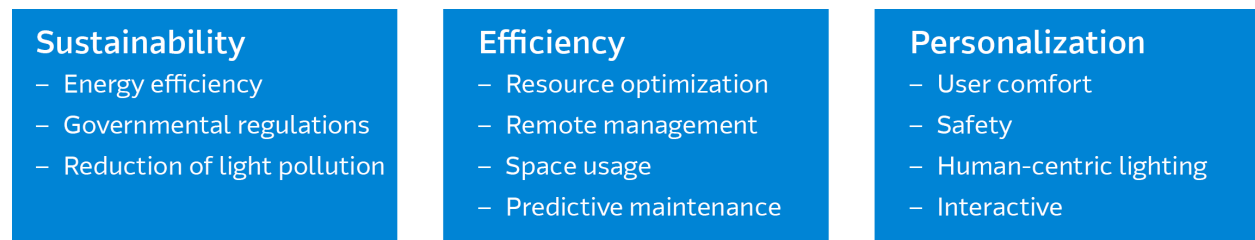


## LED Lighting Trends and Opportunities for Growth

The world of lighting has been undergoing rapid changes as innovations enhance the efficiency, durability, and cost-effectiveness of lighting applications in a wide variety of commercial and non-commercial settings. In addition, the focus on sustainability has spurred the need for environmentally friendly lighting solutions in recent times. LED lights have emerged as the preferred choice by households, governments, industrial and commercial organizations due to their efficiency and ease of use. LEDs are highly efficient and the latest products can use 90% less energy than incandescent bulbs. Rising electricity prices, increasing concern over climate change, and a desire by countries to be energy independent are creating unprecedented demand for highly efficient LED light sources. In most regions of the world, governments are taking steps to promote LED lighting by banning incandescent bulbs and giving subsidies to LED lighting manufacturers. Another important factor driving LED adoption is user preference. Since LED lights have user-friendly controls, consumers can interact with the lighting and personalize their lights to suit their needs.



**Figure: Drivers for LED Adoption**

### Types of LEDs

A variety of factors need consideration in choosing the right LED for an application. For most applications - effective illumination, improving product life, reducing maintenance costs, and optimizing the total cost of ownership are key considerations.

- **High Power LEDs:** High power LEDs are characterized by high power handling capability by using a large die and are assembled using very robust packaging techniques, typically with a ceramic substrate and silicon overmold. They can offer very high efficiency, industry-best lifetimes, and excellent optical performance. They are suitable for many outdoor and portable applications, as well as applications where precise optical control is needed.
- **CSP (Chip Scale Package) LEDs:** Chip scale LEDs are similar to high-power LEDs but are available in smaller packages. CSPs offer excellent value in terms of lumen per dollar and offer high lumen densities. These features make CSP LEDs particularly well suited for applications like automotive headlights, entertainment settings, street, or outdoor lighting. Lower cost and smaller form factors have made CSP LEDs the preferred option in a variety of emerging high-growth market segments.
- **Mid Power LEDs:** Mid Power LEDs are constructed by embedding a LED chip in silicone and packaged in plastic. These LEDs are available in a wide range of price and performance classes. These LED types

have seen sustained expansion and can cater to specialized needs. New color schemes and improved reliability and robustness, make Mid power LEDs well suited for general indoor lighting, outdoor area lighting, horticulture, and linear applications.

- **COB (Chip on Board) LEDs:** These LEDs have fewer growth prospects as they are most suitable for specialty applications and targeted product offerings that need unique spectrums with an emphasis on color quality and binning. Other applications include tunable white devices or SD and HD options.
- **High Output Mid Power LEDs:** This line of LEDs incorporate several die which are mounted within a plastic housing with a silicon encapsulant. They can provide very high lumen output and excellent lumen/dollar while maintaining good efficacy. This is a fast-growing market segment with high output mid power packages replacing traditional high power LEDs in outdoor applications such as area lights as well as being used to replace multiple mid power LEDs



**Figure: Types of LEDs**

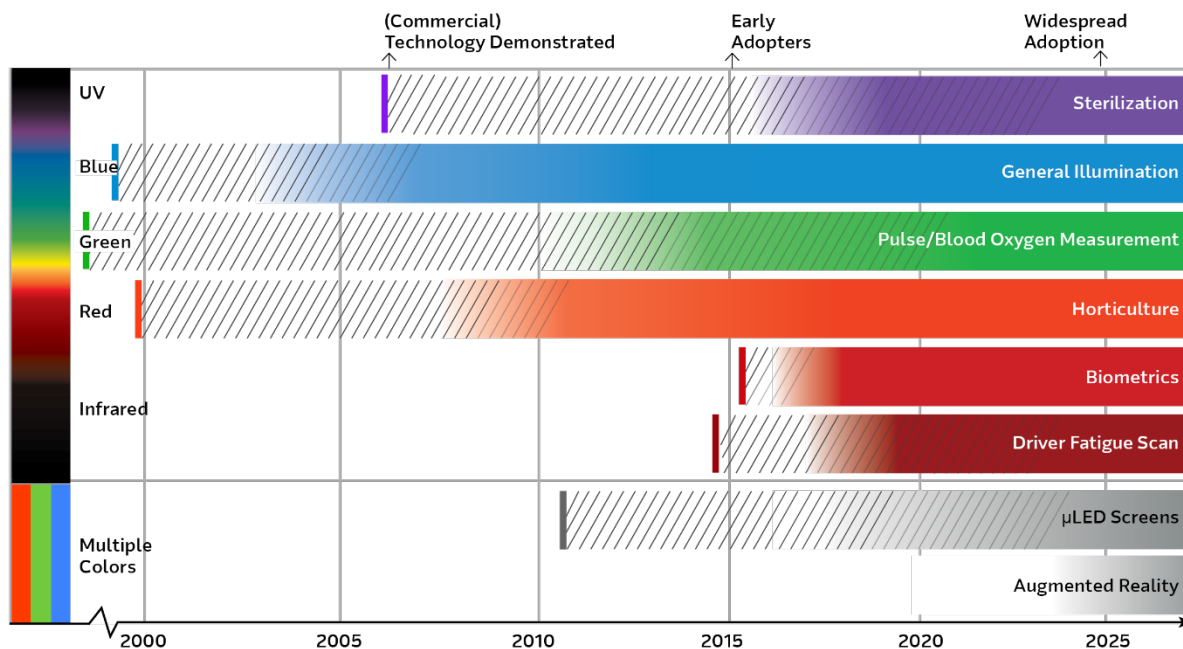
### LED Applications and Adoption

Technological advances, increasing efficiency and reliability, reduced cost of the components, enhanced quality of light, and new functionality beyond basic illumination are all driving LED use in new applications.

Key Commercial/Industrial application segments include:

- **Outdoor**
- **Horticulture**
- **Architectural**
- **Theatrical**
- **Medical**
- **Portable**
- **Consumer Products**
- **Automotive**
- **Connected/IoT**

Since there is wide applicability of LED technology beyond general illumination, LEDs can be customized and targeted to specific applications as the **figure below** indicates. It is forecasted that in the next few decades, LEDs are poised to find application in a varied gamut of use cases.



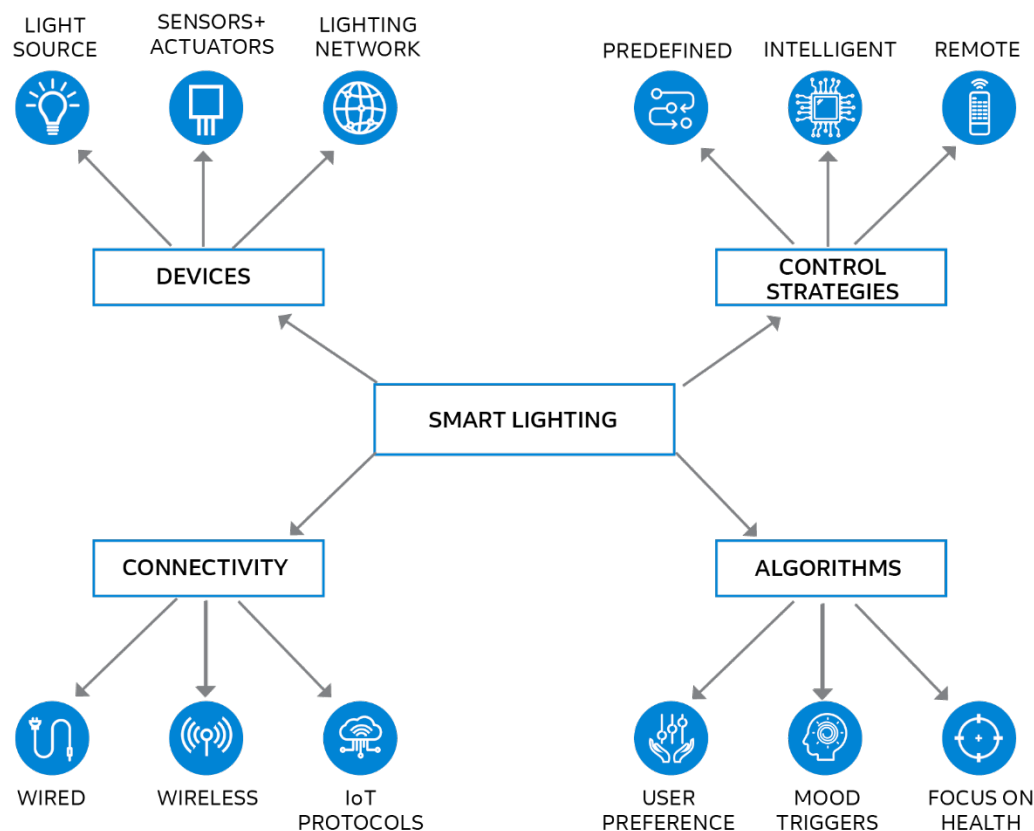
**Figure: LED Adoption Phases by Application**

## Smart Lighting

Smart lighting involves a range of solid-state technologies like LEDs and OLEDs being used in combination with digital sensors, actuators, drivers, and communications interfaces. These lighting systems are programmed using advanced control algorithms and can be organized into lighting networks to operate remotely. Many solutions change the light spectrum or color on demand. Control of the level of illumination in a room can also be accomplished by utilizing factors like occupancy and motion. Typical applications include occupancy-driven lighting control or motion detector-based illumination in outdoor spaces.

Smart lighting systems enable automation and programmability, unlike traditional systems. The lighting network is usually programmed with an initial setup and includes the facility to reprogram each independent light to cater to individual tastes and specific situations throughout the day. Diverse digital communication interfaces intended for smart lighting are readily available. The digital addressable lighting interface (DALI), Ethernet, Wi-Fi, Li-Fi, ZigBee light link or Bluetooth are a few protocols in use for programming of predefined areas and spaces. In smart lighting systems, areas for illumination are segmented by occupancy or events and the appropriate levels of illuminance suitable for different tasks. When organized as a network, smart lighting systems can allow different lights to interact and be synchronized. Remote management is a useful feature that drives user preference and ease of use.

Users can use an application from a graphical interface of a mobile phone or a web browser, turn lights on/off, calculate the power consumption in real-time and monitor the system operation.



**Figure: Smart Lighting Ecosystem**

Lighting control systems can be wired, wireless, or a combination of the two (hybrid). Wired devices are often less expensive to purchase but require additional costs for installation or retrofitting. Wireless technology offers a natural grid for connectivity, enhances operational efficiency, and assists in developing new business avenues. Wireless systems also offer many benefits including flexibility, cost-effectiveness, and ease of installation.

As smart lighting systems gain footprint, it is likely that new models for lighting purchases will come to the fore – leasing, ‘pay-as-you-use’, and other models such as ‘smart-lighting-as-a-service’ are expected to gain traction.

### How Arrow Lighting Accelerates Smart Lighting Product Development

The smart lighting ecosystem work requires coordinated efforts of numerous stakeholders, including engineers, systems integrators, street-lighting vendors, IoT vendors, and communications service providers. For stakeholders looking to implement smart lighting systems, vendors and solution integrators who can cover a wide range of competencies are crucial.

Arrow Electronics enables customers to connect and integrate all the lighting system components and act as a single point of coordination to navigate the complex ecosystem. Analyzing design tradeoffs between High and Mid Power solutions, integrating complex smart lighting connectivity and smart lighting implementations are our core competencies. Arrow has a proven track record of architecting smart lighting solutions for offices, retail spaces, factories, warehouses, municipalities, and entire smart cities. We are best positioned to be your partner of choice when embarking on smart lighting projects.

## References

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