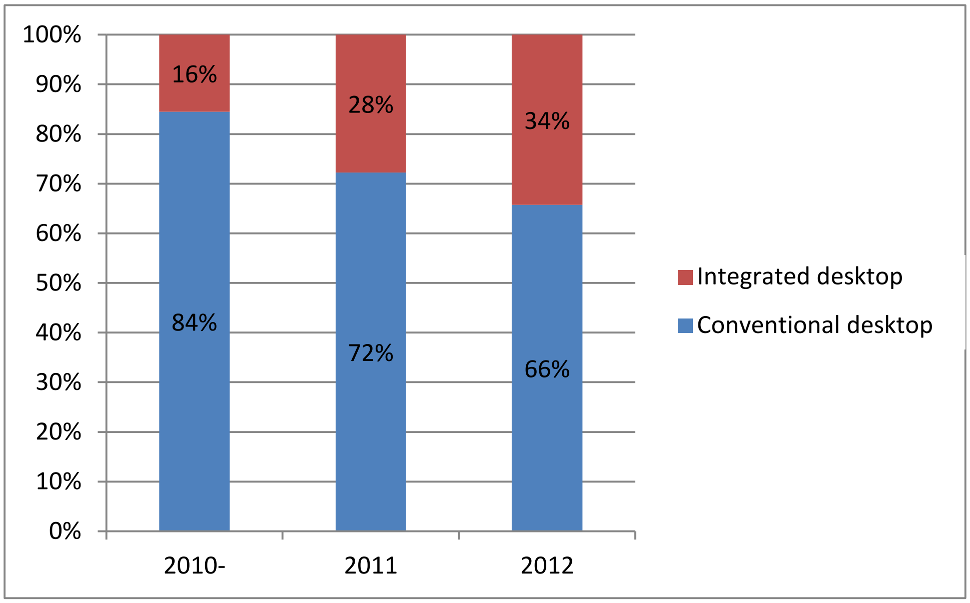
Conventional and integrated desktops should be separated into distinct classes. They have different consumer utilities, and standards based on the limitations of conventional products would likely be weaker than justified for integrated products which don't have the same limitations.

Conventional desktops provide unique utility relative to integrated desktops in that they are designed for upgradeability. For example, it is easy to add new extension cards and replace components, allowing users to upgrade the performance and extend the life of the computer. This upgradeability comes with an energy penalty, using technology currently in the market, because it increases resistive losses in wiring and conductive traces, and because it limits the use of efficiency solutions such as graphics switching.

The distinct utility and the increased energy requirements of conventional desktop upgradeability warrant a separate class relative to integrated desktops. If these products were kept in the same class, setting energy requirements that correspond to efficient and cost-effective integrated desktop technology may not be compatible with the upgradeability of conventional desktops. Similarly, setting levels that are appropriate for conventional desktops would give all integrated desktops an unwarranted allowance, allowing most of them, even those with inefficient designs, to comply.

Integrated desktops represent a significant and growing share of the desktop market, more than one third in 2012.

Figure 1: Share of Integrated vs. Traditional Desktops in ENERGY STAR Qualified Product List (QPL)



We urge DOE to create separate categories for these two form factors in order to be able to set appropriate energy requirements for each and to remove the least efficient designs in each category without impacting consumer utility in conventional desktops.

***Item 5-5** DOE requests comment on the granularity of seven graphics categories consistent with the market of available GPUs.*

We recommend that DOE revises graphics categories, moving from a category-based approach to a progressive allowance approach, and that it applies this approach to both integrated and discrete graphics.

The seven discrete graphics categories used in ENERGY STAR v6.0 based on IEC 62623 were well suited to the market when they were defined by ECMA-383 in 2010. However, they need to be reexamined in the light that DOE standards will likely come into effect in 2021 at the earliest, 11 years after the creation of this categorization structure. Performance characteristics of discrete graphics have already evolved considerably since 2010, and are expected to continue to do so, rendering this categorization structure obsolete by 2021.

The highest performance G7 category contained very few products when the categorization structure was initially designed. There are now many products on the market in the G7 category, with a large range of performance capabilities, and this category will represent a large and increasing share of the market going forward.

With the G7 category being open-ended, a fixed allowance does not provide a performance-based approach. If the G7 allowance were set at a level reflecting cost-effective efficient technology at the low-end of the G7 performance range, higher performance GPUs would be penalized. If the allowance were set for GPUs at the high-end of the range, lower performance GPUs would get a large unwarranted allowance, while future higher performance GPUs would still be penalized. We recommend that DOE consider a progressive allowance based on frame buffer bandwidth or any another appropriate graphics performance metric. This would enable DOE to set appropriate and future-proof graphics allowances.

G1 to G6 categories could also be replaced by a progressive equation, as proposed for G7, which would simplify the structure and avoid boundary effects.

Finally, we encourage DOE to consider using this progressive allowance approach not just for discrete graphics, but for all graphics, discrete and integrated. There is no difference in consumer utility between discrete and integrated graphics of equivalent performance. Providing a performance-based allowance to any type of graphics would allow integrated and discrete graphics to compete on cost and efficiency. It would strengthen the performance-based quality of the entire standard.

Graphics allowances are critical to the effectiveness of future DOE computer standards. Graphics allowances in existing standards (ENERGY STAR v6, EU Ecodesign, and other minimum energy performance standards) are very large, significantly larger than the allowance for the rest of the system in the higher-end categories. Setting a graphics allowance at a level higher than necessary therefore provides a large unwarranted allowance for inefficient computers to comply. The most efficient GPUs available on the market today already use less than half of the idle power than their corresponding ENERGY STAR v6.0 allowance (per the CASE report update being prepared by the California IOUs for CEC, expected to be submitted in October or November 2014). This represents a potentially large loophole, which will get even larger as the efficiency of graphics technology improves over time.

Item 6-1 *DOE requests information that would contribute to the market assessment for computers, computer servers, and UPSs that would be covered in this rulemaking. DOE particularly seeks information on shipments, trends in product feature and efficiency, distribution channels and estimates of market shares for the computers, computer servers, and UPSs considered in this rulemaking.*

The Collaborative Labeling and Appliance Standards Program (CLASP) recently conducted research on the computer market in China and on the energy performance of gaming computers. These studies are in the process of being published by CLASP.

China Computer Market Energy Performance Research

The China study reveals that a large proportion of computers in the China market can meet energy levels significantly lower than ENERGY STAR v5.2 and comparable to ENERGY STAR v6.0. The objective of the research was to assess the energy performance of the entire computer market. The ENERGY STAR QPL is, by definition, limited to the most efficient computers in the market, it does not represent the overall market. The CLASP research focused on China because China’s minimum energy performance standards for computers require all computers in the China market to be registered in a publicly available online database. CLASP determined that the China market is reasonably similar to the US market in terms of manufacturers and models, with 47% of manufacturers listed in the China database also listed in the US ENERGY STAR database for computers, and accounting for 79% of China models.

Detailed conclusions of the CLASP China research include:

- 92% of desktops and 98% of notebooks in the China market could meet ENERGY STAR v5.2 TEC limits.
- 49% of desktops in the China market would meet energy limits 30% lower than ENERGY STAR v5.2 which is roughly equivalent to ENERGY STAR v6.0.
- 57% of notebooks would meet energy limits 40% below ENERGY STAR v5.2 which is roughly equivalent to ENERGY STAR v6.0.

While there are inherent uncertainties in the exact numbers due to differences in data and efficiency standards between China and ENERGY STAR, the CLASP study suggests that ENERGY STAR v6.0 energy levels are likely already being met by a large share of the U.S. market. Note that the study looked at energy levels only, not other ENERGY STAR requirements such as power supply efficiency and power management requirements.

Gaming Computer Energy Performance Research

CLASP's gaming computer research aimed to assess the energy performance of the highest-performance gaming computers relative to ENERGY STAR v6.0 levels. The research was based on energy measurements by online gaming websites which did not follow the ENERGY STAR testing procedure, often indicating a much higher energy consumption than under ENERGY STAR conditions. Despite this bias, the research found no significant relationship between performance and energy consumption. Some of the highest performance computers were able to meet ENERGY STAR levels and over half of the motherboards in the sample were within 20% of ENERGY STAR levels. This indicates that ENERGY STAR V6 levels would not be a barrier for high performance gaming computers.

ENERGY STAR Unit Shipment Data (USD)[11]

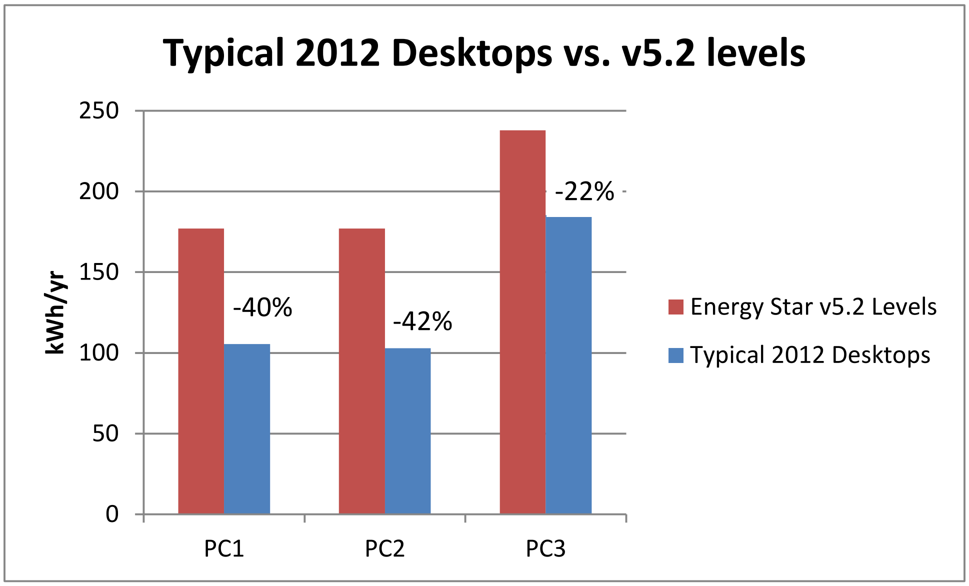
ENERGY STAR's annual USD report estimates the market share of ENERGY STAR at 25% for desktops and 74% for notebooks (relative to ENERGY STAR v5.2 which was in effect in 2013). This is inconsistent with the CLASP China research, as well as with other estimates:

1. **California IOUs** market research and testing[12] shows that the energy use of typical 2012 desktops was 22% to 42% lower than v5.2 levels and close to v6.0 levels. As v6.0 levels are designed to represent the top 25% of the market, this infers that the market share of desktops meeting v5.2 energy levels is significantly higher than 50%.

[11] http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2013_USD_Summary_Report.pdf

[12] California IOUs market research and testing: http://www.etcc-ca.com/reports/cost-effective-computer-efficiency

Figure 2: Typical 2012 Desktops vs. ENERGY STAR v5.2 levels



(*) Using v5.2 categories and duty cycle

2. **NEEA** Market Progress Evaluation Report #4 (2012) on the 80 PLUS program[13], estimated the ENERGY STAR market share for desktops in 2011 at **43%**, compared with EPA USD's estimate of 17%.

3. **IDC** reported that **57%** of desktop computers sold in the US in 2011 were ENERGY STAR (IDC 2012, from NEEA Market Progress Evaluation Report #4 on the 80 PLUS program referenced above).

We believe that this discrepancy is explained by two primary factors:

1. **Many models that meet ENERGY STAR v5.2 energy levels do not meet the power supply requirements**
ENERGY STAR qualification requires models to meet not just energy limits, but also power supply requirements. It is a well-known fact that many models can meet ENERGY STAR limits but do not qualify because of non-compliant power supplies. This is confirmed by the ENERGY STAR v6.0 Data Collection dataset which shows several models meeting energy levels but not power supply requirements.

2. **Models that meet ENERGY STAR v5.2 requirements but are not submitted for qualification due to manufacturer marketing strategy to avoid qualification costs in certain market segments -** It also appears that some models that meet both energy limits and power supply requirements are not submitted for qualification due to the cost of the ENERGY STAR third-party qualification

[13] NEEA 80 PLUS Market Progress Evaluation Report #4 - 2012: http://neea.org/docs/reports/80-plus-mper-4-final-06-11-12.pdf

process, leading manufacturers to not submit some products in market segments that have low sensitivity to ENERGY STAR qualification.

The ENERGY STAR USD report, while informative, is not representative of the share of the market that meets ENERGY STAR v5.2 levels. The CLASP China study suggests that ENERGY STAR v5.2 is higher than 90%, and that of v6.0 around 50%.

***Item 6-3** DOE welcomes comments on the preliminary technology options for computer systems identified in this section and whether there are other technology options it should consider. In commenting on technology options, please discuss their impacts, if any, on safety, performance, and user utility, as well as cost of the technology options.*

DOE has identified 12 technology options that can be used to improve computer efficiency. We add another six options. This plethora of technology options offers manufacturers a high degree of choice and flexibility to make computers more efficient in a cost effective manner.

As identified by DOE, there are many technology options available in the market today that can reduce energy consumption in computers. We list them here for reference: efficient power supplies, efficient hard drives, energy-efficient Ethernet, passive cooling, ACPI-based power management, switchable graphics, dynamic voltage and frequency scaling, resilient circuitry, clock gating, CPU utilization management, suspended state to Flash, and internal network proxy. Here are some additional technology options with the potential to reduce energy consumption that are not included in DOE's Framework Document:

- **System on Chip** – Intel's Haswell architecture and AMD's Richland APU now include the GPU, much of the chipset, and even voltage regulators, on the system on chip (SoC), reducing losses, and allowing deeper power management through reduced latencies.
- **Motherboard integration** – As identified by the CA IOUs in their "Cost-Effective Computer Efficiency" report,[14] motherboard integration is a key strategy to increase efficiency. One of the key differences between conventional laptops and the Apple MacBook Air is a very high level of motherboard integration in the MacBook Air.
- **Low-power idle in GPUs** – As demonstrated by the 2012 CLASP-NRDC[15] and 2013 PG&E[16] research on discrete graphics card energy performance, new technology such as AMD's Zero Core Power can dramatically reduce the power use of discrete graphics cards in idle mode.
- **Real-time power management** ("keystroke sleep") – One of the largest opportunities for energy savings in computers may be real-time power management. This consists of optimizing the power state of all components in the device, not just the CPU, at a millisecond level rather than 15-minute level with conventional ACPI. Apple has implemented this technology in its computers and sometimes referred to it as "putting the computer to sleep between keystrokes." AMD is including this approach as one of its three key strategies to meet its

[14] http://www.etcc-ca.com/reports/cost-effective-computer-efficiency

[15] http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2012/Impact-of-Graphics-Cards-on-Desktop-Computer-Energy-Consumption.aspx

[16] Pacific Gas and Electric Company. 2012b. Updated Discrete Graphics Processing Unit Testing Results. http://energystar.gov/products/specs/sites/products/files/California%20IOU%20%20NEEA%20Comments_Public.pdf.

"25x20" goal[17] and AGGIOS has demonstrated similar technology on an IP gateway, which shares many components with computers.

- **Display efficiency** – the rapid improvement in display efficiency, as evidenced by the ENERGY STAR for Displays qualified product list (QPL) provides another opportunity for energy reduction in notebook and all-in-one computers.
- **Panel self-refresh** – This technique allows the display panel to refresh itself when images are static, using a small amount of memory in the display itself.[18] This allows the display controller and the main GPU to go to sleep, saving energy in the computer.

These technologies are already implemented in some computers, but there remain many computers in the market that don't take advantage of these technology options and could achieve substantial energy savings by implementing them.

Conclusion

Thank you for the opportunity to comment on this Framework Document. We look forward to working with DOE and other stakeholders on this important rulemaking. Please contact us if you have any questions or require any further information.

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[17] http://www.amd.com/en-us/press-releases/Pages/amd-accelerates-energy-2014jun19.aspx
[18] http://www.anandtech.com/show/7208/understanding-panel-self-refresh

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