The Role of Standby Power in the Functioning of Lighting Systems

GLOBAL LIGHTING ASSOCIATION

THE ROLE OF STANDBY POWER IN THE FUNCTIONING OF LIGHTING SYSTEMS

Introduction - Setting the scene

In today's world, energy efficiency in lighting is more crucial than ever due to increasing concerns about climate change and environmental sustainability. The lighting industry is continually seeking ways to reduce energy consumption while maintaining high-quality illumination.

Daylighting techniques, lighting controls, connected lighting systems, and integrating lighting controls with building management systems for 'smart buildings' are all methods being utilised to provide people with light when they need it and decrease electricity usage for lighting.

The advancements in Light Emitting Diode (LED) technology have provided new opportunities for energy efficient lighting solutions. However, one area of current debate is the contribution of standby power in lighting systems and its effect on energy efficiency.

Note: 'standby mode' power is a subset of 'non-active mode' power. Refer **IEC 63103:2020 Lighting equipment – non-active mode power measurement.**

This international standard defines standby mode (of lighting equipment) as:

- mode when the equipment is connected to a supply voltage with the illumination function off, while capable of being activated by an external trigger not being a trigger from a network

And networked standby mode (of lighting equipment) as:

- mode when the equipment is connected to a supply voltage with the illumination function off, while capable of being activated by an external trigger being a trigger from a network

This Global Lighting Association (GLA) White Paper aims to provide a comprehensive understanding of standby power in lighting systems. In **Part 1** it showcases the value of LED lighting technology as a major enabler of energy efficiency in lighting and in **Part 2** it acknowledges the concerns of non-governmental organisations (NGOs) who often advocate for the broad reduction (in application terms) of standby power in lighting systems.

Some view standby power as a waste of energy and resources, while others argue that it is essential for ensuring the proper functioning of lighting systems, particularly in critical applications where reliability and human security and safety is essential. In **Part 3** we explain why excessive reduction in standby power limits in lighting systems can cause several unforeseen issues leading to: design and performance limitations, compatibility and reliability challenges, cost implications, loss of energy-savings opportunities and reduced safeguards for human security and safety.

While standby power is essential in several lighting applications (**Part 4**), there are many other opportunities to save energy and reduce the environmental impact of lighting. The global lighting industry continues to focus on implementing energy efficient technologies such as LED lighting, automation and smart controls, sensors and switches to optimise energy usage. These are outlined in more detail in **Part 5**, motivating people, businesses and governments to transition to these technologies that can significantly optimise energy usage.

Ultimately, perspectives around standby power in lighting systems highlight the complexity of balancing energy consumption in the different states of activity with the energy saving facilitated by these states. It is important to understand the intricacies, opportunities, and constraints of standby power to make informed decisions about setting regulatory requirements. Standby power should not be evaluated separately but rather assessed as 'networked standby mode' power as part of an energy-saving lighting control system.

1. Light Emitting Diode (LED) lighting technology as a major component of energy efficiency.

Overly regulating power consumption in low-activity modes of lighting and lighting control products can have unintended adverse effects on their core functions, namely safety, security, energy efficiency, and reliability.

Such products are used in systems that are designed to provide consistent and dependable illumination that ensures safe navigation, effective resistance to security threats, and overall operational stability.

Excessive restrictions on standby or low-power consumption settings may compromise these critical roles by limiting a product's ability to react promptly and maintain essential functions, thereby undermining their value in real-world environments.

Instead, greater efficiency gains could be realised by focusing on the widespread transition to LED lighting technology. LEDs have already revolutionised the lighting industry by offering substantial energy savings compared to traditional technologies while maintaining high performance.

Since becoming fully mature around 2015, LEDs have surpassed conventional lighting in most aspects, today representing about half of the global lighting market revenue and projected to exceed 85% by 2035.

According to CSIL report "LEDs and the Worldwide Market for Connected Lighting – Market Research" from 2024 :

- Total 26,500 million Units (100.0%)
- LED 12,000 million Units (45.3%)
- Conventional 14,500 million Units (54.7%)

From the early 2000s, the luminous efficacy of LEDs continued to increase, so that today, LED lighting products have surpassed other technologies with efficacies for non-dimmable white light that exceed 100 lumens per watt (lm/W).

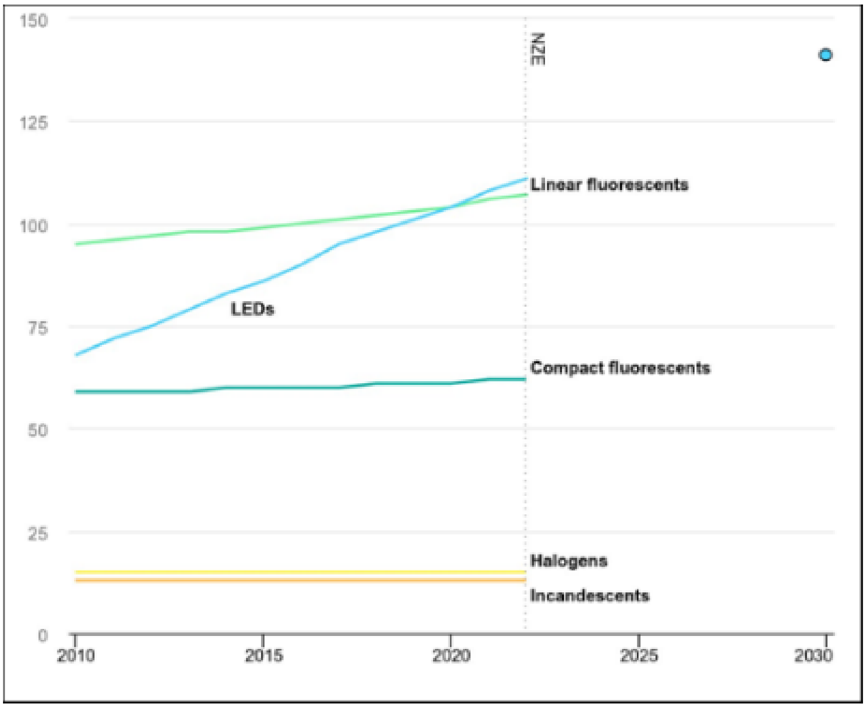


Fig.1 Lighting efficacy by technology

Moreover, LED prices are expected to decrease significantly in the coming decades, further bolstering their adoption. High-quality LED products also provide versatility through features like adjustable correlated colour temperatures and advanced controllability, amplifying their efficiency and adaptability.

Thus, rather than risking functionality through stringent power regulations in low-activity modes, focusing on accelerating the LED transition delivers more impactful and sustainable energy efficiency improvements without compromising the essential functions lighting and controls must provide.

2. Perspectives in the standby power debate

Some non-governmental organisations (NGOs), such as the 4E SSLC Platform , often advocate for the broad reduction of standby power in lighting systems, arguing that it is a waste of energy and resources. This approach tends to look at the lighting system from a very narrow perspective and ignores more effective and efficient ways of reducing overall power consumption in lighting.

The SSLC Platform also points out that trading decreased responsiveness for increased energy efficiency can be a valid strategy. However, this is often impractical and leads to poor user experience as well as reduced energy savings: for example, occupancy and vacancy detection or in the implementation of daylight harvesting in commercial buildings. There are many applications where standby power is necessary to ensure the proper functioning of lighting systems, especially in critical applications where human security and safety is key such as:

- Emergency lighting
- Road and public lighting
- Occupancy and vacancy detection in commercial buildings and outdoor spaces

It is also important to acknowledge that there are several existing regulations around the world that have already adopted requirements for standby power. For instance, the eco design regulation in the EU contains an upper limit of 0.5 watt. These regulations have demonstrated their effectiveness by enabling the increase in energy efficiency in LED based applications that benefit from additional savings in daylight harvesting, dimming control, schedule setting and occupancy sensors, as indicated below. In many respects, standby power is viewed by industry as a lighting efficiency enabler.

The diagrams below demonstrate that instead of spending efforts and resources to achieve additional energy savings by broadly reducing standby power in lighting systems, it might be more effective to accelerate the global adoption of LED technology.

This view is subscribed to by both industry and regulators who work to draft and implement standards and mandatory regulations to bring about the global switch to efficient lighting technologies. Note that standards are not mandatory. They are voluntary, but regulators may reference standards in national or regional regulations that may be deemed mandatory in those territories.

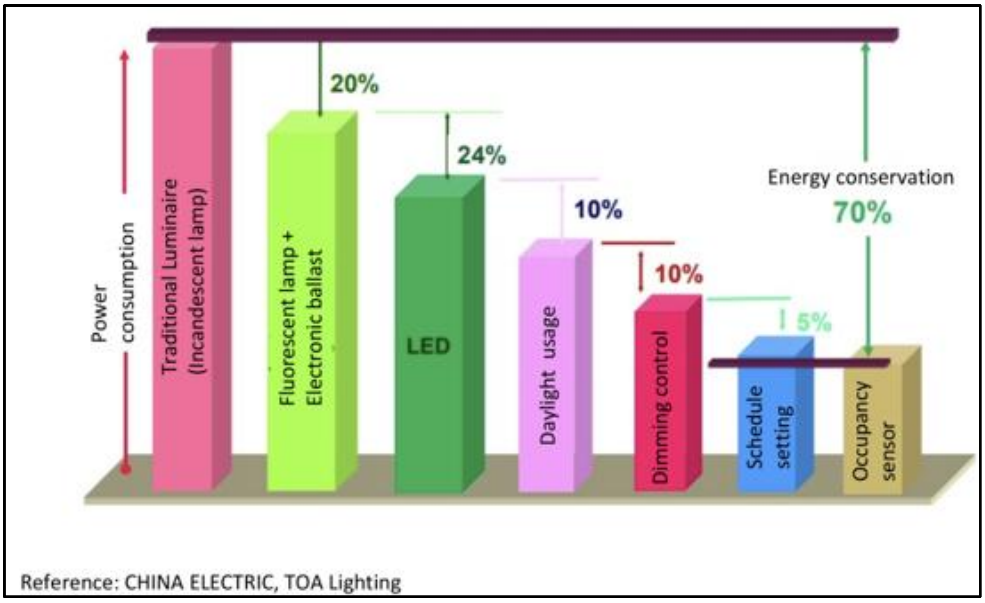


Fig. 4 Residential energy savings possible with standby power

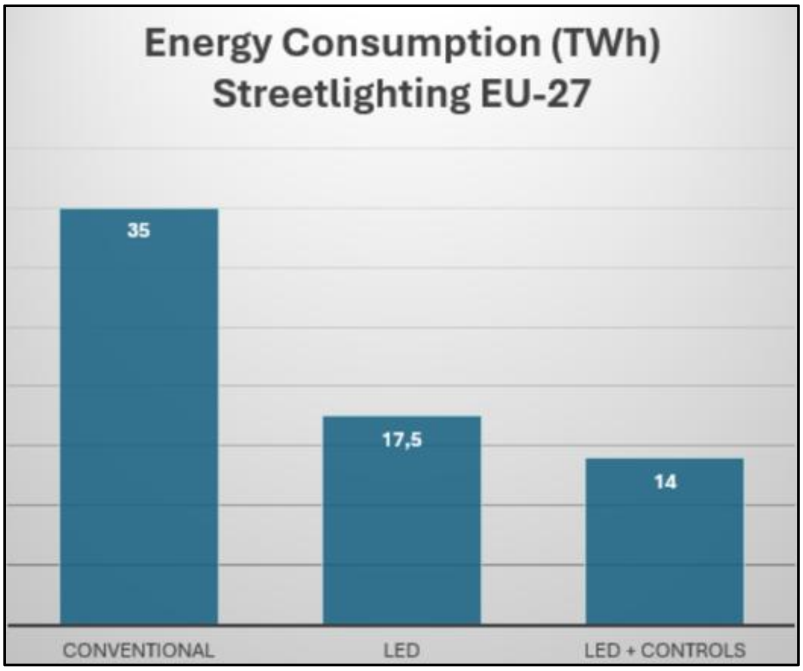


Fig. 5 Outdoor energy savings possible with standby power.
Preparatory study for Ecodesign and Energy Labeling

In the context of standby power, NGOs often evaluate lighting too narrowly. By considering the broader picture, it becomes evident that the advancements in smart lighting technology significantly reduce overall energy usage over time, highlighting their true value and contribution to energy efficiency. The significant gains in lighting energy efficiency and reduction in GHG emissions seen over the last 15 - 20 years have been significantly contributed to by advances in lighting and lighting controls. This is a result of devices and products which require low power states of activity to operate and provide these benefits. This is well documented and proven. Restricting these technologies will reverse energy efficiency and operational gains over those years.

An often-used example is that for a typical 11 W lamp (i.e. A19 bulb) with a 0.50W standby power that is turned on for one hour per day, the standby energy consumption accounted for 51% of the total energy consumption. When the same lamp is turned on for two hours per day, standby consumption accounts for 35% of the total energy consumption.

These examples overstate the share of energy consumed during standby mode. In the US, lamps in homes are typically used for three hours per day, resulting in standby power accounting for around 25% of the total energy consumption. A large study in EU homes showed an average of just over 2.5 hours for non-colour tunable light sources, just over 3 hours for colour tunable light sources, and almost 3.5 hours for full colour light sources. In commercial settings, where lamps are used for 12 hours per day, the share of standby energy consumption is much lower.

NGOs also argue that in North America, lower standby power consumption is achieved by use of the IEEE Wake-Up Radio concept which is claimed to lower the standby power to 0.01 W or less without limiting features or constraining innovation. We are not aware that this concept is implemented in commercially available lighting products. Neither are we aware that this concept is included in wireless standards like Wi-Fi, Zigbee, Bluetooth or Matter, which limits the applicability of the concept to proprietary wireless solutions. Additionally, the Title24 requirement in California to have a certain responsiveness (0.5 seconds) of light reacting to a signal could also be hampered by such a wake-up radio concept, in that there may be a safety risk if signals are not received in a timely manner.

To address the significant share of annual energy consumption per light source attributed to gateways, we agree that it is essential to optimise the use of each gateway by maximising the number of light sources it supports. The energy consumed by gateways decreases substantially as the number of connected light sources increases.

Consumers should therefore be encouraged to connect as many of their light sources as possible to a single gateway to enhance system energy performance. Additionally, manufacturers can develop more efficient gateways that consume less power and promote shared usage among multiple devices. This approach not only reduces the individual energy burden of each light source but also contributes to overall energy savings and cost reductions for consumers.

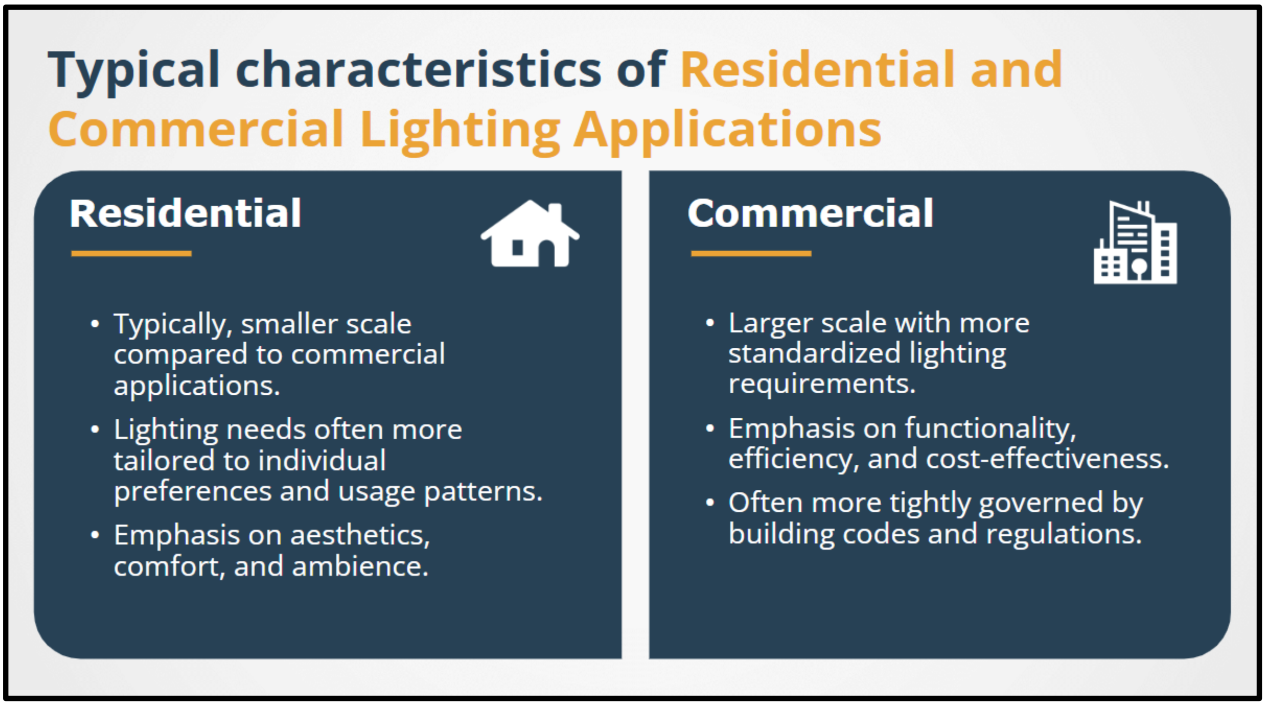
3. Excessive reduction in standby power limits in lighting systems

Excessive reduction in standby power limits in lighting systems can lead to several issues:

- Balancing the need for energy efficiency with practical considerations and user expectations is essential to avoid these potential problems resulting from excessive reduction in standby power limits in lighting systems. Here are some examples:
    - **User Convenience:** Users expect their smart lighting systems to be ready to use instantly. Excessively reducing standby power could lead to delays in system responsiveness, which would be inconvenient and frustrating for users accustomed to immediate control over their lighting.
    - **Safety and Security:** Many smart lighting systems integrate with home security features, such as automatic lighting in response to detected motion or integration with alarm systems. Lowering standby power might impair these safety features, reducing the overall security of the home.
    - **Compatibility with Other Smart Devices:** Smart lighting systems often interact with other smart home devices, like thermostats, cameras, and voice assistants. Maintaining adequate standby power ensures seamless interoperability and a cohesive smart home experience.
- **Performance Limitations:** Stringent standby power restrictions could undermine the functionality and hence the user experience of lighting systems. Reduced standby power limits could affect the user experience by limiting convenience features such as instant-on functionality or standby mode operation, responsiveness, dimming functionalities, or other attributes that enhance appeal and utility to both residential and commercial users. Given that one of the most significant avenues for enhancing the sustainability credentials of lighting products lies in their integration within lighting control systems, any factors that diminish interest and value could impede adoption.
- **Compatibility Challenges:** Overly stringent limits may make it difficult for manufacturers to design lighting systems that are compatible with various control systems, sensors, or smart home technologies.
- **Cost Implications:** Implementing more stringent standby power limits might require the integration of more complex and expensive components or technologies, which could increase the overall cost of the lighting system and reduce adoption of LED products.
- **Innovation Constraints:** Excessive reduction in standby power limits may stifle innovation within the lighting industry by constraining manufacturers' ability to develop new energy efficient technologies or features.

4. Residential versus commercial applications

When considering energy efficiency in lighting and particularly standby power in lighting systems, it is essential to differentiate between residential and commercial applications.



The energy consumption of residential lighting in the European Union is about 24% of total lighting energy consumption of 102 TWh/year. This market segment consists mainly of lamps. The typical number of lamps used per household is 33 with an average wattage of 3-4W (LED). This means most lamps are in the range of 250-400lm. The average standby power consumption of these lamps is close to zero as most of these lamps are non-connected.

According to the most recent EIA Residential Energy Consumption Survey (RECS), in 2020, electricity consumption for lighting in U.S. homes accounted for about 6% of total residential electricity use, which equalled about 81 billion kWh (81 TWh). U.S. residential lighting predominantly uses LED technology.

Standby power for residential lighting is close to zero since most LED lamps used in homes are non-connected devices without significant control gear or standby power draw. A typical U.S. household uses roughly 30+ lamps, close to the EU average of about 33 lamps per household. LEDs dominate the residential lighting market in the U.S., with increasing adoption driven by energy savings, federal incentives (like ENERGY STAR), and long lifespan.

Residential LEDs use at least 75% less energy than incandescent bulbs and last much longer, contributing to major efficiency gains. Annex 1 provides some more detailed considerations for connected lamps in residential applications and the dependency on mains voltage.

The commercial lighting application accounts for 76% of the lighting energy consumption. Typical applications are office lighting, industrial lighting, sports lighting, road and street lighting, and area lighting.

In this market segment the power and corresponding light outputs are much higher than in residential lighting, ranging from tens to hundreds of watts. Most, if not all, light sources are powered by separate control gear in these commercial applications. Given that in commercial applications, light sources with separate control gear are in on mode much longer than in residential applications, the standby power consumption is comparatively much lower than in residential applications.

Given the varying application characteristics in residential and commercial lighting, standby power usage in lighting systems should be evaluated on a case-by-case basis to minimise waste of energy and resources. This approach is essential in optimising efficiency and reducing standby power consumption.

In both residential and commercial applications, there is potential to reduce energy consumption by implementing energy saving measures such as automatic shutoffs, dimming controls, and efficient power management systems.

Products such as LED control gear (also known as drivers), occupancy sensors, and centralised lighting control systems can help minimise overall power consumption by ensuring that lighting systems operate only when needed and are powered down during periods of inactivity. By analysing energy usage patterns and adopting intelligent lighting solutions, it is possible to minimise power without compromising lighting performance.

5. Recommendations and ideas for energy saving efforts

While standby power may be necessary in certain lighting applications, there remain ample opportunities to save energy and minimise environmental impact. The global lighting industry actively adopts energy efficient technologies like LED lighting, automation, smart controls, and sensors to optimise energy usage. It is key to remember that even though standby power has a necessary place, it’s essential to explore energy saving alternatives whenever possible.

By investing in the development of these solutions, lighting manufacturers can continue to provide user options for high-quality illumination and control while significantly reducing energy consumption.

Efforts to save lighting energy should be focused on several key areas to achieve optimal environmental sustainability. These areas include:

- **Transition to LED Lighting:** LED lighting is the most energy efficient lighting technology available today. LEDs consume significantly less energy compared to traditional incandescent and fluorescent light sources while providing the same or better quality of light. Encouraging the widespread adoption of LED lighting in both residential and commercial applications is a highly effective strategy for reducing energy consumption.
- **Implementing Lighting Controls:** Utilising lighting controls such as occupancy sensors, daylight sensors, and dimmers can help optimise energy usage, for instance by automatically adjusting lighting levels based on occupancy and natural light availability. For example, luminaires can be dimmed or turned off in areas that are not in use, saving energy without sacrificing comfort or safety.
- **Promoting Energy Efficient Luminaires:** Choosing energy efficient luminaires that are designed to maximise light output while minimising energy consumption is crucial. An example is in the US where Energy Star-rated products and those certified by energy efficiency organisations which offer assurance of high performance combined with energy savings.
- **Upgrading Infrastructure:** Retrofitting existing lighting systems with energy-efficient technologies and updating outdated infrastructure can lead to significant energy savings. This includes replacing inefficient ballasts, transformers, and other components with newer, more efficient alternatives and installing lighting controls.
- **Commissioning and Recommissioning:** Properly commissioning a new lighting installation can help improve the environmental sustainability of the installation in key ways:
    - **Optimised Performance:** Commissioning verifies that luminaires and controls are installed correctly and in line with the expectations / assumptions that were used when the installation was designed and that they are operating as intended. This helps to identify and address any issues that may lead to energy waste or inefficient operation, such as physically misaligned luminaires, improper wiring, or malfunctioning components.
    - **Long-Term Maintenance:** Proper commissioning also includes creating a maintenance plan to ensure that lighting systems continue to operate efficiently over time. Regular maintenance, including cleaning, relamping, and replacing faulty components, helps to prevent energy waste and extends the lifespan of luminaires, reducing the need for premature replacements and the associated environmental impacts
- **Circular economy** – Overly stringent standby power limits risk reducing the lifetime of products and so could be counter to circular economy principles.
- **Educating Consumers and Businesses:** Raising awareness about the benefits of energy efficient and circular lighting and providing information on available technologies and incentives can encourage consumers and businesses to make informed decisions that prioritise environmental sustainability.

6. Conclusion

The debate on standby power in lighting systems highlights the challenge of balancing energy use in standby mode with the overall energy savings that systems enable. Understanding the nuances of standby power is crucial for setting effective regulatory standards.

Lighting and control manufacturers continue to advance towards even greater environmental sustainability by investing in innovative and high performing technologies. Standby power is an essential element for achieving energy savings through the effective use of lighting controls.

Collective efforts should focus on transitioning to LED lighting, implementing controls, promoting energy efficient luminaires, upgrading infrastructure, and educating consumers and businesses to drive significant energy savings and environmental sustainability in residential and commercial applications.

Standby power should be seen as a key enabling part of an energy efficient lighting system, not in isolation. The Global Lighting Association advises against stricter regulatory requirements for standby power, as these could hinder the goal of reducing overall energy consumption and providing desirable lighting solutions.

Annex 1 - Standby power considerations for residential applications

Standby power depending on mains input voltage

Table 1 presents measurement data of two comparable wireless controlled A19 LED lamps, produced for the Europe Middle East Africa (EMEA) and North American markets with their typical 230 V and 120 V mains voltages. Measurements done according to IEC 63103:2020.

Non-active mode Power [W] for different markets and mains voltages (Q1-2017)			
Product	**North America 120V/60Hz**	**EMEA 230V/50Hz**	**delta %**
A19 - white ambience light	0.243	0.307	26%
A19 – white ambience full color	0.270	0.350	33%

Table 1: Non-active mode power consumption of actual A19 LED lamp products with the same make, but produced for markets with different mains voltages

The difference in non-active power consumption for these products is significant (>64 mW). GLA's analysis shows that this is due to the low voltage supply, inclusion of an RC latch to deal with phase cut dimmer compatibility and the use of electrolytic capacitors and metal oxide varistors.

Below, we address the major contributors to the difference in power consumption in non-active mode.

Low voltage supply

Smart lighting products are permanently connected to the mains and often include a low voltage supply, e.g. when the smart lighting product is in off-state, it still needs to power a radio to remain alert and be ready to react to any incoming signal they may receive.

During this off mode, some power is still needed to power the radio. Commercially available chipsets for the radio typically require a DC input voltage of 3.3V; while the required current for the radio is in the range of 15 mA – 30 mA to ensure good functionality.

Due to strict regulations on energy consumption (during active and non-active mode) the industry implements efficient switch mode power converters to generate the 3.3V DC-voltage from the mains-voltage, often with cost effective IC's which are manufactured in high volumes. An example of such an IC is the BP8519C from Bright Power Semiconductor. With a power supply based on BP8519C, the contribution of powering the radio to the non-active mode power consumption (assuming a load-current of 15 mA for the radio) is:

- 120Vrms/60Hz: 137 mW
- 230Vrms/50Hz: 178 mW

Phase cut dimmer compatibility

To allow existing dimmer controls which are fitted to work with incandescent bulbs to be used with energy efficient smart lighting products, a dimmer compatible circuit should be implemented.

This phase cut dimmer compatibility is generally realised by adding RC-latches that are connected between phase and neutral. Such an RC latch is included in the LM3447-PAR-230VEVM from Texas Instruments. The power consumption in the non-active mode can be calculated to be 98.5mW for a mains voltage of 230Vrms/50Hz and 54.4mW for 120Vrms/60Hz.

Electrolytic capacitors

Using data sheets, e.g. from Aishi, a leading electrolytic capacitor supplier, one can infer that the power consumption due to the electrolytic capacitor leakage current approximately doubles with doubling the mains voltage, assuming the same ripple voltage for both cases. The contribution of leakage current of electrolytic capacitors is typically:

- 120Vrms/60Hz: 6mW
- 230Vrms/50Hz: 12mW

Metal oxide varistors

Metal Oxide Varistors are electronic components that limit the circuit voltages of the electronic circuitry to safe voltage levels in case of surges at the input caused by lightning, or by other electronic equipment that is connected to the same power distribution grid. The varistor manufacturer provides as a rule of thumb that the leakage current should not exceed 20μA (in normal operation). The contribution of the Metal oxide varistors to non-active mode power consumption is:

- 120Vrms/60Hz: 3mW
- 230Vrms/50Hz: 6mW

ABOUT THE GLA

The Global Lighting Association (GLA) is the leading voice for the lighting industry worldwide, representing over 5,000 lighting manufacturers and generating $75 billion in annual sales. Through its network of 27 national and regional lighting associations, the GLA advocates for policies and practices that promote sustainable lighting solutions, energy efficiency, and human well-being. The GLA is committed to fostering a collaborative environment that supports innovation, fair competition, and the growth of the lighting industry on a global scale.

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