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ITI & Technet Comments: Re CEC Energy Savings Modeling Issues

Additional submitted attachment is included below.

CEC Draft Computer Standards (Docket #14-AAER-2)

2014 Appliance Efficiency Pre-Rulemaking

ITI/TechNet Comments on CEC Energy Savings Modeling Issues

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CEC Energy Savings Modeling Issues

Executive Summary

Current IOUs and CEC computer energy savings proposals dramatically overstate potential energy savings as they do not comprehend the fundamental implications and limitations of the modeling methods used to calculate annual and lifetime energy consumption. The projected energy savings are fundamentally reliant upon significant reduction of power levels of devices during system idle with no cognizance as to whether or not the calculated savings are realizable in systems as used by real end users. Calculated savings depend on devices being resident in nonfunctional low power states for 100% of the year and can only be achieved if end users are willing to accept a complete loss of normal functionality for their PC systems in California. The projected savings are fictitious in a real world setting.

Energy Star 6.1 total Annual Energy Consumption Calculation Methodology

The California Energy Commission (CEC) published first draft of Staff Report for computers and displays as part of Appliance Efficiency Pre-Rulemaking. The Staff Report for Computers followed the ENERGY STAR® for Computers version 6.1 program requirements. The ENERGY STAR® for Computers version 6.1 specification describes a method for calculating the typical annual energy consumption (E_{TEC}) for both desk top, integrated desk top and notebook computer systems. Equation 1 below shows the formulae used to calculate the annual energy consumption according to this specification.

Equation 1

$$E_{TEC} = \frac{8760}{1000} * (P_{OFF} * T_{OFF} + P_{SLEEP} * T_{SLEEP} + P_{LONG_{IDLE}} * T_{LONG_{IDLE}} + P_{SHORT_{IDLE}} * T_{SHORT_{IDLE}})$$

Where:

- P_{OFF} = *Measured power consumption in Off Mode (W);*
- P_{SLEEP} = *Measured power consumption in Sleep Mode (W);*
- P_{LONG_IDLE} = *Measured power consumption in Long Idle Mode (W);*
- P_{SHORT_IDLE} = *Measured power consumption in Short Idle Mode (W); and*
- T_{OFF}, T_{SLEEP}, T_{LONG_IDLE}, *and* T_{SHORT_IDLE} *are mode weightings as specified in Table 1 (for Desktops, Integrated Desktops, and Thin Clients) or Table 2 (for Notebooks).*

Table 1

Mode	Weighting
TOFF	45%
TSLEEP	5%
TLONG_IDLE	15%
TSHORT_IDLE	35%

Table 2

Mode	Weighting
TOFF	25%
TSLEEP	35%
TLONG_IDLE	10%
TSHORT_IDLE	30%

Equation 1 models the annual energy consumption by summing the energy consumption calculation for 4 modes of operation. These modes consist of Long Idle, Short Idle, Sleep and Off states. Long Idle is equivalent to Short Idle with the added requirements that the display must be in a low power state (Screen blanked or standby) and any long-idle power management features, if configured as shipped, to have engaged. Since display blanking or sleep requirements are defined to be activated after no more than 15 minutes of user inactivity, Long Idle effectively represents the time that the system is active, the user is no longer present and the system has not yet transitioned into a lower power state such as Sleep or Off state. Short Idle therefore would represent the time that the user is present and interacting with the computer as well as the time the user is not present but the display has not yet transitioned into a low power state. Short Idle is therefore a proxy for end users interacting with the computer such as editing documents, composing or reading email, web browsing etc. It should be noted that there have been several attempts to define an active workload for PC's that would be a better representation of real world energy consumption and efficiency for some usage profiles than the idle mode defined in this model. There has yet to be an agreement on an acceptable alternative in spite of several attempts. Absent the definition of such an alternate active workload, idle will continue to be a proxy for active usage of a PC product and the implications of this proxy relationship need to be understood and appropriately accounted for in any energy savings regulatory activities.

Equation 1 calculates the annual energy use in each mode of operation by multiplying the average power in that mode by the amount of time spent in that mode annually using the mode weightings from **Error! Reference source not found.** for desk tops, Integrated Desktops, and Thin Clients or Table 2 for Notebooks. This is calculated by dividing 8760 hours per year by 1000 and multiplying this value (8.76) times the sum of the energy consumption in each mode.

Figure 1 is a visual representation of the relative magnitude of power levels and time in operating modes for an average category 0 desk top computer from the Energy Star qualified products list as of July 27, 2015.

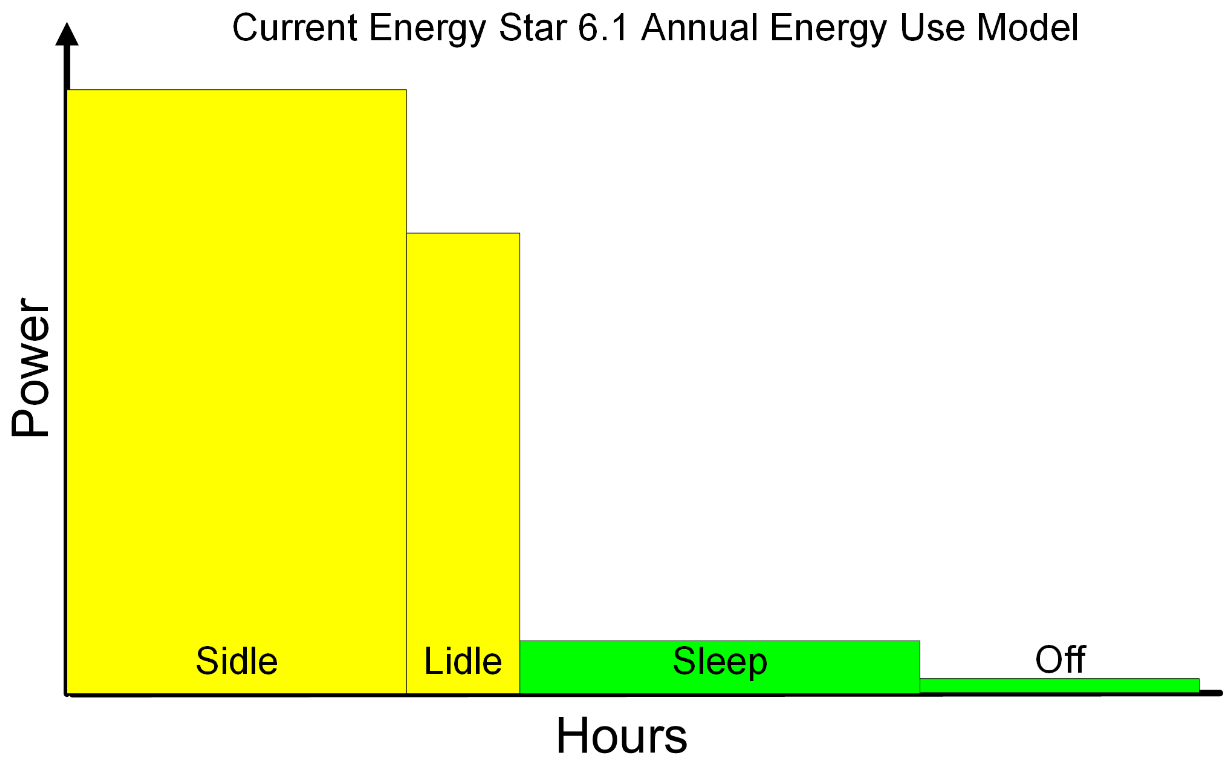

Figure 1

Average power for each operating mode was calculated by averaging the power values for that mode in the Energy Star qualified products data base for Category 0 desk top computers.

Table 3 shows the average power values for operating modes for each category of desk top computer as calculated from the July 27,2015 Energy Star qualified products data set.

Table 3

	Average Power in Mode (W)			
Category	Off	Sleep	Long Idle	Short Idle
0	0.36	1.21	10.3	13.3
I1	0.54	1.42	19.3	20.8
I2	0.53	1.38	23.5	24.9
I3	0.54	1.4	22.5	24.1
D1	0.53	1.43	31.1	32.3
D2	0.51	1.53	32.9	34.3

Figure 2 shows the percentage of annual energy consumed in each operating mode using the average power values for Category 0 from above in Equation 1 using mode weightings from Table 1.

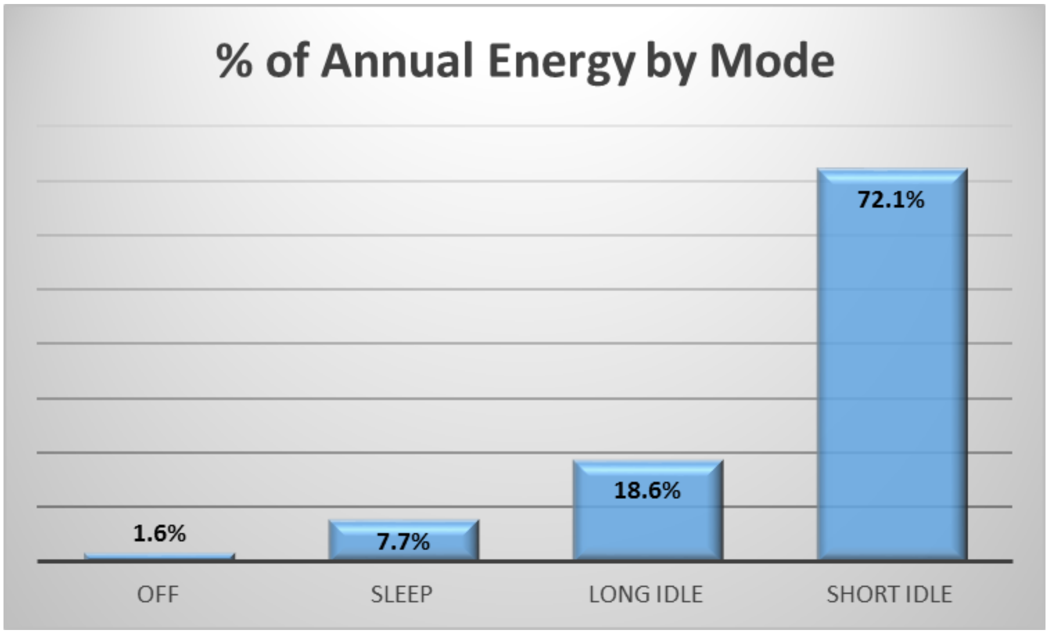

Figure 2

Using this methodology a typical Category 0 computer will have 72% of its annual energy consumption derived from short idle power mode and 18.6 percent of its annual energy consumption derived from the Long Idle mode. The average power levels in these two modes will account for 90.6% of the total annual energy consumption using this model. This indicates that reduction of both long and short idle should be focus areas for reducing energy consumption in PC systems and actually have been useful as drivers of energy reduction by the PC industry for many years. Idle power has been a useful proxy for active power since the active power for most end users is not significantly higher than the idle power for the systems in existence today the way they are typically used. The other factor allowing idle power to be a fairly good proxy is the fact that the system improvements made over time that reduced idle power also contributed to reducing the active power. Thus as idle power levels have come down the active power levels and the resulting real world energy usage of PCs have also come down.

Model Savings vs Real World Savings

The CEC and IOU's are using the above described ENERGY STAR® Program Requirements for Computers Version 6.1 E_{TEC} calculation model to determine potential energy savings and cost effectiveness of proposed changes to PC systems in the analysis used in the development of the Draft 1 PC's and displays proposed rulemaking. The ENERGY STAR® TEC model uses idle power as the proxy for active power while the PC is being used and long idle to model end user not present and the system has not yet transitioned to sleep or off mode. While this has been accepted for an extended period of time by industry and regulatory bodies, it absolutely must be understood that this modeling method is fundamentally dependent upon short idle power being an effective representation of system power while the end user is present and interacting with the PC system. The analysis and estimates using this methodology by the CEC and the IOUs fail to comprehend the limitations of the modeling method, and breaks this essential relationship between short idle power and the energy consumption of PCs as they are used in the real world.

Investigations of potential changes and the savings associated with them must comprehend whether the proposed changes and resulting savings calculated can be achieved in a real world usage scenario. The remainder of this document will describe some of these limitations and the resulting errors between calculated energy savings and real world realizable energy savings.

Modeling Idle as Proxy for Active Mode

One issue with using idle power as a proxy for active power is the potential to overestimate energy savings related to powering down certain devices in idle. For the desk top case long and short idle combined act as proxy for the entire active power of the device during the year, which based upon Table 1 weightings adds up to 50% of the total time per year (4380 hours) for desk top systems. If we assume an 80% efficient power supply we can calculate the inferred annual energy savings per watt of power reduction in idle based upon this model. Turning off a device in both long and short idle according to this model will reduce annual energy consumption by 5.475 kWh per watt of idle power reduction (4380/1000)/0.80.

To actually save the above calculated amount of energy requires the device to go from being on and active for 50% of the year to being on and active for <u>0% of the year</u>. If the device provides any essential functionality to the end user then this magnitude of savings <u>cannot</u> be achieved in the real world. Although changes can be made to the system that will allow these savings to be measured and calculated using this modeling method, the magnitude of the savings cannot be achieved while still providing a system that performs the critical uses required by the end user. The magnitude of savings being calculated requires essential components to be turned off or placed into non-functional low power states for 100% of the time and is absolutely reliant upon the device remaining non-functional for the entire year.

One of the best examples to illustrate this would be the spinning down of the hard disk drive (HDD) during idle. The CEC and IOUs assume the HDD can be spun down or placed into a "standby" state in both long and short idle and use the model calculated savings to show potential energy savings of the proposed regulation as well as to prove cost effectiveness.

An average desk top hard disk drive consumes about 6W DC during operation and about 0.8W DC when the platters are spun down[1]. This indicates that spinning down the hard disk drive will save (6 -.8) or 5.2 W of average idle power. Using the same power supply efficiency of 80% we get an AC power delta of 6.5 W and an annual energy savings of 6.5*4.38 or 28.47 kWh due to spinning down the HDD at idle. This savings analysis <u>fundamentally requires that the HDD must go from being on with platters spinning for 50% of the year to being on with platters spinning for 0% of the year</u>. The problem with this calculation is that it would be impossible to actually use the desk top PC and never spin the hard disk drive. If the end user turns the system on, receives and/or saves an email, installs any programs, runs a virus scan, saves a copy of a picture, updates any software applications, downloads any documents from the internet, or many other common PC user activities then the hard disk drive will be required to spin in order for the system to function. The only way to achieve the calculated savings is to cause the PC to be non-functional for the entire year. The Energy Star 6.1 specification requires the hard disk drive to be spinning for short idle testing largely to avoid this kind of unattainable energy savings calculations.

[1] Power values are averages of data sheet values for all 3.5 in Seagate and Western Digital drives listed on their respective website as of June 2015.

The CEC however is fundamentally relying on these unattainable energy savings for their energy savings calculations and the resultant cost effectiveness analysis in the proposed regulation.

Accurate modeling of savings due to powering down devices in idle

The problem then becomes determining the options for correctly modeling energy savings of powering down devices during idle activity in PC systems.

User Present Realizable Savings

If short idle power is to remain the proxy for active system usage then care must be taken to assure that idle power reduction techniques do not cause idle power to diverge significantly from the actual energy consumption of the product as used by the end user and that the end user experience is not negatively impacted. Only power reduction techniques that apply somewhat equally to idle and user present active power can be used without invalidating the essential proxy relationship between idle and active power. This means that devices that are essential to normal use of the product cannot be assumed to be powered down all the time.

Any devices essential to the operation of the system in normal use that are significant contributors to energy consumption during that use cannot be assumed to be off or in non-functional low power modes while the user is present and interacting with the system. The Energy Star 6.1 TEC model equates short idle to user present and interacting with the system and long idle with user not present. Thus turning off devices in long idle is consistent with the modeling methodology while turning off devices in short idle is inconsistent with the modeling methodology and likely breaks the required relationship between idle power as measured and active power when the product is actually being used.

It may still be possible to power down some essential devices even during active user present periods with a resulting energy savings. This would only be possible for some portion of the end user present time, provided there is not significant negative impact to the end user experience. The portion of end user present time any device can be powered down or placed into a low power state is dependent upon certain conditions as listed below.

1. Device can enter, reside in the low power state and resume from the low power state without causing functional issues with the operating system or any applications that use the device.
2. The time required to resume normal operation does not cause noticeable or annoying delays to end user tasks that initiate a need for the device functionality.
3. Average energy consumed during recovery process should be less than the energy saved over the average length of time the device can stay in the low power state.
    - Implies an understanding of the typical end user usage model and the resulting activity profile of the device
4. The net cost of energy saved over the life cycle of the product due to all allowable low power states must exceed the cost of adding the capability to achieve the low power state.
5. The process of entering and exiting the low power state over the life of the product should not negatively affect the reliability or usable life of the product in normal operation.

Assuming the device can be placed into a low power state during some portion of the end user present and interacting with the PC time frame and provided these can be achieved without negatively impacting user experience, it should be possible to calculate a realizable energy savings with enough information. The following is a proposed model describing the entry and exit process identifies the information gathering required to calculate potential energy savings of using low power operating states for essential devices when the end user is present and interacting with the PC.

- the average number of possible low power opportunities during use
  - Requires an understanding of typical usage model for an end user
  - Dependent on operating system, application software and end user usage patterns
- t_{dur} the average time duration of the low power events
- magnitude of power savings between active and low power modes of the device
- required time t_{entry} and average power level the device requires to enter the low power state from the normal state
- required time t_{exit} and average power level the device requires to recover to normal operation from the low power state

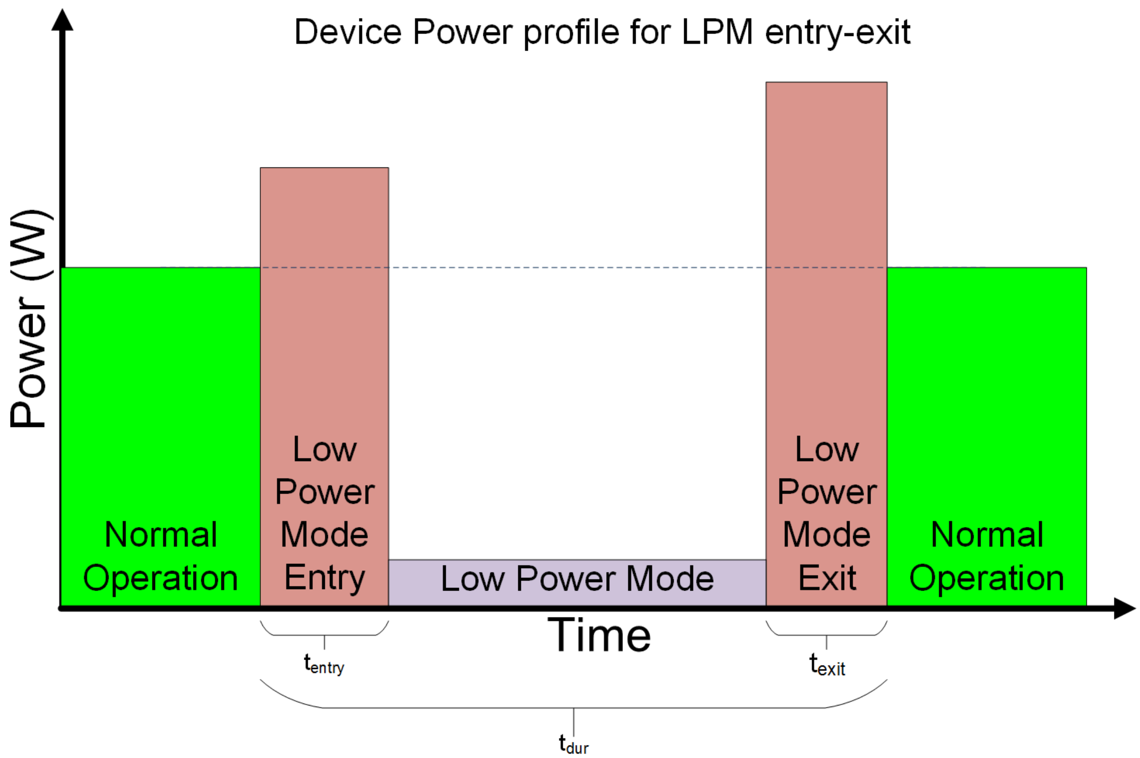

Figure 3

Figure 3 shows an example profile of a device transitioning into and out of a low power state including both entry and exit events and power levels. This diagram shows both entry and exit power levels to be above the active power levels as it is quite typical for devices to require additional activity levels and energy consumption to perform the entry and exit from low power state procedures.

Figure 4 below shows the total power for a HDD during active operation, spinning down the platters, residing on low power state and then resuming to normal operation. HDD's have a peculiar profile as the power level during entry is lower than the active power primarily due to the recovery of the energy in the platters as they are spun down. The reverse is true on low power mode exit where a very large power level is required to spin the platters back up. These two transitions can be seen as items A and B in the figure. The graph has a sample rate of one sample per second and it can be seen near callout A that it takes at least 4 seconds to transition from active to low power state for the HDD and between 4 and seven seconds minimum to transition between the low power state and the active state as be seen at callout B. The other item of note for a hard drive recovery process is that the power level rises to about 4X the active power level in order to restore the HDD to the active state from the low power state with the platters spun down.

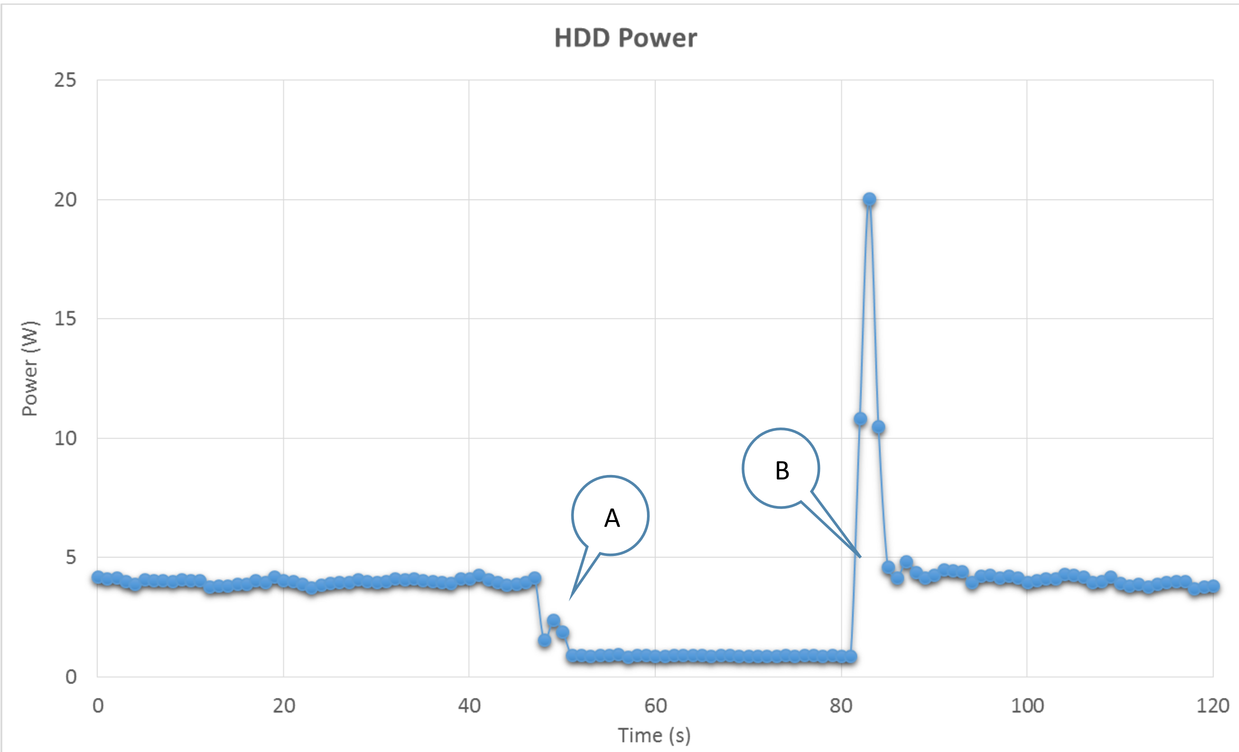

Figure 4

Potential for user not present savings (Long Idle Mode)

When the user is not present such as in the long idle state it is possible to power down some devices in the system that would be impractical to power down while the end user is present. There are still some limitations that must be considered in order to determine if the device can really be powered down or transition to a low power state for the entire long idle period. The model describes long idle as comprising 15% of the time in one year or 1,314 hours. The problem arises because in the real world this is not one contiguous block of time but instead is a very large number of shorter intervals that add up to 1,314 hours.

This means that in order to actually save the energy resulting from the device being in the low power state for the entire period of time one must first assure that the device will enter into the state prior to the assertion of that state on the system and can remain in the low power state for the duration of the long idle event. If this is not the case then we again must develop typical usage profiles and determine the number of long idle events, duration of long idle events and entry/exit profiles of the device to compute the realizable energy savings.

Our hard drive example is useful again to illustrate the inability to achieve 100% utilization of the long idle time as time in a low power state for certain devices. In order for the system to transition from the long idle state to the sleep state software will need to be executed that is unlikely to be resident in system memory and there is also likely to be critical writes of data and or system state information that will need to be written to the HDD platters. This requires the HDD to spin up the platters return to active mode, software read from the HDD, system state and other critical writes performed to the hard disk drive and then the system must transition to the sleep mode. For each of the long idle to sleep transitions of the system the HDD and other devices will need to be restored to active state for a period of time in order to execute the system transition from long idle to the sleep state.

Summary

When using idle as a proxy for user present active mode of a PC product, as is the case with ENERGY STAR® Program Requirements for Computers Version 6.1, it is impossible to save the entire energy contribution of devices that are essential to the normal operation of the PC while end users are present and interacting with the product.

Any energy savings analysis that is dependent upon powering down devices essential to normal operation during periods where the end user is interacting with the product is fundamentally flawed and provides savings estimates that are incorrect.

Any cost effectiveness analysis that is reliant on energy savings calculations which themselves depend upon powering down devices that are essential to normal operation of the product when the user is interacting with it is fictitious in nature as it relies upon savings that are unrealizable in the real world.

Real world realizable savings due to powering down devices essential to the normal operation of the product when the end user is interacting with it can only be calculated using careful analysis based upon energy profiles of the device and the development of device usage profiles based upon typical usage models for average users. These usage profiles also need to consider the impact to the end user experience of having to wait for devices to recover to active operation prior to performing required tasks.

Current IOUs and CEC computer energy savings proposals drastically overstate potential energy savings as they do not consider the fundamental implications and limitations of such modeling and analysis.

Postscript

This is the fourth document submitted to the docket by the ITI/Technet member companies documenting flaws in the IOU/NRDC analysis. The document submitted on June 1st, entitled “Intel and Dell Comments on Aggios’ Report,” provided an initial detailed technical response to Appendix C of the CEC Staff Draft. Further problems were identified at the June 10th Deep Dive meeting. The document entitled “ITI and Technet Comments: On April 15th Aggios Workshop Demo” (submitted on August 18th) identifies the failure to address issues like feasibility, user acceptance, product reliability and power consumption associated with spinning up hard drives. The document entitled “ITI and Technet Comments: Re June 1st Aggios Submission” (submitted on August 25th) identifies a number of issues; for example, estimating future savings based on technology already incorporated into computers, deviations from the universally accepted testing methodology, failure to adequately identify costs and feasibility, and the use of components with identified quality issues.

It is of concern to the ITI/Technet member companies that a fundamentally flawed analysis continues to be cited by the California IOUs and NRDC as the basis of their recommendations to the CEC, even after factual evidence was shared with them identifying concerns regarding their analysis and conclusions.

It remains imperative that the CEC estimate potential savings in a manner that is repeatable and accurate. California residents expect and current law requires any regulation promising to save money and energy to actually do so.