December 2021

LIGHTING THE WAY

Mapping the Growth of the LED Lighting Market

The Strategy Boutique

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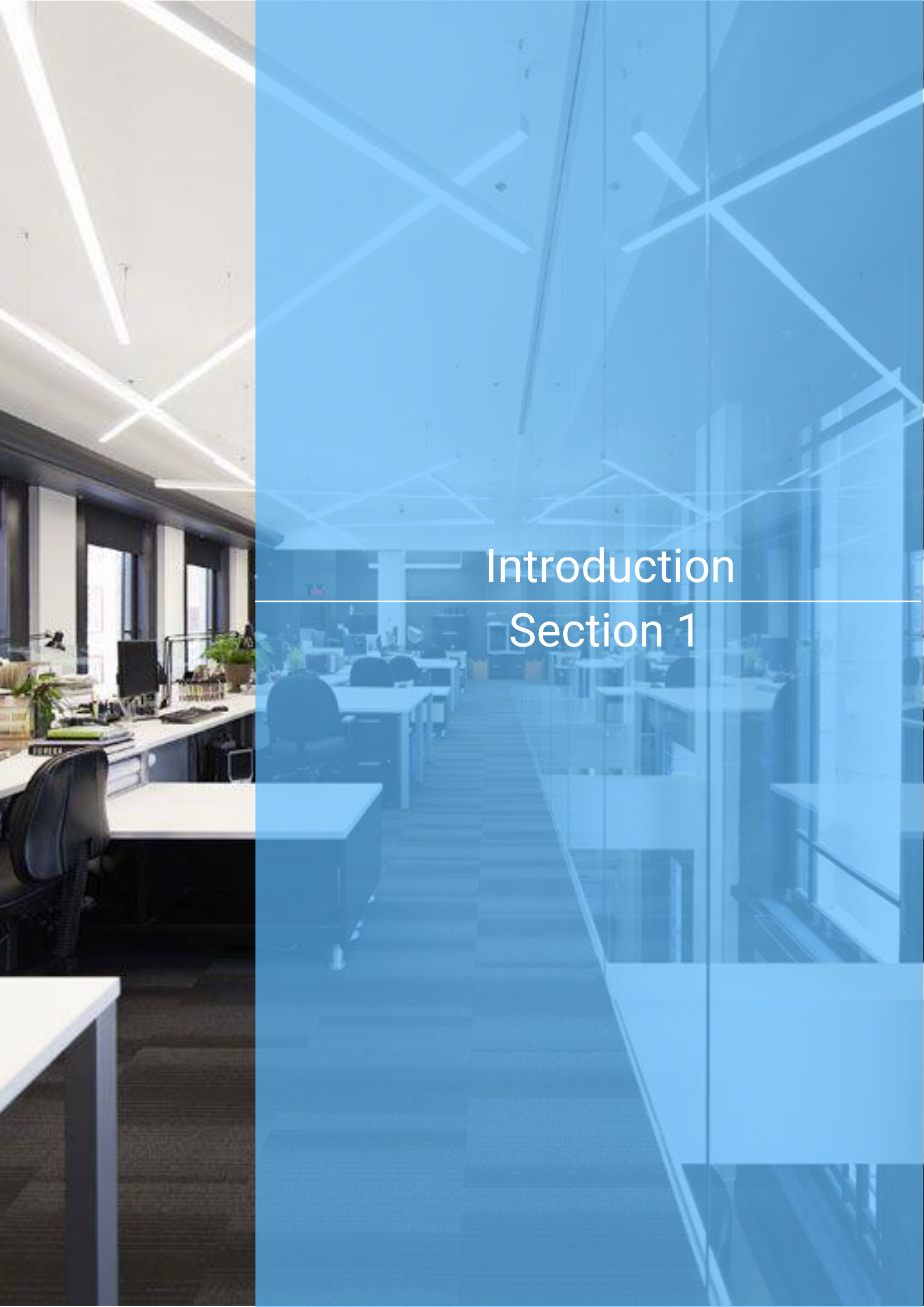


Introduction

Section 1

1 Introduction

The light-emitting diode (LED) is today's most energy-efficient and rapidly evolving lighting technology. Quality LED light bulbs last longer, are more durable, and offer comparable or better light quality than other types of lighting. This has led to a disruptive change which has made any previous technology obsolete. Within a period of just a few years the LED has become the dominant artificial light source and has taken over all the conventional light sources like incandescent bulb, CFL, fluorescent lamps etc.

The global LED lighting market was valued at USD 75.81 billion in 2020, and it is expected to reach USD 160.03 billion by 2026, at a CAGR of 14.25% over the forecast period 2021 – 2026. It is estimated that savings of USD 18 billion in electricity costs can be achieved by transitioning to energy-efficient LEDs. Furthermore, more than 160 million metric tons of carbon dioxide emissions can be avoided every year.

Private and public structures including residential buildings and commercial establishments are rapidly being upgraded with LED technology. The digital capabilities of LED have helped it expand to all domains, from street lights to hospitals. Constant development within the realm is accelerating the LED penetration rate, and this market is anticipated to grow in the near future.

Lighting accounts for nearly 10% of electricity usage in households and 18–40% of commercial premises. There is a growing need for energy saving across the world, which is creating scope for the market. It is expected that the transition to energy-efficient lighting would reduce the global electricity demand for lighting by 30-40% in 2030.

Through this report, we wish to evaluate how the LED market has grown to gain dominance in the lighting sphere, tracing its movement since its discovery in the 1960s to the latest trends in the industry.

The industry has been segmented on the basis of product and installation types, applications and end-users and by region. The external factors affecting the market, namely, political, technological, social and environmental have been detailed to understand the atmosphere surrounding the industry.

Although the market is highly fragmented with local players expeditiously capturing markets, a summary of the major players along with their role in the supply chain has been compiled in the report. An analysis of the strengths, weaknesses, opportunities and threats has also been conducted to understand the lucrativeness of the industry. Finally, the report evaluates what the future for the LED lighting market looks like.

Market Overview

Section 2

2 Market overview

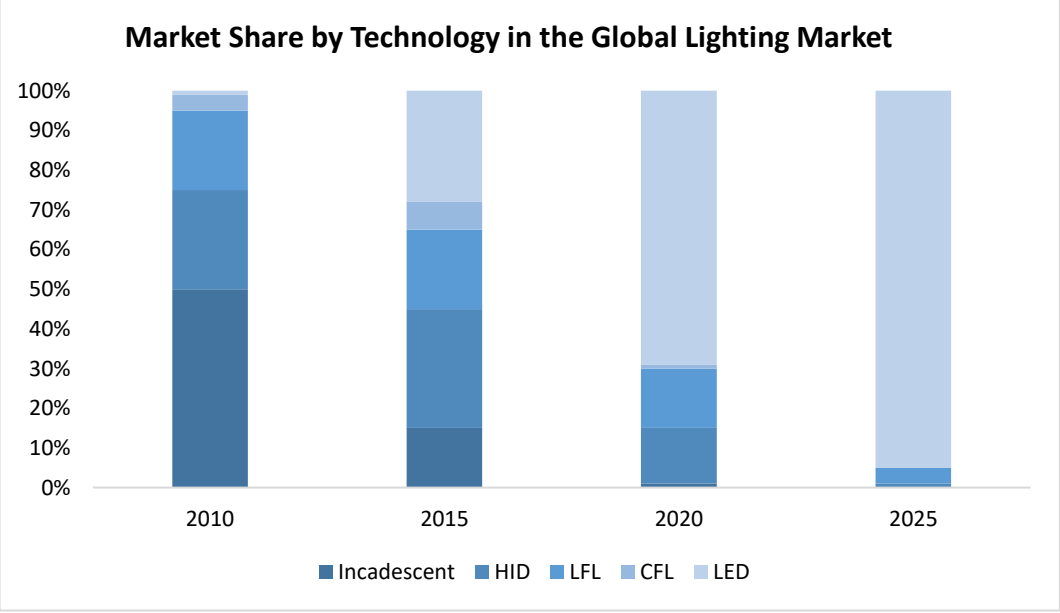
2.1 History of LED Lighting

LEDs got their start as indicator lights for circuit boards and small electrical equipment. Early specimens were very durable, had a relatively low lumens output, and accordingly were very energy efficient. Over time LEDs became brighter and more reliable. Second generation LED technology included the ability to string multiple LEDs into a single circuit. Over time, LEDs became more suitable for outdoor use. Accordingly, they were exponentially adopted by municipalities as a replacement for incandescent bulbs in traffic lights. Due to their high retail costs, LEDs saw limited success replacing fluorescent bulbs and neon in lighted signs in the 80's.

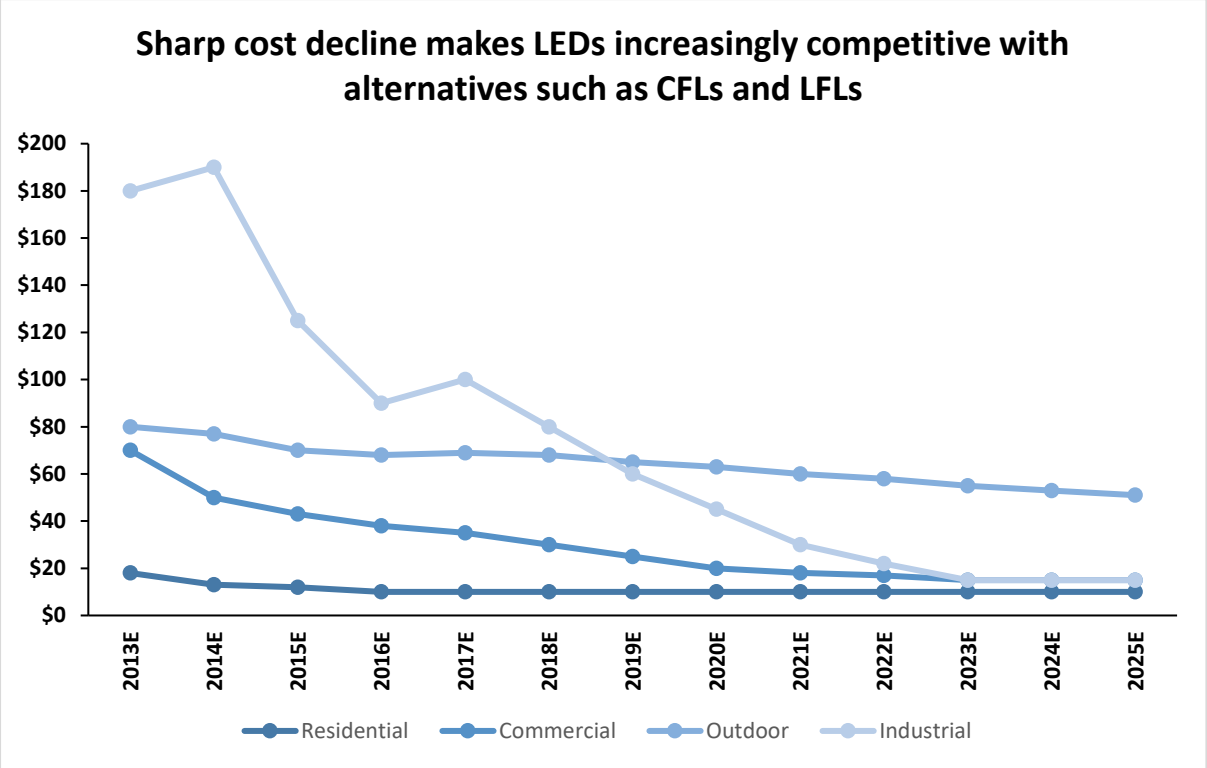
Today's LED technology is used extensively for commercial, industrial, and residential applications. LEDs' capabilities have increased across the board: increase in lifespan, increase in brightness (performance), and increase in energy efficiency. The greatly expanded use of LED technology has led to the development of warranties, industry best practices, and the introduction of government programs and standards.

When General Electrics started selling red LEDs in 1963, they retailed at USD 200 per bulb. This was extortionate compared to the USD 5 – USD 20 that people were used to paying for incandescent and fluorescent bulbs. Another reason was their unavailability in white colour. As a result, initially, it was difficult to break into the market. People were happy with the lighting they had and weren't willing to gamble hundreds of dollars on something new. By the mid-1970s, Fairchild Optoelectronics created a LED that cost just 5 cents to produce. But due to the small size of the production batches, the cost to consumers was still extremely high.

Over time as huge businesses such as IBM and HP started using LEDs, LEDs began to market themselves. As demand increased, so did production volumes. Mass production allowed manufacturers to enjoy economies of scale in which the cost per unit fell drastically. Nowadays, LEDs are available for as little as USD 3.



Source: Goldman Sachs Investment Research

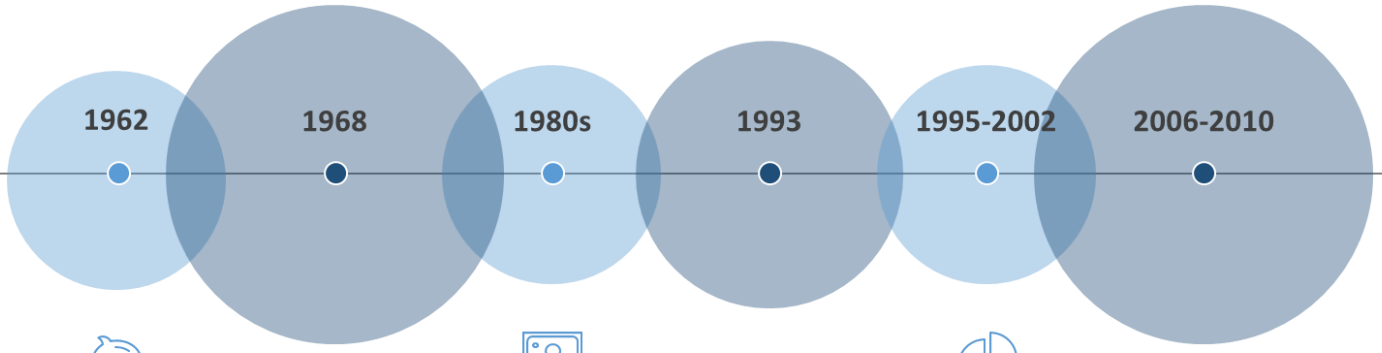


Source: Goldman Sachs investment Research

When LEDs first came on the market, they were far more expensive than they are today. The expensiveness of the LED bulbs is attributed to their greater complexity than halogens, as well as to the more sophisticated technology used in the bulb and manufacturing process of LEDs. The greater cost of manufacturing is a result of the greater number of parts used to make an LED bulb in comparison to traditional bulbs, certain components are costly before construction (such as bulbs containing a driver). Even though LEDs run considerably cooler than halogens and incandescent, the little heat they produce still needs to be dispelled. This is usually performed by use of aluminium which is costly. As a result of the abovementioned factors, LEDs are relatively higher priced owing to the use of expensive technology and parts, and an incremental growth of supply and demand that ultimately impacts the manufacturing costs.

The growth in the demand leads to increasing number of manufacturers entering and competing in the market. This promotes greater supply of products in the market which allows for competitive pricing. The fall in prices can be attributed to the economies of scale achieved due to substantial demand in tandem with the global trend of reduction in prices of the LED chips. Lighting manufacturers have begun a government-sanctioned phase out of incandescent bulbs that don't meet new efficiency standards.

Evolution of the LED



1962

Nick Holonyak, Jr. invented the first LED that could produce visible red light. He invented these red diodes while he was employed with General Electric.

1968

The first usable LED products, HP's LED display and Monsanto's LED indicator lamp, were launched. Monsanto was the first organization to mass-produce visible LEDs.

1980s

Continuous and intensive research and development work into the LED technology led to the development of the first generation of super-bright red, yellow, and green LEDs in the early years of the 1980s.

1993

Shuji Nakamura created the first blue LED as well as an extremely efficient LED light in the green spectrum. In this same year he also developed the white LED, the most common LED light sought today.

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1995-2002

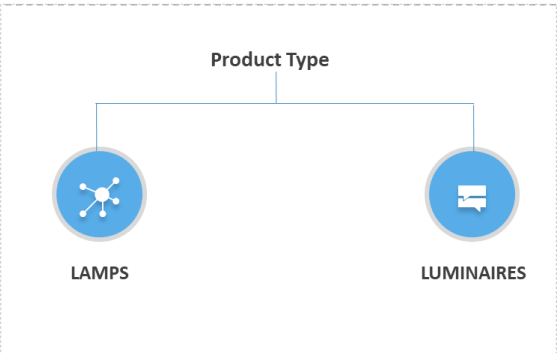
White LED lights were launched on the market 2 years after their discovery. By 2002, white LEDs for residential use became commercially available for approximately £80-£100 per bulb.

2006-2010

LEDs with 100 lumens per watt were first created in 2006 and their efficiency could only be outmatched by gas discharge lamps. By 2010, LEDs were being created with 250 lumens per watt and became popular for use in schools, offices and hospitals.

2.2 Market segmentation

By Product:



The LED luminaires segment dominated the market in 2020 and accounted for over 55% of the global revenue share. Luminaires are widely used in commercial and industrial segments.

The LED lamps segment is anticipated to register the highest CAGR over the period 2021-2028 owing to their increasing adoption in developing countries. The accentuated regulation roadmaps to phase out incompetent light bulbs are expected to contribute to the demand for these lamps in residential and commercial applications.

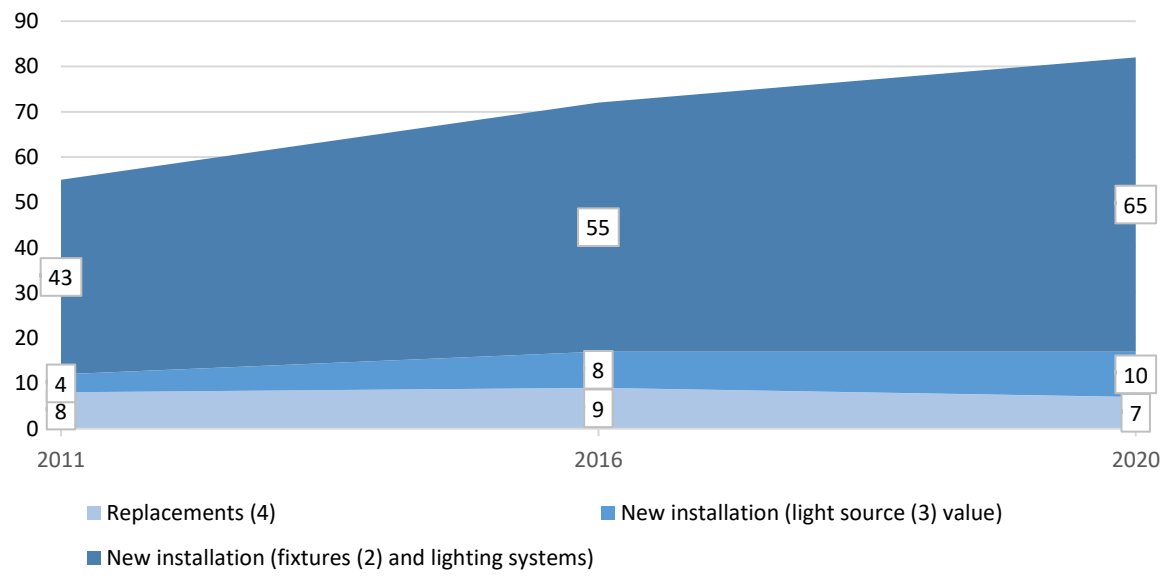
By Installation:

By installation type, the market is segmented into new and retrofit installations.

The shift towards more energy-efficient light sources with significantly longer lifetimes is impacting the replacement market. This market is witnessing a decline because consumers no longer need to replace their light sources as frequently.

In contrast, the new installation business is not being affected negatively since they follow renovation rather than lifetime cycles. The new installation market is also benefiting from LED penetration as this entails an increase in average price.

New installation and replacemnet market trend in general lighting
EUR billions



1 Total general lighting market: new fixture installations incl. full value chain, incl. lighting system control components and light source replacements

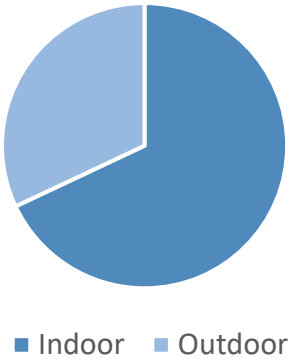
2 Fixtures include electrical components (ballasts)
3 Light sources include traditional lamps and LED modules/light engines, incl. packages
4 Replacement light sources are defined as lightbulbs/tubes in traditional lighting and LED modules/light engines in LED lighting
NOTE: Numbers may not add up due to rounding
SOURCE: McKinsey's 2012 Global Lighting Market Model

By Application:

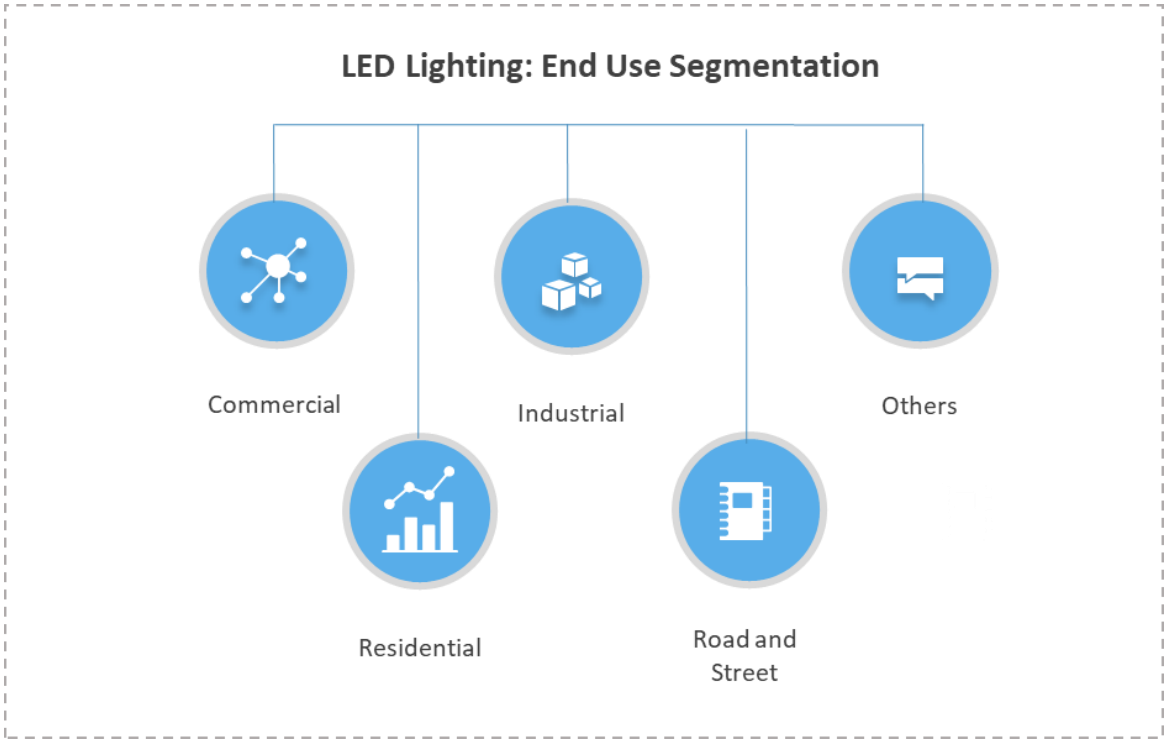
By application, the market is segmented into indoor and outdoor lighting.

The indoor segment led the market and accounted for over 68% share of the global market in 2020. The segment is expected to retain its dominant position due to high product adoption as an alternative to fluorescent, High-Intensity Discharge (HID), and incandescent lamps. The use of LED lights in offices, retail stores and malls, hospitals, and education buildings has increased in the past few years. The product demand in outdoor applications can be profoundly affected by public policy interventions and municipality support.

Global LED Lighting Market share, by application, 2020 (%)



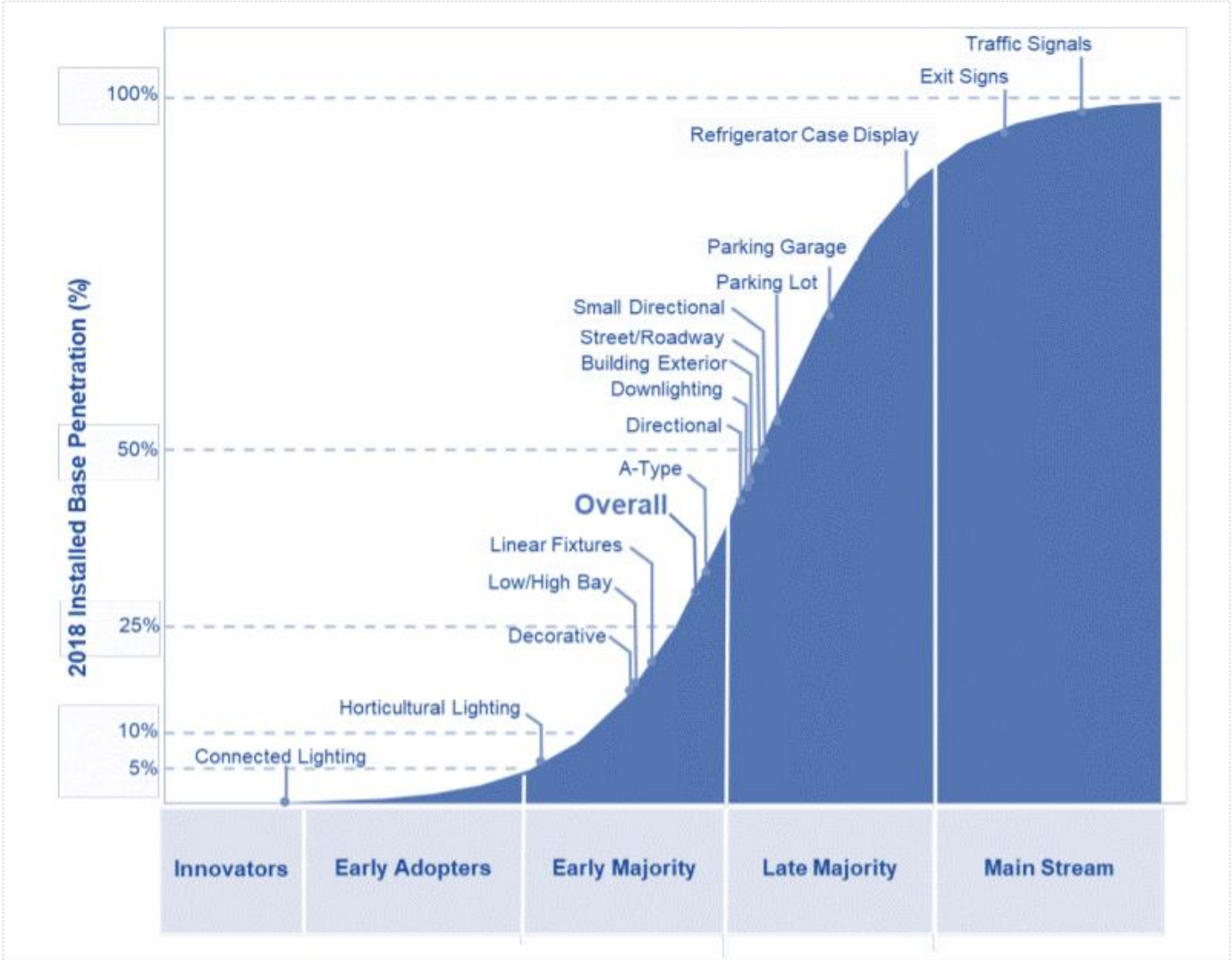
By End User:



The commercial segment dominated the market in 2020 and accounted for more than 52% of the global revenue share. The high-end lighting for commercial end-use mainly includes galleries, museums, and other exhibition lighting applications that primarily use reflectors, projectors, and downlights.

The residential segment has witnessed high growth in the last few years as the adoption of LED A-type lamps has increased exponentially owing to reduced product prices and increased subsidy programs by various governments and agencies. However, the demand in the residential sector was negatively impacted during the pandemic as some of the vendors announced a rise in the prices due to the increased expenses of product manufacturing.

High brightness LED lights are anticipated to witness major demand from the industrial lighting segment. These lights must comply with industrial lighting standards and regulations defined by various governments. Some other uses include office, road and street, hospitality, architecture, sports, health care, hospitality etc.



Installed adoption of LED lighting applications in USA in 2018. Many general LED applications reached the early and late majority phases of adoption
Source: US Department of Energy

By Region:

Asia Pacific accounted for the largest market share exceeding 42% in 2020 and is likely to retain the leading position growing at the fastest CAGR over the forecast period. Taiwan, Japan, and China are the key contributors to the regional market growth owing to the initiatives undertaken by the respective governments for adopting light-emitting diodes along with the presence of a large number of market players. The fastest-developing countries in the region, which are China, Indonesia, India, Vietnam, and Malaysia, have a booming construction industry owing to increasing local and migrated population and changing lifestyles. Thus, the rapidly growing construction sector in APAC is also contributing to the product demand in the regional market.

The debt crisis in Europe adversely impacted the demand for LEDs, as their production requires enormous capital investments. In recent times, Europe and North America have witnessed a boom in the demand for LED lighting owing to government support and the growing use of ultra-modern lighting in several industries. The trade war between the U.S. and China caused a rise in import duties and an eventual increase in the overall product prices. This factor is expected to benefit the European manufacturers.

Source: Mordor Intelligence

2.3 PESTLE Analysis

Political Factors

Regulatory Policies

Stringent regulatory policies regarding conventional lighting and energy consumption across the U.S., the European Union (EU), China, and Canada are anticipated to favor the product demand over the forecast period. Corresponding ratings and design standards categorizing energy efficiency, such as Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, Building Research Establishment Environmental Assessment Method (BREEAM) in the EU, and standards for green construction in China, are projected to bode well for the light-emitting-diode lighting market growth. In the U.S., the products are required to meet multiple regulations, including Energy Star Program, United Nations Environment Programme (UNEP), and National Electric Code (NEC).

Incentives and Rebates

Governments offer incentives and rebates on the replacement of traditional lamps with LED products, and this is helping improve the adoption of LED products worldwide. Smart illuminations are also anticipated to offer lucrative opportunities for application in industrial and commercial areas. They can adjust light using control zones. Smart city schemes have become predominant in the U.S. and several European nations with the rising focus on strategies to reduce peak power demand and overall energy consumption.

Government Schemes

In India, the ujala yojana scheme has been launched:

- It is offering free and affordable LED light bulbs to all. It is one of the first and the strongest measures taken by the central government to promote the usage of efficient light bulbs. The aim of the scheme is to preserve the environment.
- Under this scheme the applicant will be given the LED light bulbs at subsidized prices. The prices are going to be slashed down by 60%. The reduced price will be 40% less than the market price.
- The Ujala Yojana has brought both the state and the central government to work hand in hand. Earlier a similar scheme was launched but now it has been revived with the Ujala Yojana. It comprises of both the central and the state governments to work together towards achieving the goal.

A considerable increase in the number of green city projects in Saudi Arabia has facilitated the uptake of LED lighting solutions. This is supported by government initiatives, such as the Vision 2030 plan that aims to modernize infrastructure and expand the construction of smart cities. Furthermore, numerous favourable programs undertaken by the government to promote the use of LED lights are expected to create a positive outlook for the market. For instance, the government has increased tariffs on the imports of incandescent and compact fluorescent lights while implementing global energy efficiency standards in the country. On account of the aforementioned factors, the market is expected to reach a value of SAR 7,514 million by 2025, registering a CAGR of 18% during 2020-2025.

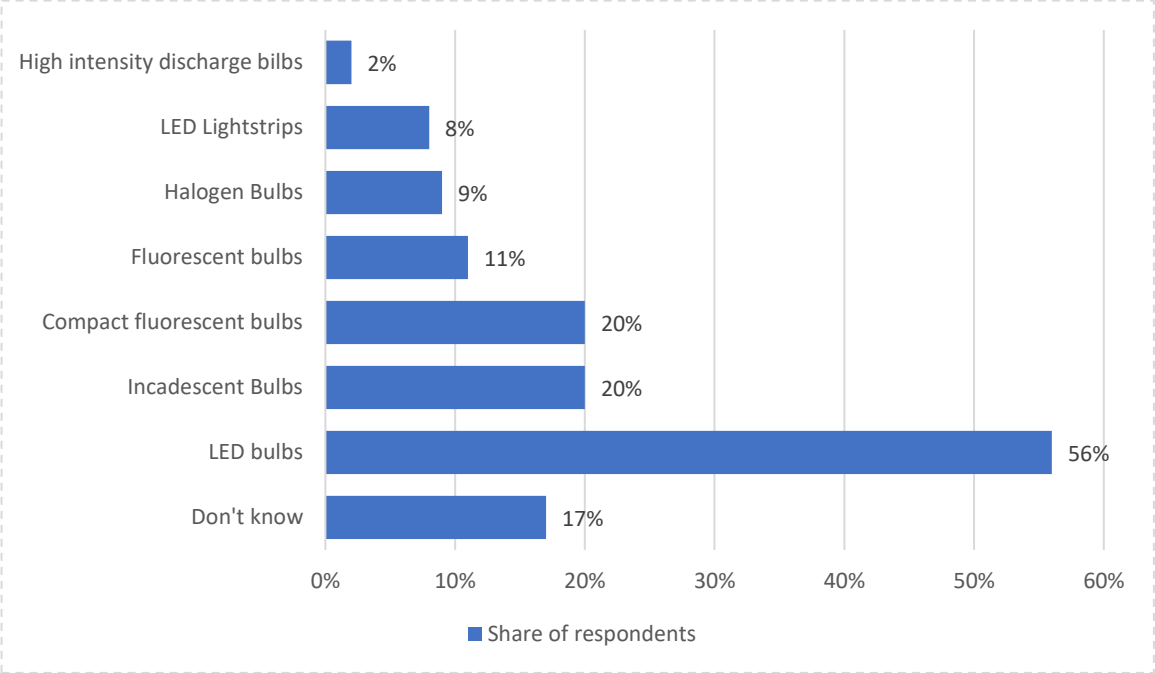
Social Factors

Consumer Preferences

Studies show that environmentally minded consumers have preferences for a certain bulb type while politically liberal consumers have preferences for low energy consumption. However, perceived personal experiences of health issues, previous use or purchase of CFLs, awareness on climate change, income and

education levels were not significant in explaining choices. Statistically significant preference for lower energy consumption and longer life was observed in conditions where estimated operating cost information was

drivers including chips, are imported from Chinese vendors and are in short supply now.



Source: Statista, Preferences for lighting in US

provided. Providing estimated annual cost information to consumers dramatically reduces their implicit discount rate, thus fostering adoption of efficient alternatives.

Impact of Covid-19

Like much of the manufacturing sector, lighting manufacturers depend on China as the source of a significant percentage of the components they use. Workers at plants where LEDs and other light fixture components are manufactured had been ordered to stay at home. This had profoundly impacted the lighting industry supply chain. Without the necessary components, production had come to a complete stop in many places. With the onset of the COVID-19 pandemic, the short-term forecast indicates a decline in demand as several commercial constructions halted temporarily.

While manufacturing an LED bulb in India, over 60 per cent of the components, which are mechanical in nature are sourced locally, while around 30 per cent, which are called electronic

Technological Factors

Though LEDs have been around and in practical use for decades, they continue to be a source of innovation and important technological development. These new developments may soon lead to new and improved products in nearly every sector where we find LEDs.

IoT

The IoT, or the Internet of Things, refers to the ever-growing network of devices that feature internet connectivity, and communication that occurs between these devices and other Internet-enabled devices and systems. The IoT, or the Internet of Things, refers to the ever-

growing network of devices that feature internet connectivity, and communication that occurs between these devices and other Internet-enabled devices and systems. IoT compatible LED lighting could be the core of systems that optimize air conditioning and heating, power grid management, and even next-generation wireless communications.

Lifi

The newest concept to come from the evolution of LED lighting is Li-Fi. Essentially, Li-Fi is the upgraded version of Wi-Fi internet connectivity using light rather than radio waves with an ability to transfer data at speeds up to one hundred times faster! Shuji Nakamura, who shared the 2014 Nobel Prize in Physics for inventing the blue LED, has even called Li-Fi the next step in LED technology. Having Li-Fi integrated into the LED lighting would create an alternate path for internet connectivity in commercial spaces and offices, where internet connectivity can sometimes pose a problem.

Human Centric LED Lighting

Human-centric LED lighting works with the people occupying the space to create the most effective environment for them. This can be done in several different ways. The first is color tuning for LED lighting. The color of light works with the natural circadian rhythms of human beings (or wake and sleep cycle). Blue light, which is typically more present in LED lighting (and the sun) than in incandescent lighting, for example, helps combat fatigue and creates an overall sensation of being awake by suppressing the production of melatonin, the body's natural sleep hormone. Red-rich lighting, on the hand, which has much less blue content, and can also be produced by LEDs, can help promote a sense of sleepiness by allowing the production of melatonin. LED color tuning technology which an LED bulb to change color electronically can be beneficial, for example, for hospital lighting. Bulbs tuned to blue-rich LED lighting can help keep nursing staff alert during night shifts, while LED lights in a patient's room can be tuned to more restful red-rich lighting.

The second and third types of human-centric technology include dimmable and occupancy sensing capabilities. The LED light would sense the ambient light in the room and adjust the brightness of the light based upon the available light coming in from windows or other sources. This technology has wide applicability from retail stores to industrial warehouses and more. Occupancy sensing helps decrease the amount of energy spent illuminating rooms that have no one in them. This could either be done by motion-sensing or heat-sensing. Both of these technologies are not just helpful for individuals, but it is also beneficial for the environment.

Dubai Lamp

One recent development in the realm of long-lasting bulbs is the Dubai Lamp. This product is said to be the world's most efficient LED lightbulb, and has the potential to save users 90% of their electricity bills. Its energy efficiency and low emissions make it a very sustainable product, and it will help the Middle East and other regions become more energy efficient. It will also reduce the amount of cooling needed, as the bulbs give off a lower level of heat. A normal LED bulb uses an LED "filament" at 1 watt each. The Dubai bulbs run at about a fourth of that which means they need more LEDs to get the same amount of light, but they should last longer and operate more efficiently.

Two Dubai developers have signed a four-year agreement to use the Dubai Lamp in their projects in the city. Dubai Municipality will coordinate the installation in buildings and facilities, and study the savings generated from the use of the bulbs. Officials expect to use 2 million Dubai Lamps in 2017, with that number projected to reach 10 million by 2021.

OLED Costs May Decline

Another update is the development of lower-cost Organic LED (OLED) technologies. Organic LEDs, unlike typical LEDs, are made from thin sheets of material, which makes them ideal for use in displays. Unfortunately, due to their high manufacturing cost and relatively lower efficiency compared to single-point LEDs, OLED displays failed to take off in the lighting sphere. All that may be about to change, though: several companies are working on bringing the cost of OLEDs down, as well as developing new form factors for OLED technology, with a special focus on architectural lighting.

Environmental Factors

LED (or light emitting diode) lighting is one of today's most energy-efficient and environmentally-friendly lighting technologies. In an age where environmental responsibility is high on the agenda for most businesses, LEDs provide an attractive alternative to other forms of lighting.

LEDs Have a Longer Lifespan than Traditional Bulbs

One of the main reasons why LED light bulbs are considered so eco-friendly is the fact that they are designed to last much longer than conventional light bulbs. LED light bulbs can last up to 20 times longer than standard forms of lighting such as incandescent bulbs or halogen bulbs, which has a very positive effect on the environment.

There's Less Energy Wastage with LED Lighting

Standard LED bulbs can be up to 80% more energy efficient than conventional bulbs, and waste far less energy than other styles of lighting. Fluorescent lights, for example, convert around 95% of the energy they produce into heat and only 5% into light. LED lights, however, convert 95% of their energy into light with only 5% being wasted as heat. This means that LEDs require less power than regular forms of lighting. As a homeowner or business owner, this is also an important characteristic – because the less energy required to produce lighting, the lower the monthly energy bills will be.

LEDs Are Non-Toxic

Fluorescent tube lights contain toxic chemicals and elements, including mercury. This means that, when disposed of in landfill sites, these toxic elements can leech out and contaminate the environment. They therefore need to be disposed of in a particular way, meaning that they need to be collected by specialist waste carriers. LED lights however, contain no hazardous materials and they do not require specialist disposal. This means there is no need to arrange for a vehicle to drive to the premises to collect and then dispose of them, so fewer emissions on the road are also produced.

2.4 Competitive Landscape

The conventional-lamp market is dominated by a couple of large global lighting players. But as LED takes off, the landscape is changing.

That's because competitive dynamics differ in the two pieces of the LED market. The first is the upstream portion of the market, known as L0/L1, which is made up of semiconductor chips and packages that are manufactured by companies not previously involved in the lighting market. The second is the lamp or module itself, known as L2/L3, which is built by combining the semiconductor packages with other components.

The rapid shift to LED lighting is leading to a large expansion of manufacturing capacity within the L0/L1 portion of the market. In this sector of the market, high R&D costs make scale a competitive advantage—hence the current wave of mergers and acquisitions. Players are also looking to build scale and reduce costs by shifting toward standardization and the manufacture of a smaller number of successful chips.

The equation is quite different in the L2/L3 end of the market. While the manufacture of conventional lamps typically involves large-scale, capital-intensive operations, the production of LED lamps in the L2/L3 portion of the market is a relatively low-scale, local-assembly process. This creates low barriers to entry, which prompted the entrance of a large number of new LED-lamp manufacturers. And the intensified competition has put downward pressure on already thin margins.

Going forward, the dynamics in this end of the market will continue to evolve. In fact, although the L2/L3 portion of the market is fragmented today, it is actually beginning to consolidate because scale in areas other than manufacturing—such as R&D and the supply chain—is growing increasingly important. Similar forces have driven consolidation in other categories, including the markets for liquid crystal displays for televisions and LFL.

Features of the Up- and Midstream Parts of the Lamp Market

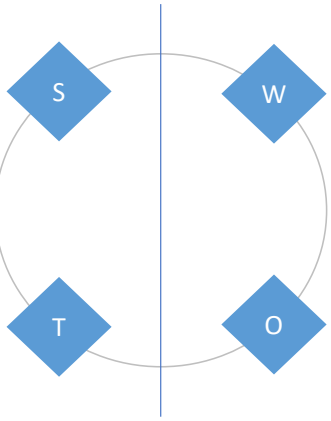
	UPSTREAM[1]			MIDSTREAM[2]	
	Wafer L0(a)	Die L0(b)	Package (L1)	Carrier (L2)	LED lamp (L3) / LED module (L3)
	• Thin layers of semiconductor materials	• Small chips of semiconductor materials enclosed in metal contacts	• Package of one or more LED chips glued or soldered to a frame and encapsulated in plastic	• One or more LED packages mounted on a circuit board with electrical and mechanical fixings	• LED lamp: equivalent of a conventional lamp, including LED carrier, heat sink and driver • LED module (for integrated LED luminaire): carrier with optics and heat sink to form the light-producing element
Key market characteristics	Capital intensive because of high R&D and capacity requirements			Low-scale, assembly business	
Entry barriers	High entry barriers			Low entry barriers	
Key clients	OEMs (including lighting manufacturers)			Wholesalers, professional clients	
Key players	Semiconductor and LED manufacturers (for example, Cree, Nichia)			Traditional lamp manufacturers, Asian entrants, private label (for example, Philips, Osram)	

[1]This portion of the value chain is known in the industry as L0/L1
[2]This portion of the value chain is known in the industry as L2/L3
Source: BCG Report

	BASE COUNTRY	PUBLIC/ PRIVATE	PORTION OF THE VALUE CHAIN	PRICE TO EARNINGS RATIO (USD)
AcuityBrands.	USA	Public	L2/L3	23.73
HUBBELL	USA	Public	L0/L1	30.58
SEOUL	South Korea	Public	L0/L1	16.66
siteco	Germany	Private	L2/L3	-
PHILIPS	Netherlands	Public	L2/L3	8.46
Future is this HALONIX	India, owned by Hong-Kong based PE firm	Private	L2/L3	-
LSI	USA	Public	L0/L1	27.89
HAVELLS	India	Public	L2/L3	0.96

2.5 SWOT Analysis

- Rising adoption of LED because of its long shelf-life and greater energy savings.
- LEDs have the lowest life-cycle cost option
- Wide applications, endless colour options
- LED lamps have same style as old-style lamps and installed in any fixture
- Readily available for households
- Gained popularity since the phase-out of standard incandescent light bulbs



- High initial cost of installment
- Lower operating cost but high fixed costs
- LED components are susceptible to stress fractures which can be induced during manufacturing
- Fractures are small and can shorten the expected lifetime or reliability of the finished product

- Highly fragmented
- Highly competitive
- Constant innovation that can be threatening for existing players with poor R&D
- Trending practice of forward integration; semiconductor manufacturers trying to establish themselves as lighting manufacturers

- Decreasing manufacturing cost due to cheaper components
- Growing consumer awareness for sustainability
- The requirement of energy-efficient connected lighting controls in ongoing and upcoming smart city projects in developing economies acts as a driver for the LED lighting industry.

Way Forward

Section 3

3 Way Forward

The government push to phase out inefficient lighting, decline in prices and consumer awareness about the same have all led to LEDs gaining the largest market share. Continued technological advancement in LED lighting has poised these product offerings to enter and advance through the growth phase. Recent advancements in light-emitting diode technology have allowed LED lighting products to penetrate the commercial lighting market, with enormous potential for growth. Major manufacturers are actively developing the LED lighting business with the rising LED lighting penetration rate. Moreover, the rapid urbanization and the increasing construction activities in the commercial sectors of different countries has fuelled market demand.

Developments within the realm are accelerating the LED penetration rate. LEDs have transformed lighting from analog to digital, enabling users to remotely control and monitor them. The digital capabilities of LEDs enable tremendous customisation in terms of light output and application and has also brought illumination and IoT (Internet of Things) together, allowing lighting systems to participate in the IoT. This has led to the emergence of connected lighting, marking a significant shift and transforming lighting from a commodity product to a fully integrated lighting system that can seamlessly connect with a wireless network or Ethernet, allowing users to remotely control and monitor their lighting systems. This has multiple applications in smart cities, buildings and homes, making lighting intelligent and personalised. Signify, one of the global leaders in lighting products has recently launched Li-Fi, which is a technology in which high-quality LED lighting provides a stable and fast broadband Internet connection through light waves.

Urban populations are growing rapidly, and by 2030 it is predicted that close to 60 per cent of the world population will be living in cities. In the home of 2030, lighting will be able to synchronise with everything from doorbell to television and music and will be fully adjustable to individual preferences.

Survival in this new business and its enormous potential, therefore, requires the development of a wide and steadily growing range of products. Lighting manufacturers need not only be fit in lighting technology; in this new era, they need to understand and implement new technologies for being competitive in this volatile market.

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