

ITI COMMENTS

ENERGY STAR Computer Program Draft 1 Version 5.0

General Comment: We are greatly concerned regarding the number of initiatives that EPA has underway, including multiple requests for data collections and submissions, that are creating significant strains on ENERGY STAR partner resources. This problem is magnified by similar or related initiatives underway in Australia, China, Europe and Japan.

This level of activity is also placing significant stress on our and our suppliers' product development cycles, creating a scenario where manufacturers may have to prioritize their commitment of resources in such a way that, ultimately, it may limit the availability of qualified products and technology in the Federal marketplace. There is already an indication that this may be occurring.

This matter is a fundamental concern of our industry and our customers. We wish to discuss this during the April 8 online meeting.

Our comments and recommendation regarding the Draft 1 provisions follow:

1) Definitions

d. Internal Power Supply:

Remove the text "separate from main computer board." Some internal power supplies could be integrated into a section of the main logic board. This type of power supply implementation should not be exempt from the efficiency requirements in the ENERGY STAR specification.

Remove "intermediate circuitry" wording. Some internal power supplies employ a separate AC line filter between the AC power cord and the integrated power supply. This type of power supply implementation should be covered by the ENERGY STAR specification.

h. Integrated Desktop Computer:

Integrated Computer Definition – Change to "Integrated Desktop Computer". The term "Integrated computer" implies coverage of notebooks. Changing the term to "Integrated Desktop Computer" makes the scope of the term very clear.

i. Thin client

Please Note: This topic is of distinct interest to ITI member companies, and we may have additional input and recommendations during the next round of comments, if not sooner.

k. Workstation

Please Note: This topic is of distinct interest to ITI member companies, and we may have additional input and recommendations during the next round of if not sooner.

l. Off Mode: The industry wishes the off mode definition to be corrected and suggests the following change to this paragraph and will provide an explanation for the change:

l. Off Mode: The power consumption level in the lowest power mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions. For purposes of this specification, Off Mode correlates to ACPI System S5 state, where applicable.

In ACPI terms, the S4 is a type of “sleep” state, and S5 (also the G2 state) and the G3 states are off states, the distinction being the S5/G2 state is the soft-off state and the G3 state is the mechanical off state; where S5 waits for an event from the power button to reboot the machine, and the G3 state is where the machine is electrically disconnected from the power mains.

Sleep and Off states are distinguished by sleep states resuming the machine back to the previous application and OS context while off states force a re-boot of the operating system (previous OS and application context is lost). In many cases, non-experts confuse the states because the S4 and S5 states can look similar electrically; however the impact on the user is very noticeable (the difference between rebooting the system and resuming back into the system).

Additionally “sleep” states are those which will have wake-events such as USB wake-events for keyboard or mouse movement or a modem wake-up event (for example). But the concept of waking the system out of an off state, where the OS reboots and there exists nothing to catch the event on the other end (i.e. OS and application context are not maintained from an off state reboot) makes wake-up events in S5 not very useful.

The industry notes that there is a single case for Waking the system from the off-state where an enterprise class machine can be enabled for Wake-from-off. In this case the wake-from-off is used to provision a new operating system on the machine, and then is never used again. As such we don't feel the wake-from-off should be specified, tested, or regulated from the ENERGY STAR standpoint as its not a normal operating condition that is used in the consumer or enterprise space (its one-off and used perhaps once if at all).

For these reasons the industry feels S4 should be deleted from the definition of the Off definition.

m. Sleep Mode: The industry wishes the Sleep mode definition to be less specific to allow the industry to innovate in this area. Currently the sleep mode is defined by the ACPI system level S3 state (suspend to RAM), however as noted in comments on Off, and from reading the specification, the ACPI outlines four different sleep states (S1, S2, S3 and S4) which all perform the same function but provide different implementations of the sleep state which allow differentiation between resume latency (time to get back into the working state) and sleep state power.

The industry feels that requiring the Sleep state to be the S3 state limits innovation. Firstly the computer manufacturer should be allowed to implement a sleep state in anyway that will meet the power requirements specified by the ENERGY STAR targets, why require a specific implementation; if this can be meet with an S1 or an S4 state should it matter? Secondly the regulating of an S3 state prevents innovation where a new definition of the ACPI sleep state could be created and added to the standard, yet the regulatory language would prevent the use of this state which might provide even better power and latency characteristics.

The industry recognizes that certain quality levels needed to be maintained in order to make the sleep state usable by the end user and also recommends that a minimum resume time latency for the sleep state also be required. In particular the industry recommends the following language change to the sleep state definition:

Sleep Mode: A low power state that the computer is capable of entering automatically after a period of inactivity or by manual selection. A computer with sleep capability can quickly “wake” in response to network connections or user interface devices. For the purposes of this specification, Sleep mode correlates to any of the defined ACPI System Level sleep states, where applicable while maintaining a resume latency time of at least x seconds.

Additionally, long-term the S3 (suspend to RAM) platform power will be dominated by memory power which will continue to increase as DRAM densities increase and end user need for more memory increases, making it more difficult to meet ENERGY STAR requirements long-term. Allowing more innovation in the sleep area with a limited resume latency could allow the sleep power to start migrating closer to the S4 power and approaching the system off power if latency and other platform issues can be resolved. However such innovation can not take place if the industry is required by law to implement the S3 state.

For these reasons the Industry recommends that the sleep mode definition be allowed a more broad definition as presented.

Power Management Requirements:

These comments are addressing Table 5. First we will address where globally the industry wishes the ENERGY STAR to move in regards to power management, and then will address some specific issues with proposals for power management (in table 5).

The industry agrees with the first two requirements where ENERGY STAR will regulate that systems should enter low power system states as default configurations for ENERGY STAR requirements. However, other than these two specific cases (Sleep mode and Display Sleep Mode setting requirements), the industry feels that the systems should be tested with power management features set as shipped by the factory. The rest of these comments will argue why the industry feels this is an appropriate direction.

In the previous Tier 1 specification, the EPA explicitly called out that HDDs should be spinning when tested for idle power measurements, and that desktop computers should be tested with displays on, and notebooks and all-in-one computers be tested with displays blanked. While the industry understands the reasons for this approach in Tier 1, we feel conditions have changed in Tier 2 and feel such statements should no longer be required or regulated, as it prevents innovations which could make platform power characteristics and performance even better.

The Tier 2 direction is to measure the systems when idle and when active. We feel that the HDD and monitor values (for example) should be allowed to engage for the idle test, while the active portion of the benchmark will exercise any sort of active power management features. There is a checks and balances as if the power management features is too aggressive (say HDD spins down too much) a poorer performance will result. The combination of idle power against active efficiency and performance will encourage the proper balance of power management and performance features.

Ethernet:

While requiring 802.3az is a good direction, this specification will not finalize until after the enforcement for Tier 2 ENERGY STAR has begun (end of 2009) and Ethernet PHYs and switches that support 802.3az will follow this. As such, this technology is more suited for consideration in a future revision of the specification, or sometime after 2010.

Network Connectivity:

While this sounds interesting, there is no platform-independent industry standard to define what “full network connectivity while in a sleep mode” means. Once a reference to this is

made, then the industry can examine what it takes to implement such a solution and then give feedback if such a solution can occur in this timeframe.

Sleep Mode Definition – Allow Hibernate (S4) to qualify as a sleep mode. For future computer systems, it may be possible to implement a lower power state by using S4/hibernate as a sleep state. S4/hibernate should be allowed as a sleep state if it can be demonstrated that the computer can quickly wake.

n. Idle State:

Idle State/Active State Definitions – Change terms to “Idle Mode” and “Active Mode”. The section heading is “Operational Modes” so the term “state” should be changed to “mode” for the sake of consistency.

Idle State/Active State Definitions– Add more detail about “as shipped” equipment settings and turning off ancillary functions. Further description of the computer settings is needed. Add the following text: “ In idle mode, automatic network functions such as software updates, background network activities such as “back up, synchronization, background application, etc. may be turned off”. Power management settings; such as processor settings and hard drive sleep must be set in the “as shipped” condition. Ancillary functionality such as wireless networking, backlit keyboards, integrated cameras, etc. shall be turned off.”

Networking and Power Management:

New class of clients without Ethernet NICs.

ITI believes that the EPA needs to recognize a new class of low power computers which will not have Ethernet NICs (being replaced by 802.11 NICs). The industry feels these computers should be able qualify for the ENERGY STAR logo and the version 5.0 of the specification needs to accommodate these sorts of machines. This could be done by testing these machines with built-in Ethernet enabled and connected to a wireless access point, or if the benchmark can't be readied in time, then tested without the networking. We are sure the industry and EPA can come to a working solution for this new class of machines in regards to the definition and testing methodology in the version 5.0 specification.

p. Network Interface:

Network Interface Definition– Add the option for using wireless as a means for testing ultra portable notebooks and tablets that lack an IEEE 802.3 wired Ethernet interface.

Some ultra-portable notebooks do not ship with a dedicated wired Ethernet port. Since these systems are typically very energy efficient, they should not be excluded from the ENERGY

STAR program based on the lack of a specific form of network port. The EEcoMark test method for active mode testing must allow for the use of wireless networking (e.g. 802.11n) as an option for operating the EecoMark test tool. To the last sentence of the definition, add “ or IEEE 802.11 wireless networking”

r. Wake on LAN (WOL)

Wake On LAN (WOL) Definition– Clarify WOL as applicable to IEEE 802.3 Wired Ethernet interface only. Some ultra-portable notebooks do not ship with a dedicated wired Ethernet port. WOL criteria in the standard should only apply to equipment with wired Ethernet interface. This clarification is needed due to the change in the definition of “Network Interface” above.

s. Energy Efficiency Performance Assessment:

Energy Efficiency Performance Assessment (EEPA) Definition– Add further description to illustrate the intent of the EEPA (i.e. to simulate a typical user activity level and determine a system performance ranking). Proposal: Change definition to the following:

“An evaluation of a computer’s effectiveness in translating energy into desired work output based on the following test elements:

- Overall energy consumption while in off mode, sleep mode, idle mode and while executing an “active mode” workload (e.g. word processing, spreadsheet, email, internet access, etc.)
- Performance scores obtained during the execution of certain application functions in the “active mode testing” for the intent of scaling power consumption limits to allow higher power limits for higher performing computers
- System characteristics that add functionality to the computer system (e.g. extra memory, extra hard drives, high performance graphics, etc.)

Energy Efficiency Performance Assessment: Further investigation is needed on how much time machines spend in idle vs. sleep, etc. How does the industry want to approach power management features, any changes proposed? The draft indicates a desire to approach annual energy consumption.

Workload Definition– Add further description to illustrate the intent and functionality of a workload (i.e. to simulate typical user activity). Change definition to the following:

“A defined set of computational activities to be performed over a period of time with the intent of simulating a typical user’s activity on a computer. The workload may be different for different classes of computers (e.g. office productivity, media rich, workstation, etc.)”

t. EEPA Tool: The tool appears to lead to more categories. Generally we support the additional complexity of more categories if more products are able to be qualified.

u. Workload: Does the ECMA or GWPG tool provide a method to deliver annualize energy consumption? GWPG will deliver benchmark results significantly different from the ECMA/BAPCo tool

v. Enterprise Channels

Enterprise Channels Definition– Change to “Institutional Purchasers” Change definition to the following:

“Institutional Purchasers – normally large and medium-sized business, government organizations, and educational institutions, with the intent of identifying machines that will be used in managed client/server environments

The term “Enterprise” implies private business purchasers, not education and government. “Institutional purchasers” implies a larger set of customers. Also it would be good to harmonize on language used in the EPEAT program.

2. Qualifying Products

Handhelds vs. small laptops criteria – >8” screen size proposed

Item V (line 416) – Integrated Computer Systems– Recommend changing reference to “Integrated Desktop Computer Systems,” to distinguish the intended product from other All-in-One systems.

3. Energy Efficiency and Power Management Criteria

A. Power Supply Efficiency Requirements:

As an industry do we recommend alignment with Climate Savers Computing Initiative Bronze Levels?

Computers Using an Internal Power Supply

Proposal: Include separate criteria for lower power internal power supplies ≤ 75 Watts. For these power supplies, active PFC would not be used.

PFC is not used on internal power supplies below 75 Watt input power since it reduces overall power supply efficiency. Note: Basing PFC requirement on the 75W output rating (instead of the input rating) is based on precedence in the ENERGY STAR External Power Supply spec, version 2, draft 1. Let me know if we should base this on input power rating of ≥ 75 W or not.

Note: ITI should support the internal power supply efficiency levels of 85% minimum efficiency at 50% of rated output and 82% minimum efficiency at 20% and 100% of rated output, with Power Factor ≥ 0.9 at 100% of rated output.

(B) Efficiency and Performance Requirements

1) Desktop, Integrated, Notebook and Tablet PC

Line 467 - 471: ITI believes that the E_{annual} formula has several structural issues that need to be addressed. We will have additional input and recommendations during the next round of comments, if not sooner.

2) Workstation Levels

Lines 528-538: As noted, ITIC agrees that the EEPA tool would NOT be applicable for workstations. Key considerations are both the workload and the duty cycle. As highlighted by the industry in ENERGY STAR for Computers v4.0 development, the usage model for workstations does NOT follow a typical client device, especially in the compute intensive workloads and collaborative computing models already highlighted. Specifically, an EEPA method combining a benchmark (for active mode) with an annual energy calculation with fixed duty cycles in various system states, would not be consistent with the usage model of these machines.

We recommend that the SPEC GWPG benchmark quantify the energy consumption in a typical graphics and compute cycle, while the capacity of the system be used to scale the system. We believe that given:

- the compute intensive nature of these systems, and
- consistency with premium characteristics described for workstations,

The workload transition required in the GWPG benchmark should replicate the duty cycle of both active and inactive states of the machine. Therefore, an annual energy calculation with specific mode duty cycles does not (and would not be used to) represent the usage model of these machines. The duty cycle and manageability of the system during inactive states is part of the default power management settings (policy) defined on the platform as shipped. The energy savings from these modes (duration and transitions) should be reflected in the execution of SPEC's benchmark. We also recommend that to capture the variety of configurations, the capacity scaling of the Tier 1 specification be reused. This should result in a specification that compares typical use as a percentage of maximum capability. i.e. $TEC = SPEC\ GWPG\ energy$, and the criteria would be $TEC < xx\% \text{ of } max_capability$ (Peak power at a worst case workload).

Workstation Levels EEcoMark will not be the basis of the workstation workload. It may be similar in concept, but the workload will be based on SPECpower and SPECviewperf.

4) Desktop Derived Server Levels

Lines 558-564: ITIC members agree that without additional information, the EPA may need to use the previous levels for Desktop Derived Servers (DDS). We also agree that a workshop is needed to both understand the barriers in achieving these levels and investigate the usage model for this class of computer.

Do recognize that by the definition, some of the manufacturers may have simply applied under the desktop categories. As client devices move to a usage model based specification, the DDS workshop should address the usage model difference, including network monitoring and small business operations. Based on anecdotal evidence, night time operations for commerce support appear to increase the active % of the time. One will also note that there is an emerging usage model of a desktop derived server in the home, as a means of communication and entertainment consolidation. This usage model is not prevalent at this time, but considerations for future investigations may be warranted. As implied this usage model not only defines the type of hardware employed, but, also displays a different power profile. This difference is inconsistent with the EEPA tool and E_{annual} criteria being proposed for the other client categories.

(C) Power Management Requirements

Table 5 – IEEE 802.3az is not yet a standard and should be removed

Line 589 – Table 5: Power management Requirements – Wake on LAN (WOL)

Proposal: Exempt computers that do not employ an integrated wired Ethernet port.

Ultra-portable notebooks are coming on to the market without wired Ethernet ports. These products are designed to support wireless connectivity as the primary/exclusive means of

connecting to a network. Wired WOL is not an appropriate requirement for these types of devices and could exclude some very energy efficient notebook and tablet models from the ENERGY STAR program. This would be a direct contradiction to the ENERGY STAR goal of saving energy.

Line 589 – Table 5: Power management Requirements – Network Connectivity

Proposal: Remove criteria for full network connectivity in sleep mode.

This functionality has not been incorporated into Ethernet standards and is not ready to be implemented as an industry standard. This criteria should be incorporated into the next version of ENERGY STAR once an industry standard is finalized.

Line 589 – Table 5: Power management Requirements – Wake Management

Proposal: Exempt computers that do not employ an integrated wired Ethernet port from remote wake events.

Ultra-portable notebooks are coming on to the market without wired Ethernet ports. These products are designed to support wireless connectivity as the primary/exclusive means of connecting to a network. Wake management over wired Ethernet is not an appropriate requirement for these types of devices and could exclude some very energy efficient notebook and tablet models from the ENERGY STAR program. This would be a direct contradiction to the ENERGY STAR goal of saving energy.

Line 629 – User Information Requirement

Proposal: Remove text “This information should be near the front of the user guide”

User guides are written in sections that are ordered in a logical sequence to best optimize the user’s experience and comprehension. Specifying the exact placement of the ENERGY STAR information in the user guide hinders the writers ability to create a user guide that describes the computer’s operation in a logical sequence.

Line 707 – Qualifying families of products

Proposal: Since EEcoMark will have a performance element to it, it may be difficult to test just the highest performance system to represent a lower performance system. An option should be given for the manufacturer to determine the worst-case configurations to represent the family of products. Since power allotments will be based on performance, a system with maximum processor and maximum memory may have a higher power allotment than the same system with a slower processor and minimum memory. Representative testing is going to be a very difficult, similar to the current workstation test method. To expedite testing, it

may be useful to specify representative testing as testing a system with the same processor model and speed with max and min memory configurations.

Testing every combination of memory and processor would be an unrealistic amount of testing. Setting a defined method of representative testing would allow manufacturer's to streamline testing.

4) Test Procedures

A. Models Capable of Operating Multiple Voltage/Frequency Combinations

Table 6 – We propose alignment to the CSCI- ECOS aligned test procedure for internal PSU's

For compliance testing, we believe that self certification and 3rd party testing facility should be allowed. The 3rd party testing would aid in supporting companies without dedicated facilities and would be at the courtesy of the ENERGY STAR Program.

For the testing specification, power supply testing procedures should be directed to the industry supported methodologies, xxxxxx.org. Similarly, the testing procedures for energy efficiency benchmark testing should reference an industry documented and supported procedure. We recommend that with the delivery of the benchmark, ECMA and BAPCO deliver the industry documented procedures, to be maintained and updated by the responsible industry organization, ECMA. This level of industry support and tracking will ensure testing issues are directly addressed and ensure data consistency. We recommend that a publicly accessible link to these test procedures be available from the industry organization. Given the complexity in the testing and setup, any testing program being conducted through a 3rd party test facility, the 3rd party test facility, procedures, and data undergo regular updates under the review of the industry organization. This process will also ensure consistency which may not occur with companies not represented in the industry organization.

Test Procedures (lines 669-681 and Table at Line 797) – Multiple Voltage/Frequency Testing

Proposal: Add a table with the standard voltage and frequency test combinations to represent global ENERGY STAR coverage (similar to the ENERGY STAR Monitor spec).
Example:

Supply Voltage/Frequency	Regions
100V ac (+/- 1%), 50 Hz (+/- 1%)	Japan
115V ac (+/- 1%), 60 Hz (+/- 1%)	US, Canada, Mexico, Taiwan, Central America, South America
230V ac (+/- 1%), 50 Hz (+/- 1%)	Europe, Australia, New Zealand, China, India, Korea, South America, Africa

Justification: To simplify global certification of products, ENERGY STAR should specify three distinct test voltages/frequencies that are representative of worldwide power grids. Since results are nearly identical for Japan 100V test voltage at 50Hz and 60Hz, a single frequency should be selected as representative. The way the standard reads now, it implies that separate testing would be required for every variation of input voltages (e.g. 127V, 60Hz for Mexico, 220V, 50Hz for Greece, 240V, 50Hz for Australia, etc.)

Section II, Testing Requirements (lines 803 & 804) – UUT Connection to Ethernet Switch

Proposal: Add the following text to address ultra-portable computers and tablets that do not have a dedicated wired Ethernet port: “Ultra-portable computers and tablets that do not have a dedicated wired Ethernet port may be tested connected to a live wireless network”

A test method is needed for computers that do not have a wired 802.3 Ethernet port and are intended to be connected to the network by wireless only.

Section II, Testing Requirements (lines 812-815) – UUT Preparation, Item 2

Proposal: Add the following text to address ultra-portable computers and tablets that do not have a dedicated wired Ethernet port: “Ultra-portable computers and tablets that do not have a dedicated wired Ethernet port may be tested connected to a live wireless network”

Justification: A test method is needed for computers that do not have a wired 802.3 Ethernet port and are intended to be connected to the network by wireless only.

Section II, Testing Requirements (lines 818-819) – UUT Preparation, Item

Proposal: Add the following text to address some power meters that come with a power strip as part of the standard equipment configuration (e.g. Yokogawa WT210 meter)

“No power strips or UPS units should be connected between the meter and the UUT (exception: power strips designed to function with the meter and that do not contribute to the power load on the meter).

The preferred meter for the EEcoMark testing (Yokogawa WT210) utilizes a power strip.

Section II, Testing Requirements (lines 827-828) – UUT Preparation, Item

Proposal: Change “bits per pixel” to “color depth (bits per pixel)”
Color depth is the characteristic, bits per pixel is the unit.

Section II, Testing Requirements (lines 829-830) – UUT Preparation, Item 10

Proposal: Clarify that energy saving features in the “as shipped” state are left enabled for testing (e.g. hard drive sleep, processor napping/scaling, etc.)

In the past, the decision was made after issuing the final version of ENERGY STAR 4.0 to disable energy efficiency features for testing. This is in conflict with testing the computer in it’s “as shipped” condition and discourages advances in power management improvements.

Section II, Testing Requirements (lines 838-841) – UUT Preparation, Item 10, section c –

Please Note: This topic is of distinct interest to ITI member companies, and we may have additional input and recommendations during the next round of comments, if not sooner.

Section II, Testing Requirements (lines 842-843) – UUT Preparation, Item 10, section d –
Leave primary wireless radio on for ultra-portable and tablets without a wired Ethernet port

Proposal: Include the option to leave the primary wireless radio (e.g. 802.11n) on for testing of ultra-portable and tablets without a wired Ethernet port

A test method is needed for computers that do not have a wired 802.3 Ethernet port and are intended to be connected to the network by wireless only.

Section II, Testing Requirements (lines 842-843) – UUT Preparation, Item 10, Add new section e – Disable extra features that may come with the product

Proposal: Insert a new section e as follows:

“Power to extra features (e.g. lighted keyboard, camera, etc.) should be turned off for all tests”

Justification: Power allowance adders are not typically provided in ENERGY STAR specification for extra features that may require a small amount of extra power. To avoid penalizing a computer design with added functionality, the best approach is to test with the

additional features turned off. The alternative would be to create power allowance adders that compensate for the added features desired by the customer.

Section II, Testing Requirements (line 864) – Idle Mode Testing, Item 14 – Change accumulation of power values to allow intervals faster than 1 second

Proposal: Change the accumulation of power values interval to “ ≤ 1 second”.

Section II, Testing Requirements (line 869) – Sleep Mode Testing, Item 15 – Change accumulation of power values to allow intervals faster than 1 second

Proposal: Change the accumulation of power values interval to “ ≤ 1 second”.

Additional General Comments:

Testing of the Display

In Tier 2 the testing will be done in off, sleep, idle and active states. We propose a change to how the system is tested versus Tier 1, such that all idle testing be done with the display blanked (regardless of platform) and that the display be tested on during the active portion of the test, which will allow the maximum exercise of display power management techniques for idle and active workloads. In the on portion of the test, the brightness of the display will be important to the power consumed by the display, and it is proposed that and existing methodology already employed by ENERGY STAR for displays be used to set the intensity of the displays for integrated desktops, notebook computers and thin clients (those platforms with integrated displays).

Customer Demand for Functionality and Corresponding Power

As users desire for new features occur, the industry will have to integrate these systems into the platforms, and these devices can have impact on the idle and active power of the system which will justify the value of the feature. It is within the interest of the EPA's ENERGY STAR program and the industry to allow such new capabilities to qualify as ENERGY STAR even though it might be difficult to describe what these new capabilities could be. For example, TV tuners and BlueRay DVD drives are becoming very popular, but the inclusion of the devices (even doing nothing) can raise the overall idle and active power of the platform.

It is the industries proposal that such the version 5 specification address a new way of allowing this sort of innovation of new technologies in ENERGY STAR qualified products and wish to work with the EPA to define a mechanism to allow a generic mechanism to allow the feature to not impact the pass/fail of the system without necessarily identifying the new feature because of the competitive marketplace. Such optimizations to the process might allow the OEMs to

manually turn off select features during testing or by providing a power/energy capability adder for a given function.