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Philips Lighting Comments on Low Power Mode - 9-18-17 - Final

Additional submitted attachment is included below.

California Energy Commission
Docket Office, MS-4
1516 Ninth Street
Sacramento, California

RE: 17-AAER-12 (Low Power Mode and Power Factor)

Dear Mr. Nelson,

Philips Lighting appreciates the opportunity to provide the attached comments on the Phase 2 Appliance Efficiency Pre-Rulemaking for Low-Power Mode and Power Factor.

Philips Lighting is a global leader in lighting products, systems and services. Our understanding of how lighting positively affects people coupled with our deep technological know-how enable us to deliver digital lighting innovations that unlock new business value, deliver rich user experiences and help to improve lives. Serving professional and consumer markets, we sell more energy efficient LED lighting than any other company. We lead the industry in connected lighting systems and services, leveraging the Internet of Things to take light beyond illumination and transform homes, buildings and urban spaces. In 2015, we had global sales of over 8 billion USD and currently we have approximately 36,000 employees in over 70 countries. Our North American headquarters is located in Somerset, New Jersey.

We are responding to this comments request with two documents; this document addresses each one of the posted questions. We are docketing a separate document which provides the technical background necessary to address the posted questionnaire. After considering the questions posted by the commission, we have three major conclusions.

1) Low power mode and power factor for lighting systems should be treated in two separate roadmaps for different product clusters as some product groups already have proven, published standby power consumption test methods. However, almost no research has been published about measuring power factor in low power mode for most clusters.

2) We strongly support the proposed system-oriented, horizontal and vertical policy with respect to low-power mode which reflects the new reality that connected luminaires are increasingly likely to have embedded within them devices to support non-lighting applications.

3) Power factor in low power mode is a complex discussion; current instrumentation provides a measurement value; however, it is difficult to correlate this value with the physical reality of an electrical system. It is therefore not prudent to regulate power factor and harmonics in low power modes (See Technical Note Number: 221190 docketed separately).

Philips Lighting applauds the Energy Commission for moving forward in this area and developing an updated perspective on Low-Power Mode. We support the roadmap approach and believe it is more collaborative than the traditional standards development process and is a more appropriate regulatory framework as we move towards the Internet of Things (IoT) and connected lighting systems.

Our response to each of the posted questions begins on the following page. We look forward to continuing our work with the CEC on the road mapping process.

Sincerely,

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2017 Appliance Efficiency Phase 2 Pre-Rulemaking
Response to Additional Guidance on Roadmap Proposals

Low-Power Mode, Docket 17-AAER-12

September 18, 2017

Philips Lighting appreciates the guidance offered by the Energy Commission's document *"Additional Guidance Roadmap Proposals,"* published on 8/22/2017. Our response follows. We have also docketed a technical support paper entitled ***LED Lighting Devices and Power Quality*** *(*ref. TN Number: 221190*)*. This paper supports in more detail the responses to the questions listed below and includes technical rational, engineering modeling, testing data, and a literature review. We will address the questions in the order presented by the Energy Commission.

Low-Power Modes and Power Factor

1. Should power factor and low-power modes be treated together in the same roadmap or should two separate roadmaps be developed? Should the product clusters align if the roadmaps are separated? What are the advantages and disadvantages to your proposed approach?

We propose to treat power factor and low power modes for lighting devices and lighting systems in separate roadmaps. Low power modes, their associated power factor limits, and test methods are in need of additional research. ANSI and IEC are currently developing power consumption testing methodologies for some lighting devices operating in low power modes. It is unknown if the same methods, with the same testing apparatus, will be system level scalable.

We recommend separating roadmaps for different product clusters as some product groups have proven, published standby power consumption test methods. However, very little research has been published to date on measuring power factor in low power mode for most clusters.

The main advantage of approaching power factor and low power modes by clusters is that different test methods and limits may be developed in parallel.

2. What are the products that would be included in each cluster? What is the best size for each category? For example, should we assign a category for all connected edge devices or should we break this into several smaller categories such as connected lighting devices, connected audio and video devices, connected heating and cooling devices, etc.?

The regulation of low power modes and power factor for lighting devices and systems may benefit if they are separated into their own clusters. They may be organized in a matrix structured by the type and number of adjacent technologies that may consume power from the same power supply, while the lighting function remains in standby power. See Figure 1 below. It is still early to characterize such matrix fully.

A lighting device or system that includes a network communication feature may require a different test method than a device or system that includes video capabilities. The same holds true for a device or system that supports only one communication mode and one power supply for video versus a device or system that supports 10 video recording cameras.

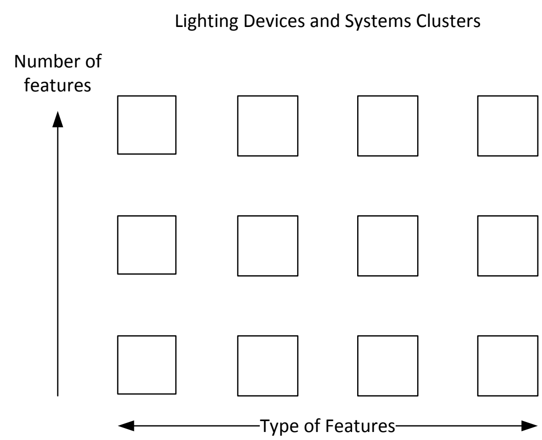

Figure 1, *lighting devices and systems cluster matrix concept*

3. What should be characteristics of different clusters of products that can be grouped together to evaluate low-power-mode performance? In other words, what should be the main function in the low-power mode among the devices in each group (the horizontal function)? Examples include searching for infrared light signal of a remote control, or sensor signals of a security camera.

Lighting devices and systems are characterized by their main function which is general illumination and by their secondary functions such as networking and sensing. They may be arranged in different clusters as described in Figure 1 above. Consider the cluster example outlined in Figure 2 below which characterizes the lighting system's secondary functions.

Number of Devices	Digital Communication	Low Voltage Analog Interface	Infrared Sensor	Ultrasonic Sensor	Wireless Communication	Auxiliary Power Supply	Video Management	Sound Management	Other	
1	A					C				
2			C							
3	B									
4							C			
5										

Figure 2, *Lighting system cluster example*

Cluster "A" may include a device which has one digital communication port only; whereas, cluster B groups all devices or systems that have three digital communication ports. Cluster C encompasses lighting devices or systems that include one auxiliary power supply, two infrared sensors, and four video management ports. The lighting device cluster space will include all the matrix's cells permutations. Unfortunately, it is too early in the development of IoT lighting technology to fully characterize the proposed matrix. As additional features and more powerful devices and systems are introduced, the makeup of the cluster will continue to grow and evolve. Therefore, it is expected that the scope of the cluster makeup will have to be periodically revisited.

4. What are possible additional functionalities of products in each group that require additional power consumption allowances in low-power mode (the vertical functions)? For example, maintaining clock function while the security cameras are in standby mode to stamp the time of the recordings.

Some lighting devices and systems additional functionalities are already known,

- Digital interfacing (DMX, DALI and other)
- Analog interfacing (0 to 10V and other)
- Wireless communications (Wi-Fi, Bluetooth®, Zigbee, NFC, other)
- Infrared interfacing
- Occupancy sensor interfacing and powering
- Other sensor types
- Auxiliary power supply

- Environmental sensors (humidity, fire, temperature)
- Timekeeping
- Cameras

However, LED lighting devices and systems continue to innovate at a rapid pace. It's hard to establish an accurate list for all possible future features to be included as a cluster differentiator as there are a number of emerging technologies and sensor types that have yet to be designed in (e.g. facial recognition).

5. Different groups of products might have different types of low-power modes. These low-power modes should be determined and defined for each group of products. What are the different types of low-power modes (standby "active," standby "passive," off) for each group of products?

The American National Standards Institute (ANSI) C137 committee, the Institute of Electrical and Electronics Engineers (IEEE), and the International Electrotechnical Commission (IEC) are among the institutions developing standby terms and definitions and testing methods. According to the United States Code of Federal Regulations (CFR), Title 42, Subchapter III Improving Energy Efficiency, Part A, Energy Conservation Program For Consumer Products, Article42 USC §6291(41):

the term ''standby mode'' means the lowest power consumption mode, as established on an individual product basis by the Secretary, that—

(A) cannot be switched off or influenced by the user; and

(B) may persist for an indefinite time when an appliance is—

(i) connected to the main electricity supply; and

(ii) used in accordance with the instructions of the manufacturer.

Whereas, 42 USC §6295 Energy Conservation Standards, (gg) Standby mode energy use (1) definitions describes,

(*A) In general*

Unless the Secretary determines otherwise pursuant to subparagraph (B), in this subsection:

(i) Active mode

The term ''active mode'' means the condition in which an energy-using product—

(I) is connected to a main power source;

(II) has been activated; and

(III) provides 1 or more main functions.

(ii) Off mode

The term ''off mode'' means the condition in which an energy-using product—

(I) is connected to a main power source; and

(II) is not providing any standby or active mode function.

(iii) Standby mode

The term ''standby mode'' means the condition in which an energy-using product—

(I) is connected to a main power source; and

(II) offers 1 or more of the following user-oriented or protective functions:

(aa) To facilitate the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer.

(bb) Continuous functions, including information or status displays (including clocks) or sensor-based functions.

Both sections address a no-load condition; however, neither provide a general definition applicable to lighting devices or lighting systems for such condition. The United States Department of Energy (DOE) has expressed interest in the past to evaluate some consumer products in a similar way as the European Union does; thus, following the IEC 62301 Household electrical appliances – Measurement of standby power standard.

Concurrently; the IEC 62301 definitions shown in Table 1 are applicable when evaluating consumer products under this standard.

Table 1, IEC 62301 definitions used to measure standby power

3.2 mode	*a state that has no **function**, one **function** or a combination of **functions** present.* *NOTE 1 The **low power mode** categories in this standard are intended to provide guidance for the development of specific **mode** definitions for TC59 products by the relevant subcommittees.* *NOTE 2 [IEC 62301] Annex A provides guidance on expected **modes** found in various product configurations and designs based on their circuitry and layout, but it does not define these **modes**. Annex A also provides background and guidance to users of this International standard regarding the development of **mode** definitions for specific products.* *NOTE 3 See Annex C for examples of how to calculate total energy consumption from power measurements where the duration of each relevant **mode** is known.*
3.3 Product mode	***mode** where the **functions** present, if any, and whether these are activated, depend on the particular product configuration.* *NOTE The issue of devising appropriate names for **product modes** is a matter for the relevant product committees. While a **product mode** name should generally reflect the **functions** that are activated, they need not contain the terms "standby" or "network" even where the **product mode** falls within these **mode** categories.*
3.4 low power mode	*a **product mode** that falls into one of the following broad **mode** categories:* *· **off mode**(s)* *· **standby mode**(s)* *· **network mode**(s)*

	NOTE 1 ***Low power modes*** *are classified into one of the* ***mode*** *categories above (where applicable) on the basis of the* ***functions*** *that are present and activated in each relevant* ***mode****. Where other* ***functions*** *are present in a* ***product mode*** *(in addition to the ones required for the* ***mode*** *categories specified above), these* ***functions*** *do not affect the* ***mode*** *classification.* *NOTE 2* ***Low power mode*** *categories are defined in order to provide guidance to users of this international standard and to provide a consistent framework for the development of* ***low power modes****.* *NOTE 3 Any transition that occurs between* ***modes****, either through user intervention or automatically, is not considered to be a* ***mode****.* *NOTE 4 Not all* ***low power mode*** *categories are present on all products. Some products may have more than one* ***product mode*** *in each of the* ***low power mode*** *categories with different combination of* ***functions*** *activated. The power consumption in each* ***low power mode*** *depends on the product design and the* ***functions*** *which are activated in the particular* ***product mode****.*
3.5 off mode(s)	*any* ***product modes*** *where the energy using product is connected to a mains power source and is not providing any* ***standby mode****,* ***network mode*** *or* ***active mode function*** *and where the* ***mode*** *usually persists. An indicator that only shows the user that the product is in the off position is included within the classification of* ***off mode****.* *NOTE Guidance on* ***modes*** *and* ***functions*** *may be found in Annex A.*
3.6 standby mode(s)	*any* ***product modes*** *where the energy using product is connected to a mains power source and offers one or more of the following user oriented or protective* ***functions*** *which usually persist* *· to facilitate the activation of other* ***modes*** *(including activation or deactivation of* ***active mode****) by remote switch (including remote control), internal sensor, timer;* *· continuous* ***function****: information or status displays including clocks;* *· continuous* ***function****: sensor-based functions* *NOTE Guidance on* ***modes*** *and* ***functions*** *may be found in Annex A. A timer is a continuous clock* ***function*** *(which may or may not be associated with a display) that provides regular scheduled tasks (e.g. switching) and that operates on a continuous basis.*
3.7 Network mode(s)	*any* ***product modes*** *where the energy using product is connected to a mains power source and at least one network* ***function*** *is activated (such as reactivation via network command or network integrity communication) but where the primary* ***function*** *is not active.* *NOTE Where a network* ***function*** *is provided but is not active and/or not connected to a network, then this* ***mode*** *is not applicable. A network* ***function*** *could become active intermittently according to a fixed schedule or in response to a network requirement. A "network" in this context includes communication between two or more separate independently powered devices or products. A network does not include one or more controls which are dedicated to a single product.* ***Network mode*** *may include one or more standby* ***functions****.*
3.8 Active mode(s)	*a* ***product mode*** *where the energy using product is connected to a mains power source and at least one primary* ***function*** *is activated.*

	NOTE The common terms "on", "in-use" and "normal operation" also describe this ***mode****.*
3.9 Disconnected mode	*the state where all connections to mains power sources of the energy using product are removed or interrupted.* *NOTE Common terms "unplugged" or "cut off from mains" also describe this* ***mode****. This* ***mode*** *is not part of the* ***low power mode*** *category.*

Any of these definitions work well when evaluating simple devices capable of operating in standby mode. Consider a fluorescent ballast capable of powering off the output as a response to a command, and powering on the output as a response to a different command. However, additional definitions are needed to address more sophisticated devices that may have multiple functions, multiple interfaces, or when there is a need to measure standby power for a large lighting system.

Future lighting devices and systems may include an aggregation of different functions (lighting, sensing, video and other), as well as intermittent functions that may be changing modes from off, to standby, to active, and back to off. Standby power and power factor of such complex devices are difficult to measure, particularly if the intermittent functions have a non-rational period of occurrence in relation to the mains voltage.

The CFR, DOE, and IEC definitions described above are a starting point. They do not seem to be sufficiently descriptive to encompass the rapid innovation and frequent product introductions that characterize today's lighting industry.

6. What should be the proposed targets and milestones for efficiency (including base levels for horizontal function and adders for vertical function(s)) for each product cluster? These targets or milestones should also include proposed pathways to improve the energy efficiency for each cluster of products or examples of models of the same products that are more energy efficient with the same or better utility and performance.

LED devices and lighting systems efficiency is a complicated question. The IEC and ANSI are working on standards based on a system approach. We therefore have no proposal until these standards are complete. Until that time, consider these preliminary values:

Function	Value (W)
DALI communications	0.2
Wireless communication per interface	0.25
Other hard wired communication per interface	0.1
Sensor (per sensor port)	0.15
Other functions (per function)	0.1

7. What are technical barriers to improved efficiency and technical solutions to achieve efficiency levels? In particular, specify whether increased energy efficiency for each group of products has an adverse impact to their utility; if it does, propose solutions. For example, latency can significantly impact the expected utility of small network equipment; what are ways to decrease latency while improving efficiency?

With complex multi-function systems, efficiency improvements are often realized through component-level innovation; SoC improvements and sensor miniaturization, for example. More broadly, IoT-related factors such as latency, reliability, emergency modes, etc., may be more effectively addressed through a higher-level approach encompassing the IoT infrastructure itself.

8. What are proposed test procedures for each cluster or product within that cluster (for both test setup and measurements)? Specify the metrics used for each cluster to evaluate efficiency.

Lighting Devices and Lighting Systems test methods are under development by The American National Standards Institute (ANSI), The National Electrical Manufacturers Association (NEMA), Illuminating Engineering Society (IES), and The International Electrotechnical Commission (IEC). Once complete, we recommend aligning state regulation test methods with these national and international practices. Among these, ANSI C82.11 describe the energy efficiency test procedures for both dimming and fixed output electronic ballast. Whereas, ANSI C82.16 describes the LED drivers energy efficiency test method. Standby power test methods for these two standards are currently under review. The IEC has an active working group developing standby power characteristics and methods as well.

9. What research and development is needed to further improve the efficiency of each cluster or product within the cluster?

Additional research for lighting devices and lighting systems energy efficiency is needed in the areas of: low energy modes, standby power, the use of lighting components for functions other than lighting within the system, security and privacy (cyber security and cyber privacy specifically), energy consumption, non-periodical power usage, energy efficiency, energy usage, and metering phenomena.

Other system aspects such as latency, system level error/deviation handling, memory management and its energy consumption, system level safe failure, and other high-level system topics may be better addressed at the state or federal IoT infrastructure level.

10. How can the Energy Commission track whether roadmap goals or milestones are being met?

One direct approach is to engage directly with the manufacturers. As long as there is some assurance of confidentiality, the Commission could ask manufacturers to provide product data. A second way is to track ANSI and IEC standards developments related to devices and systems throughout the year.

11. What are the benefits of power factor correction and who receives those benefits?

Power factor correction aims to help end users as it reduces their electricity cost, improves energy efficiency, supports its infrastructure by operating at a lower rms current, and by avoiding thermal stress. Power factor correction aims to help energy distribution by maximizing the energy transfer from the distribution transformer to the end user, to improve the system reliability, and to extend the useful life of the transformer and system wiring. Power factor correction aims to help power generators by maximizing the energy flow through the system.

However, power factor is a combined metric that include two fundamentals, current displacement, and harmonic content. The expected benefits described above are not equally achieved by correcting power factor for a single device. The power factor benefit is contingent to the root-cause of the power factor degradation. One device may have a low power factor because a substantial amount of power is carried by the 3^{rd} and the 5^{th} harmonics. Other devices in the network may also be carrying power in these harmonics with a different phase. The power factor correction of each component will not result in any system level benefit because the result is the same as the natural system harmonic cancellation. Congruently, some devices current displacement may be inductive (motors) and other capacitive (power supplies), individual components power factor correction may not result in any benefit because its effect is the same than the load aggregation in a building.

To better understand if a power factor correction is needed, at this time, we recommend following IEEE, ANSI and IEC proposed metric of expressing power factor in terms of displacement and distortion. For state regulation of lighting devices and systems, a close alignment with ANSI C82.77 may be helpful. This standard is under review to consider displacement factors for LED devices.

(Please reference TN Number: 221190 for additional details to support this response).

12. Are correcting both kinds of power factor, displacement and harmonic distortion, equally beneficial? To whom?

Correcting power factor may be beneficial for consumers, energy distributors, and energy generators as described above. Displacement factor correction may have a more direct impact in the energy flow from the power generation plant to the consumer usage in general. Regardless of this generic statement; energy savings from lighting devices and systems are directly linked to the light source efficacy (output lumens/input power), and the power supply efficiency (output power/input power), as opposed to a weak linkage to power factor. Thus, a high displacement factor or a high harmonic factor does not necessarily result in the realization of larger energy savings, as compared to replacing the light source from traditional lighting to LED, or by introducing smart controls.

Lighting devices and lighting systems applications may benefit from both displacement factor and harmonic factor correction up to a point where it makes economic sense. The benefit versus cost ratio is maximized when lighting devices limit their harmonic content to the limits described in ANSI C82.77. The minimum displacement factors are still under debate. A minimum limit set for lamps operating in full power mode has been published by the IEC TC34A (lighting source sub-committee). ANSI is considering adopting these same limits. Additional research is needed to consider all lighting devices, and to consider modes of operation other than full output power.

13. What research and development is needed to better quantify the benefits of power factor correction?

Research and development is needed in various areas as described in the reference paper. Further details are outlined in the document. Some lighting devices and lighting system power quality topics that are in the need of additional R&D are listed here.

- Electrical parameters measurement for non-repetitive operation conditions as well for intermittent modes of operation.
- Displacement factor for low power modes
- Harmonic Factor for low power modes
- Apparent power for low power modes
- Electrical parameters measurements in aggregation or system level
- Displacement factor aggregation compensations when the same system include capacitive and inductive loads
- Harmonic factor aggregation cancellation derived from harmonic phase angles diversity
- System standby mode energy consumption vs. system full power mode energy consumption to understand if a low power mode may pose any threat to its electrical system. See reference paper.

Additional Comments

Today, connected lighting systems are becoming increasingly widespread across indoor and outdoor environments, from residential to commercial and public spaces. In addition to traditional advanced lighting control, lighting systems are increasingly being used as a platform for a growing portfolio of data-driven applications. These can range from applications yielding increased system-oriented energy savings, to safety and security of public spaces.

To enable these applications and their benefits, these lighting systems not only perform their base function of illumination, but incorporate secondary functions like networking, energy storage, sensing and imaging.

We think that work on low-power mode is particularly timely, as connected, smart systems and the IoT are experiencing exponential growth. The IoT offers great promise for the future. Adaptive, connected systems will become pervasive. Big data and associated analytics will drive new insights and increased awareness about our environment and we expect that many new and innovative data-driven services will emerge. Connected indoor and outdoor lighting-based systems will simultaneously enable multiple benefits to owners and end users with features that facilitate the management of Assets, Scenes, Space Utilization, Parking etc., and perform services like Incident Detection, Pedestrian and Vehicular Traffic Control, Environmental Monitoring, Navigation and Lighting Energy Optimization to mention but a few.

We strongly support the proposed horizontal and vertical policy with respect to low-power mode. It reflects this new reality that connected luminaires are increasingly likely to have embedded within them devices to support non-lighting applications. To this end, we recognize that illumination is the 'base function' in this case, and that sensors and networking are important additional functions that may support applications such as space utilization and public safety. We support the way the Energy Commission has characterized sensors and networking as 'adders' to the base function. Our collective challenge will be to establish the proper adder (allowance) for each of these functions. We note that this will require a fundamental change from the current 'component' based regulatory approach to one that looks at the system as a whole. If implemented properly, these policies can drive energy efficiency and simultaneously enable innovation. We look forward to working with you in this regard.