

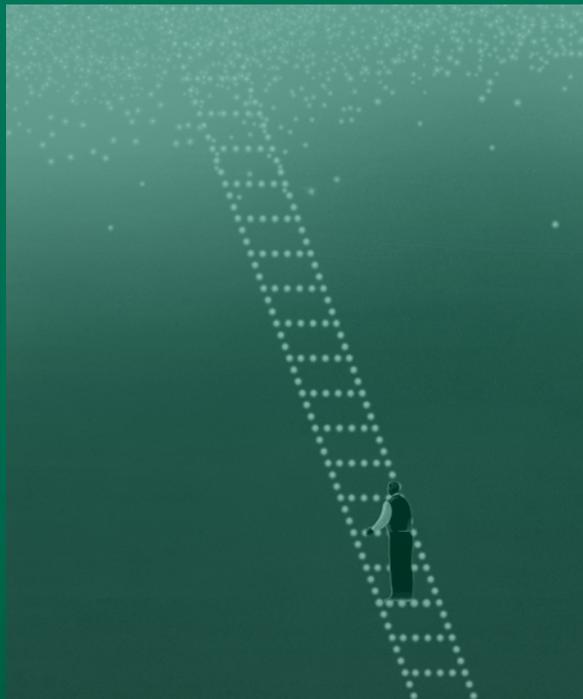
HOW TO WIN IN A TRANSFORMING LIGHTING INDUSTRY



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HOW TO WIN IN A TRANSFORMING LIGHTING INDUSTRY

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EXECUTIVE SUMMARY

THE \$112 BILLION GLOBAL lighting market is undergoing a rapid transformation, driven by two trends: the growing adoption of light-emitting-diode (LED) technology and the increasing popularity of connected lighting systems.

These powerful, mutually reinforcing trends are fundamentally altering the underlying economics and dynamics of the market. As a result, new sources of competitive advantage are emerging, requiring players to revamp their strategies across the lighting value chain.

Revenues in the lighting industry will continue to grow at 3 percent annually, with global revenues topping \$130 billion in 2020. Although overall growth is holding steady, the dynamics within the lighting market are shifting dramatically.

- The advantages of LED—including low energy consumption, a long lifetime, and enhanced versatility—are driving market share gains. The rapid growth of LED adoption will continue as prices for the technology fall. We expect that the average price of an LED point (a point is a type of LED light source, or LED lamp) will drop from more than \$6 in 2014 to less than \$3 in 2020 and that the prices of LED linear lamps (the long tube-like lamps used largely in professional settings) will fall by 18 percent over that period.
- Connected lighting systems (also known as smart systems) are growing in popularity, in part because they allow significant cost savings—another 40 percent on top of the sizable savings generated by LED technology.

We view the industry according to three major categories comprising six key segments.

- *General Lighting.* This category includes four segments: lamps, which include both points and linear lamps; electronics (the units

that regulate the electric current in lighting equipment and in the LED light sources known as modules); consumer, which includes consumer luminaires (the piece of equipment that combines the fixture and the electronics to create a usable end product) and lighting systems; and professional, which includes luminaires, systems, and services.

- *Automotive Lighting.* This segment comprises all elements of lighting systems in cars including electronics, luminaires, and lamps.
- *Backlight.* This segment is made up of the lighting used in devices such as TVs, smartphones, and tablets.

Revenues in the lamp segment will decline, with two distinct markets emerging: one for conventional lamps (older technologies such as incandescent and compact fluorescent lamps, or CFLs) and one for LED lamps.

- The total lamp volume will decrease, for two reasons. First, the long life of both LEDs and more efficient conventional technologies (such as CFLs) will reduce the overall demand for replacement bulbs. Second, the development of LED luminaires (which use not a separate lamp but a built-in module) will mean that fewer lamps will be needed in general.
- Revenues for conventional lamps will decline from roughly \$13 billion in 2014 to about \$5.5 billion in 2020; margins will hold steady. Companies competing in this area will need to rationalize their manufacturing operations amid that contraction.
- In LED lamps, manufacturing scale will not be an advantage as it is in conventional lamps; this is because LED-lamp production is an assembly operation rather than a scale-manufacturing operation. LED-lamp revenues will climb to nearly \$10 billion by 2020 but decline thereafter, and margins, currently almost zero or even negative for most players, will remain weak.

The electronics segment is made up of two primary products: drivers, which regulate the current flowing through the lamp, and modules. This segment will grow at a robust pace in the coming years.

- Although some conventional lighting technologies do not use a driver, all LED lights do. Consequently, as LEDs' market share expands, the market for drivers—in the burgeoning low-end consumer segment as well as others—will grow rapidly. And as LED-luminaire sales take off, demand for modules will experience a similar trajectory.
- Overall electronics sales will jump from roughly \$8.2 billion in 2014 to about \$16 billion in 2020. And profits will increase from about \$550 million to \$950 million as margins hold relatively stable at 4 to 8 percent.

- Companies that make conventional drivers will be well positioned in high-end LED electronics, in part because of their established relationships with luminaire makers. Competition will be more fragmented in the low-end electronics market.

The professional market will see an uptick in growth thanks to the shift to LED and new business opportunities created by the uptake of connected lighting.

- By 2020, 80 percent of professional luminaires sold (measured in volume) will be LED luminaires—and 25 percent of all luminaires sold (measured in revenues) will be part of a connected lighting system; much of that shift will occur in the professional luminaire category.
- The professional market is expected to show compound annual growth of about 4 to 5 percent through 2020, up from the 3 to 4 percent rates from 2010 through 2014. Total revenues should hit \$65 billion in 2020, with margins holding steady.
- The growth of professional connected-lighting systems will create new opportunities for high-end, professional services.

In the consumer market, the shift to LED luminaires for residential use will be rapid. The adoption of LED home-lighting systems, however, will be slower than in the professional market.

- Luminaires—both conventional and LED—will dominate the consumer market as systems remain a small, but fast-growing, segment in the near term.
- By 2020, LED luminaires—which cost about 1.8 times as much as conventional luminaires—will account for about 60 percent of volume in the consumer luminaire market. That shift will help the consumer market post growth in line with the historical 3 percent annual rate to hit \$24 billion by 2020.
- The consumer luminaire market will remain fragmented, so understanding consumer tastes within specific geographic markets will be critical.

In the automotive market, LED is gaining market share as sophisticated lighting systems become a key differentiator for automotive brands.

- The shift to LED provides a boost to automotive-lighting revenues given that the technology is more expensive than the primary competing automotive-lighting technologies. But automotive-lighting volume growth will be modest overall, in part because fewer lights will be needed per auto as a result of the increased brightness yielded by all technologies.
- The automotive-lighting market is expected to grow by about 3 percent annually through 2020 to hit \$25 billion.

- The fragmented LED automotive market is likely to see consolidation in the years ahead, and close collaboration between lighting providers and automakers will become the norm.

The \$3.8 billion backlight market—which is already dominated by LED—will decline in the years ahead owing to the need for fewer backlights per screen and the falling prices of LEDs.

- Today's average backlight revenue per screen will fall by 70 to 90 percent by 2020. And revenues for the backlight market will slip to \$2.6 billion.
- Amid declining revenues, backlight companies must also navigate the transition to a new technology: organic light-emitting diode (OLED). But while OLED is gaining ground in the backlight market for mobile phones and larger-screen TVs, the technology will not see widespread adoption in other areas because of limitations including the technology's higher energy consumption when used continuously.
- Scale will be increasingly important in the backlight market given that companies need to fund significant R&D investments.

AN INDUSTRY IN FLUX

THE \$112 BILLION GLOBAL lighting market is undergoing a rapid transformation driven by technological change—and the rules of the game are changing for players across the industry.

The upheaval stems from two powerful shifts: the move toward light-emitting-diode (LED) lighting and the growing adoption of connected lighting systems. These trends, which reinforce one another, are fundamentally altering the underlying economics and dynamics of the market. Existing players are scrambling to adapt while new players—such as manufacturers in Asia and companies that market private-label products—are entering the fray. Attractive new product markets are emerging. And the advantages conferred by scale are withering in some segments but growing in others.

The result: companies across the complex lighting ecosystem must evaluate where they can compete effectively amid the changes and adopt new strategies to win in the future.

The Ecosystem Is Complex

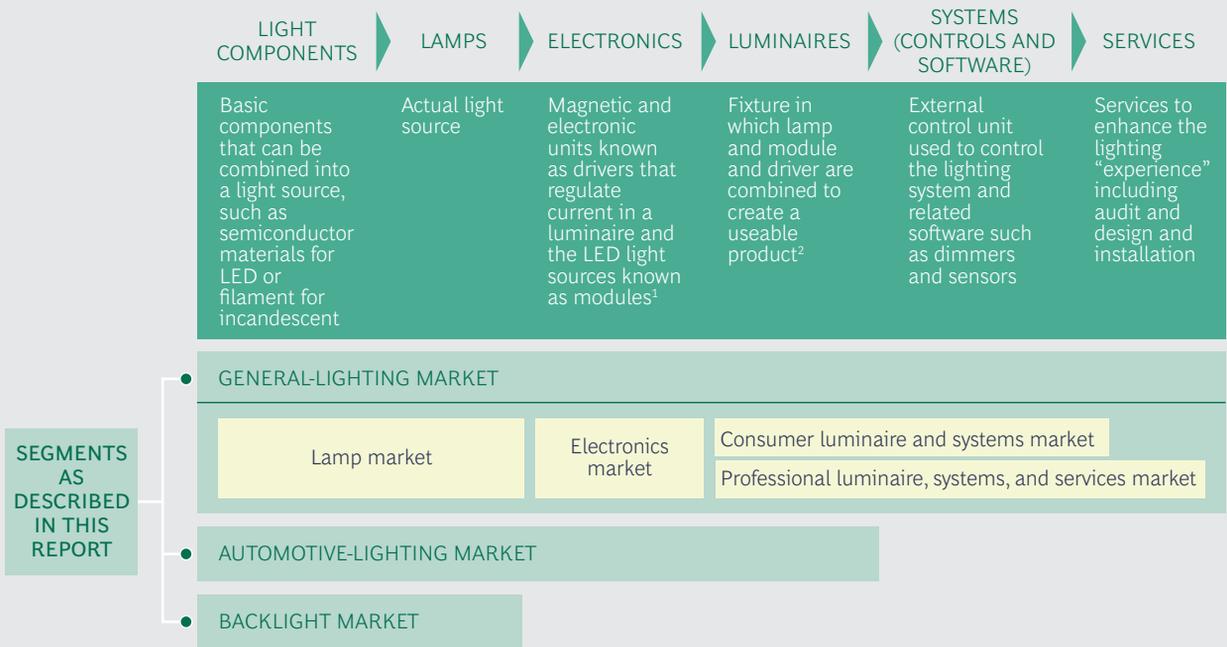
The global lighting industry encompasses major markets across the value chain, from lamps (the light source commonly referred to in lay terms as lightbulbs) to the sophisticated systems used in office buildings and cars to the backlight used in laptops, smartphones, and other devices.

For the purposes of this report, we break down the industry into three major categories comprising six key segments (see Exhibit 1):

- *General Lighting.* This segment includes four categories: lamps, which include both points (one type of LED light source, or LED lamp) and the linear lamps typically used in ceiling fixtures; electronics (the units that regulate the electric current in lighting equipment and the LED light sources known as modules); consumer, which includes household luminaires (the piece of equipment that combines the fixture and the electronics to create a singular usable end product) and systems; and professional, which includes professional luminaires, systems, and services.¹
- *Automotive Lighting.* This segment comprises all elements of lighting systems in cars including electronics and lamps.²
- *Backlight.* This segment is made up of the lighting used in devices such as TVs, smartphones, and tablets.

Globally, the developed markets of North America and Europe account for about 45 percent of the total lighting market. The professional segment is the largest; it makes up nearly 40 percent of the global market. (See Exhibit 2.) Within the general-lighting category, luminaires (both professional and consum-

EXHIBIT 1 | The Lighting Market Comprises Six Key Segments

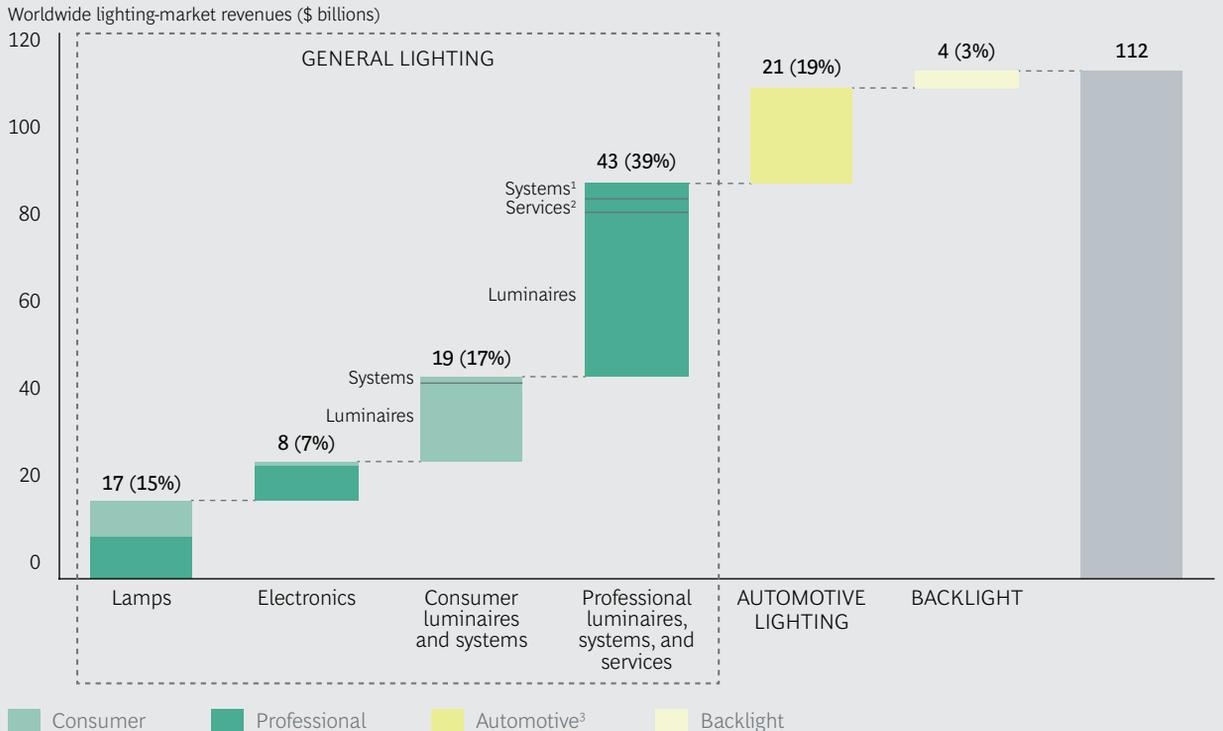


Source: BCG 2020 Lighting-Market Model.

¹Drivers and modules are always needed in LED lamps and luminaires; for conventional technologies, drivers are needed only for certain technologies.

²Lamps are integrated into LED luminaires and called modules; lamps are separate in conventional luminaires.

EXHIBIT 2 | Global Lighting Revenues Exceed \$110 Billion



Source: BCG 2020 Lighting-Market Model.

Note: Electronics for automotive lighting are not modeled separately given the limited size of the market.

¹Includes the value of controls and software; excludes the value of lamps and luminaires that are part of the system.

²Includes consulting, audit, design, commissioning, systems integration, and data technology services, for example.

³Includes the value of lamps, electronics, luminaires, and systems; luminaires make up approximately 80 percent of the overall value of systems.

er) are by far the largest piece of the value chain, making up roughly 65 percent of total general-lighting revenues. Within the luminaire market, professional luminaires account for the largest share: about 70 percent.

We also consider the marketplace opportunity from the perspective of several application, or customer, segments. One is a general consumer segment; the others are professional segments: roads and streets, sports, architectural, offices, industrial, retail, hospitality, and health care.

Steady Growth Belies Major Change

Historically, growth in the lighting market has tracked global GDP growth, running at about 3 percent on a compound annual basis from 2010 through 2014. In the developed world, growth is driven by economic expansion and the annual increase in the number of households; in developing markets, growth stems not only from both those factors but also from increasing access to electricity. In fact, rapidly developing economies such as China and countries in Latin America accounted for about 70 percent of lighting-industry growth over the last five years.

In the years ahead, growth will continue at the 3 percent annual pace, with lighting revenues topping \$130 billion in 2020. But although overall growth will hold steady, the dynamics within the lighting market are changing dramatically because of the move toward LED lighting and the adoption of connected lighting systems.

The Rapid Rise of LED. The lighting market is undergoing a fundamental shift toward energy-efficient technologies, with LED playing a leading role.

LED's Winning Value Proposition. LED technology boasts major advantages over conventional technologies such as incandescent, halogen, and compact-fluorescent-lamp (CFL) lighting.

First, LED is currently four to five times more energy-efficient than conventional technologies and is expected to become even more ef-

ficient—a critical edge considering that more than 50 percent of the total cost of lighting stems from energy consumption.

Second, LED is more versatile than other technologies. LED lights come in a wider variety of colors, for example, and are smaller than those of other technologies, so LED can be used in creative new ways.

In the next few years, the shift toward LED technology is likely to accelerate.

Third, LED lamps last about 15 years, roughly four times the life span of CFL lighting and more than ten times that of incandescent lights. That extended life, combined with the versatility of LED, has led to a significant new product: the LED luminaire, in which the light source (an electronic unit called an LED module) is no longer a separate element such as a point but is integrated directly into the luminaire. (See the sidebar “The End of the Lightbulb?”)

In the next few years, the shift toward LED technology is likely to accelerate, for two key reasons.

First, although LED technology is still more expensive than conventional lights (currently about five to ten times more) the price is falling precipitously, owing to technological advances in manufacturing and increasing LED efficiency (fewer LEDs are required for a similar amount of light output). We project that the average price of an LED point will slip from more than \$6 in 2014 to less than \$3 in 2020.

Second, there is an increasing focus on the total cost of ownership (TCO) of lighting—TCO includes not only the initial cost of lamps and luminaires but also the expense of replacing lamps and costs for energy. As buyers pay greater attention to this measure and as manufacturers market their products by pushing the message about LED's lower total costs, LED technology will gain additional traction. And as LED prices continue to fall, that TCO

THE END OF THE LIGHTBULB?

How many people does it take to change a lightbulb? In the LED world, the answer is frequently “none.”

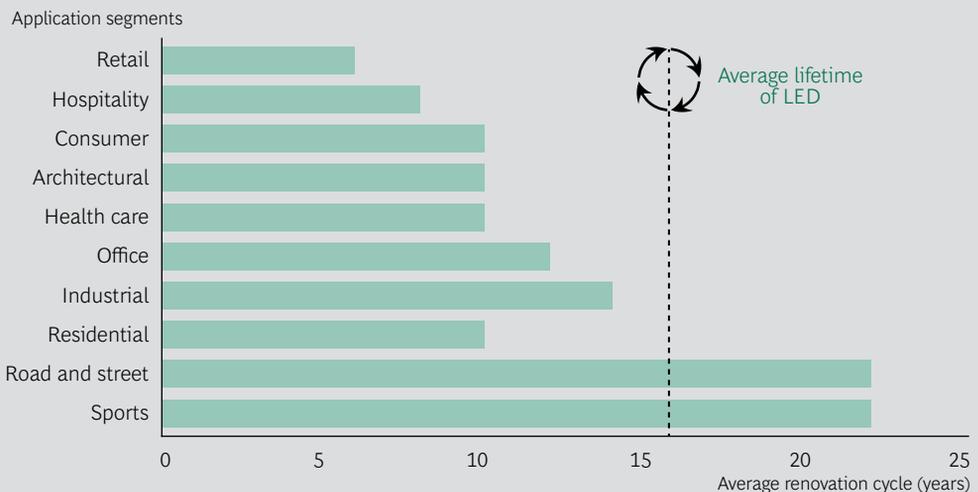
Comparing renovation cycles (essentially, the time between major overhauls in various segments of the market) with the lifetime of lamps explains why. The average life of an incandescent lamp, for example, is one to two years; for a CFL, four to five years. The renovation cycle in most application segments of the market, including residential, office, and hospitality, is longer than those lamp lives. As a result, bulbs typically burn out before a renovation leads to the replacement of all the luminaires.

But the average LED lamp lasts about 15 years. So, the lamp will continue to work throughout the entire period between renovations in most application segments. (See the exhibit below.) Thus, a separate and replaceable lamp is not needed. Rather, the LED light source—or module—can be integrated directly into the luminaire itself because the entire unit will be replaced before the light source burns out.

This is good news for luminaire makers, which now capture the revenues previously generated through the sale of a separate lamp.

LED Longevity Pushes the Market Toward LED Luminaires

RENOVATION CYCLES BECOME MORE IMPORTANT THAN TECHNOLOGY LIFETIME



Sources: BCG 2020 Lighting-Market Model; expert interviews.

calculation will become an even stronger selling point. This will be a major factor for linear LED lamps in particular. Prices for linear LED lamps are still relatively high, but we expect them to drop by about 18 percent annually from 2014 through 2020. (See Exhibit 3.)

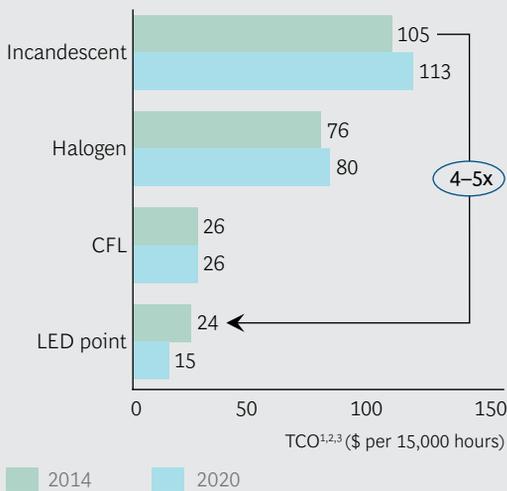
Regulations favoring LED have had a major impact in the past, but we expect regulatory moves to have a muted effect going forward. (See the sidebar “The Most Powerful Regulator.”)

The Varying Speed of LED Adoption. The forces driving LED adoption will certainly play out differently in various customer segments as well as in different geographies.

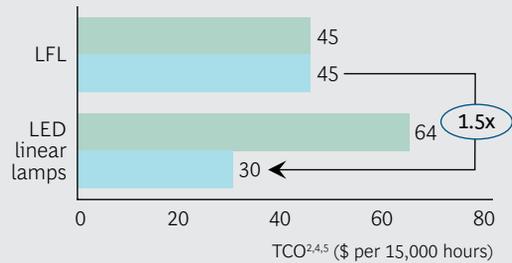
In the professional segment, the TCO is central to purchase decisions. As a result, professional customers have already moved to more-efficient conventional technologies such as CFL and are now shifting to LED. Consumers, by contrast, are more focused on the purchase price of the lamp when making

EXHIBIT 3 | LED's Total Cost of Ownership Is Low and Falling

THE TCO OF LED POINTS IS TYPICALLY ALREADY LOWER THAN THAT OF CONVENTIONAL LAMPS



THE TCO OF LED LINEAR LAMPS IS EXPECTED TO BECOME MORE FAVORABLE BY 2020



Sources: Expert interviews; Frost & Sullivan; Amazon.com; Walmart Stores; Infiniti Research; U.S. Energy Information Administration.

Note: The total cost of ownership includes lamp replacement and energy costs. CFL = compact fluorescent lamp; LED = light-emitting diode; LFL = linear fluorescent lamp; TCO = total cost of ownership.

¹Total cost of ownership for a 60-watt equivalent point (750 to 900 lumen).

²Based on \$0.10 per kilowatt-hour.

³Based on U.S. retail prices as of March 2015.

⁴Total cost of ownership for a 25-watt LFL equivalent (2,600 lumen).

⁵Based on EU retail prices as of March 2015, converted to U.S. dollars.

a buying decision. We expect the tipping point for consumers—the point at which adoption will accelerate—to arrive by 2020, when LED lamps are likely to cost just two to three times more than conventional lamps.

The rate of LED adoption will also differ by region. Japan and China will probably be the countries that move most rapidly to LED, owing to high rates of customer acceptance and strong regulations, followed closely by Europe and North America. LED adoption will be a bit slower, meanwhile, in developing economies in Latin America and Africa. In those regions, CFL and linear fluorescent lamp, or LFL, technology have not been widely embraced because they remain expensive relative to incandescent lighting. But as LED prices decline over the next decade, emerging markets are likely to leapfrog CFL and LFL, moving directly from incandescent to LED. Adoption rates for various lighting technologies—and the amount that customers are willing to pay for those technologies—also differ across geographies on the basis of customer preference for warm or soft light (a variable known as “color temperature preference”).

The exact speed at which LED technology will penetrate the market is highly dependent on several uncertainties. Technological developments and competitor dynamics might change the pace of the LED-price decline and therefore the pace of the transition. Furthermore, consumer acceptance of LED is difficult to predict, in particular because some perceive LED as less warm and less attractive than other technologies.

The Shift to Connected Lighting. The increasing popularity of LED gives momentum to another significant shift: the adoption of connecting lighting systems (also called smart systems). Given the versatility of LED in terms of factors such as brightness and color variation, connected systems make more sense for use with LED than when conventional lighting technology is used.

Other factors are driving the adoption of connected lighting as well. Connected lights can be programmed and controlled in an expanding variety of ways, which further strengthens the demand for systems. In offices, for example, lighting can be automatically adjusted in

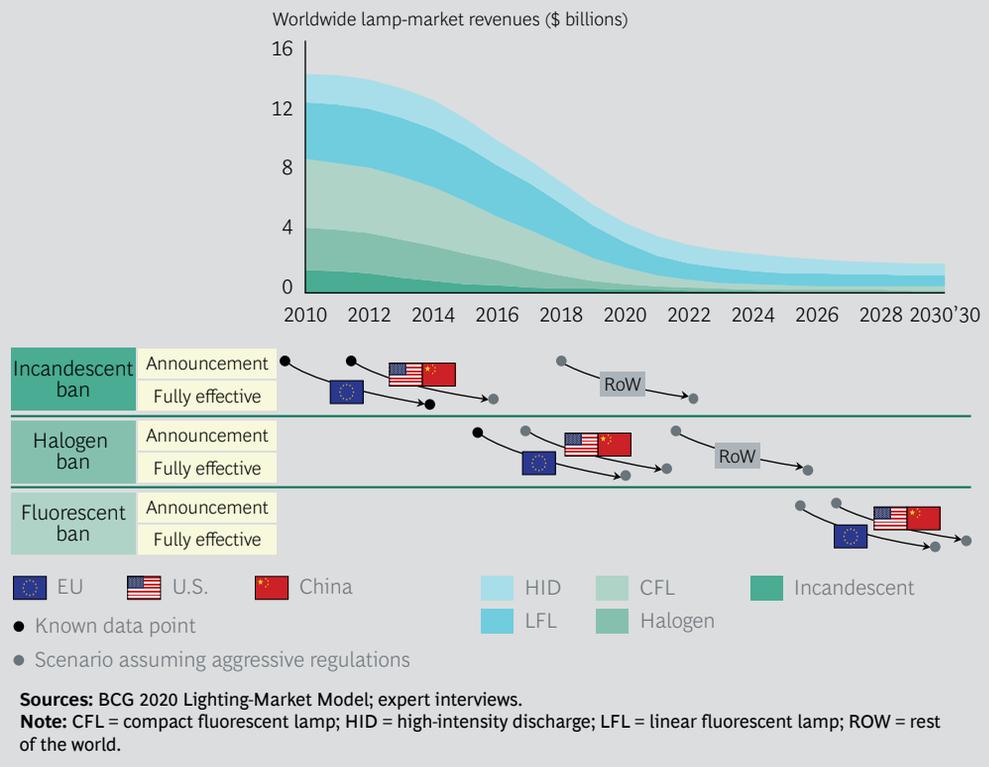
THE MOST POWERFUL REGULATOR

Over the past decade, the push for energy efficiency in many parts of the globe has led to regulations aimed at phasing out older lighting technologies. Incandescent lights have been banned in most developed countries, and China and Brazil will ban them starting in 2016. The EU has passed regulations phasing out halogen by 2018, and the U.S. and China are expected to soon follow suit.

Future moves to ban or phase out older, energy-hogging technologies are likely to

have a muted impact, however, because new regulations typically take five to seven years to be fully implemented. But by that time the share of the lighting market held by these older technologies will have already plummeted dramatically owing to the rapidly falling price of LED. (See the exhibit below.) In this case, market forces will effect in short order changes that might take regulators many years to achieve.

New Regulations Will Lag the Market Shift to LED



response to the level of natural lighting, which in turn can enhance employee productivity. And smartphone apps can be used to easily manage connected lighting systems, a feature that makes those systems increasingly accessible to a broader group of customers.

Connected lighting also offers cost-saving opportunities. Energy cost reductions from efficiently controlled systems can be substan-

tial—another 40 percent on top of the already hefty savings offered by LED alone. And data generated by connected systems—automated alerts to show where lamps have burned out, for example—can pare other costs, such as maintenance expenses.

Meanwhile, existing regulations are making energy-saving light systems more attractive. In the U.S., for example, regulations require

that lighting in most buildings be controlled automatically to adjust light usage according to the hour of the day or the occupancy of the building. Also, energy suppliers are encouraging their customers to adopt connected lighting because those energy-efficient systems can help reduce big energy-demand peaks.

The shift to connecting lighting will be most swift in the professional segment in developed countries. Given that these professional systems typically control a large network of lights, the savings based on TCO are usually significant. Furthermore, the enhanced functionality of connected lighting appeals to many professional customers. One large global retailer, for example, has installed sophisticated, cost-saving systems that adjust the intensity of lights within its stores according to the amount of natural light coming from outside. This enables the retailer to consistently showcase products in the best possible lighting, thereby increasing appeal and potentially sales. And the city of Los Angeles has developed a centralized connected-lighting system for streets throughout the city.

Home systems—smart connected lighting for the consumer market—generally deliver less dramatic cost savings for the end-user relative to professional systems owing to the smaller number of lights in a household and the lower frequency with which lights are used. As a result, growth in the consumer systems market will likely lag that of professional systems.

NOTES

1. The lamp category includes both components and a light source. In LED lamps, the components incorporate semiconductor materials. Given the enormous size and scope of the semiconductor industry, we limit this report to the mid- and downstream parts of the value chain and do not examine the semiconductor materials portion of the market in detail here.
2. In this report, lamps and electronics used in automotive lighting and backlight are included in the automotive and backlight segments, not separately in the lamp and electronics segments.

THE IMPACT ON PLAYERS ACROSS THE VALUE CHAIN

THE SHIFTS TOWARD LED and connecting lighting will fundamentally alter the composition of the global lighting market by 2020. (See Exhibit 4.) To understand how the changes will affect market dynamics, we examine the three categories across the value chain and the six segments within those categories, including lamps, smart systems, and lighting services.

The General-Lighting Market Will Be Transformed

In the general-lighting market, various changes are under way, including the decline in the market for conventional lighting and the development of lighting-related services.

The shifts under way will fundamentally alter the global lighting market by 2020.

Lamp Market: Volumes and Prices Decline.

The shift toward longer-lasting technologies, and specifically the rise of LED, will translate into an overall decline in the volume of lamps sold, for two reasons:

- Because newer conventional technologies (such as CFL) and LEDs have longer lives

than older conventional lamps (including incandescent and halogen), fewer replacement lamps will be bought.

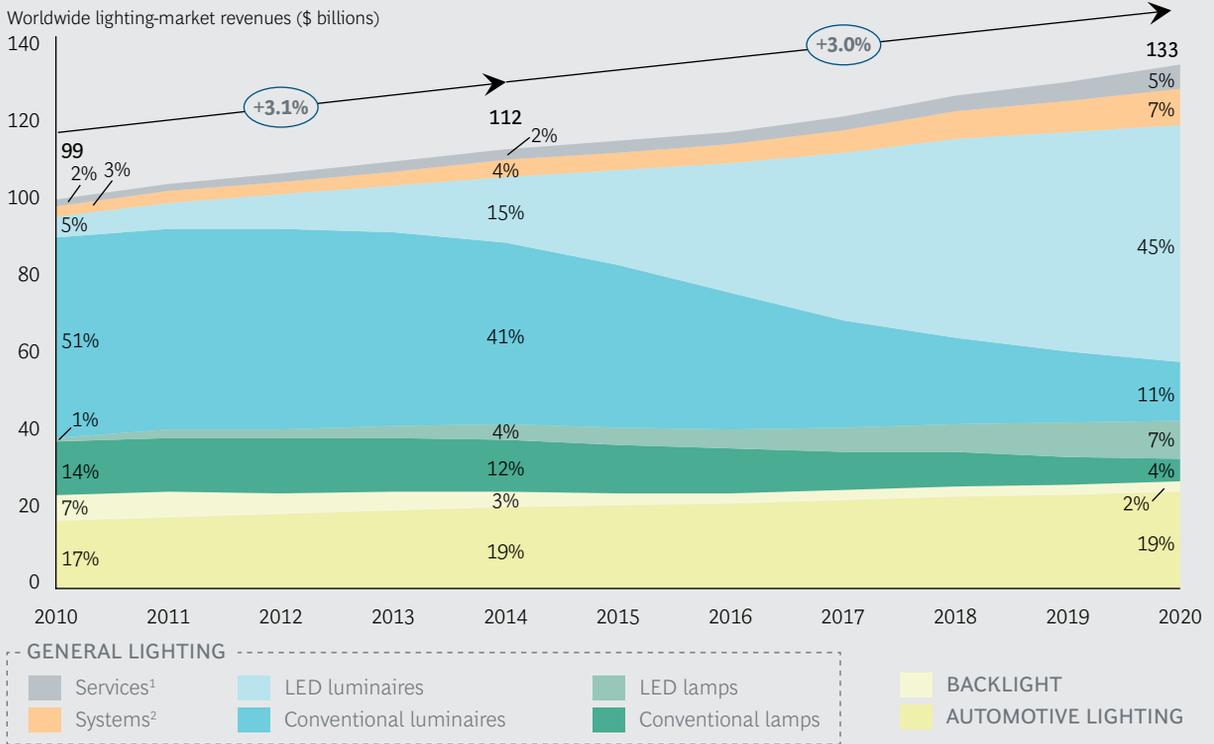
- As LED luminaires gain in popularity, fewer lamps will be needed.

Growth in demand from emerging markets will boost lamp volumes but not by enough to offset these two downward forces.

The impact of falling volumes will be tempered somewhat by the higher price of LED-based light sources relative to conventional technologies. Conventional lamps have already moved toward use of more-efficient technologies, such as CFL. And by 2020, more than 30 percent of lamp volume will have moved from conventional to the more expensive LED technology. (See Exhibit 5.) As a result, total lamp revenues will roughly hold steady between 2015 and 2020.

Within the total lamp market, however, two distinct lamp segments—conventional and LED—will emerge, each with very different economics. (See the sidebar “A New Game in Lamps.”) Within the LED-lamp segment, volumes will grow—by about 30 percent on a compound annual basis during the period from the end of 2014 through 2020. After 2023, however, volumes will decline as a consequence of LED luminaires’ cannibalization of the LED-lamp market. The upshot: we ex-

EXHIBIT 4 | The Changing Composition of the Lighting Market



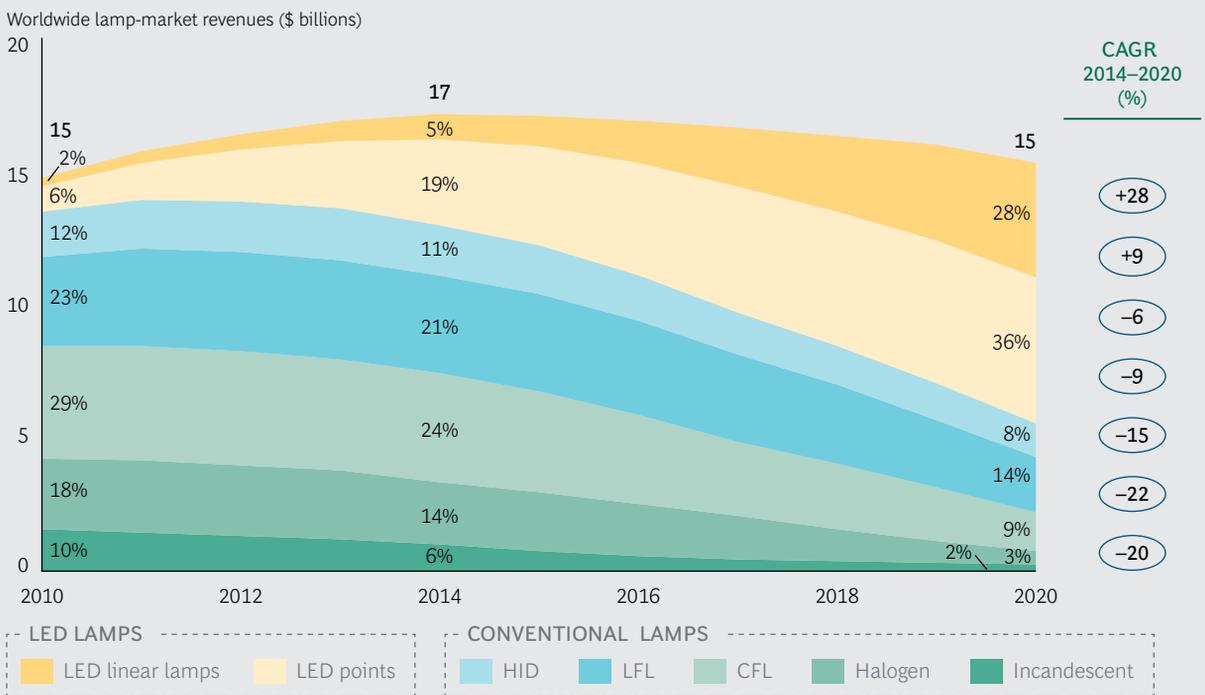
Source: BCG 2020 Lighting-Market Model.

Note: LED electronics used in LED luminaires are included in the LED-luminaire market total; blue-collar services are excluded.

¹Includes white-collar services (such as data technology services and systems integration).

²Includes only the added value of the system, not the lamps and luminaires included in the system.

EXHIBIT 5 | The Lamp Market's Rapid Shift to LED



Source: BCG 2020 Lighting-Market Model.

Note: CFL = compact fluorescent lamp; HID = high-intensity discharge; LED = light-emitting diode; LFL = linear fluorescent lamp.

A NEW GAME IN LAMPS

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

That's because competitive dynamics differ in the two pieces of the LED-lamp market. (See the exhibit below.) The first is the upstream portion of the market, known as

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)
	<ul style="list-style-type: none"> Thin layers of semiconductor materials 	<ul style="list-style-type: none"> Small chips of semiconductor materials enclosed in metal contacts 	<ul style="list-style-type: none"> Package of one or more LED chips glued or soldered to a frame and encapsulated in plastic 	<ul style="list-style-type: none"> One or more LED packages mounted on a circuit board with electrical and mechanical fixings 	<ul style="list-style-type: none"> 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)	

Source: LED industry reports.

¹This portion of the value chain is known in the industry as L0/L1.

²This portion of the value chain is known in the industry as L2/L3.

pect LED-lamp revenues to rise to nearly \$10 billion in 2020 and decline thereafter. And margins, currently almost zero or even negative for most players given the intense competition for shelf space, will remain weak in the near term.

The conventional-lamp segment, meanwhile, will shrink quickly. Revenues are expected to decrease from roughly \$13 billion in 2014 to about \$5.5 billion in 2020, as sales throughout the segment (particularly for incandescent, halogen, and high-intensity discharge, or HID), decline. Overall margins, however, are expected to hold steady.

At some point after 2023, LED-lamp prices will bottom out and lamp volumes will stabilize. (See Exhibit 6.) That's because two trends that depress lamp volume will have run their course:

- As LED market share approaches 100 percent, the drag on total lamp volumes created by the shift from conventional to longer-life LED lamps will lessen.
- The market share gains for LED luminaires will flatten, which means that the erosion of the LED lamp market due to cannibalization from LED luminaires will subside.

The result: after 2030 the total demand for light sources—including both lamps and the modules that provide the light in an LED luminaire—will return to the historical 3 percent compound annual sales growth rate.

Meanwhile, the market for replacement lamps will still exist in 2030 despite the shift to LED luminaires. (See Exhibit 7.) The reason: renovation cycles are relatively long—on

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 has

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 lamp categories, including the markets for liquid crystal displays for televisions and LFL.

Meanwhile, large players in conventional lamps are responding to the contraction of that market by closing factories and consolidating with other players to boost plant utilization—another sign that the repercussions of the rise of LED are widespread and powerful.

average, 12 to 15 years. As a result, beyond 2030 some 35 to 45 percent of the installed-luminaire base will still take replacement bulbs, whether conventional or LED lamps.

Electronics Market: New Opportunities Emerge. The rise of LED will also transform the electronics market within lighting—but in this category the result will be expanded opportunity.

Electronics within lighting comprise two key elements: drivers and modules.

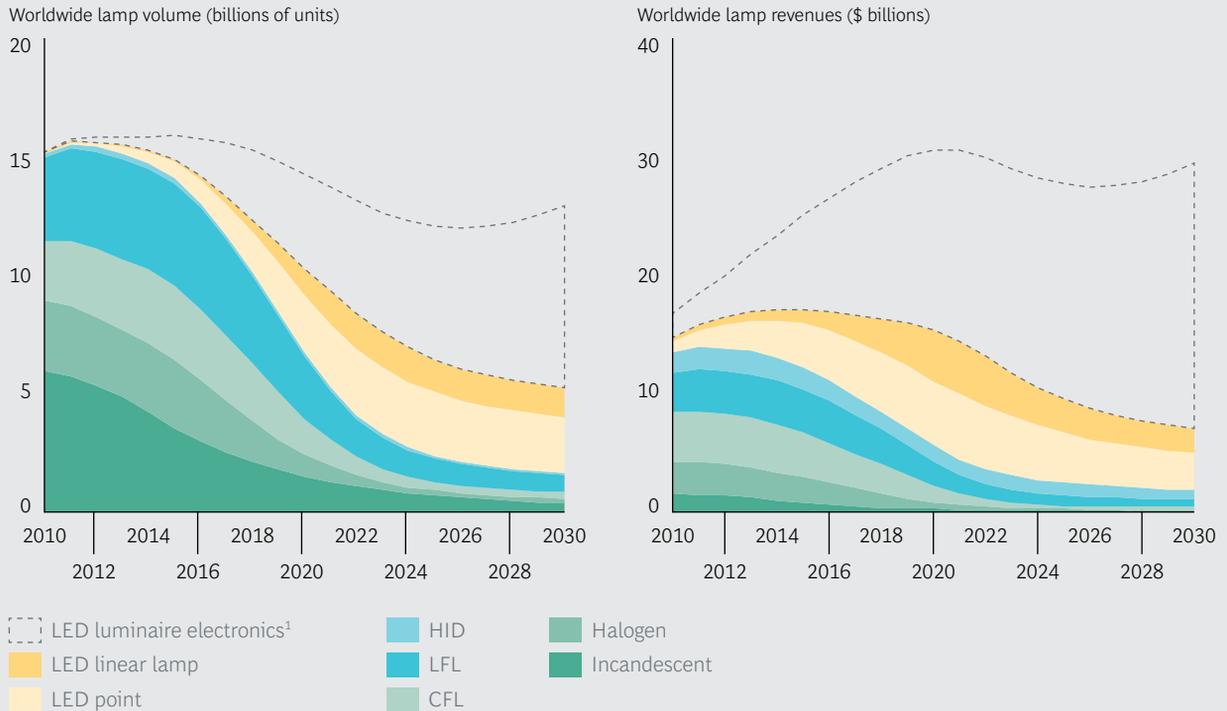
Drivers regulate the current going through the light source. Some conventional lighting technologies, which are used most commonly in the consumer segment, do not need a driver at all. For other technologies, mostly those used in the professional segment, a driver is

required. Meanwhile, all LED-lighting products—whether lamps or luminaires—use a driver. So, as LED grabs a greater share, the market for drivers will expand, mainly because the use of drivers will rise in the consumer segment. (See Exhibit 8.) This trend will open up a new market for low-end drivers given that reliability and product longevity requirements are generally lower in the consumer segment.

Modules, on the other hand, exist only in LED lighting. And with the growing popularity of LED luminaires, the module market will also grow rapidly.

In the high-end (largely professional) LED-electronics market, manufacturers of conventional drivers have made inroads. Their move into LED drivers and modules makes sense for two reasons: the extensive

EXHIBIT 6 | Lamp Volume and Revenues Will Stabilize After 2020

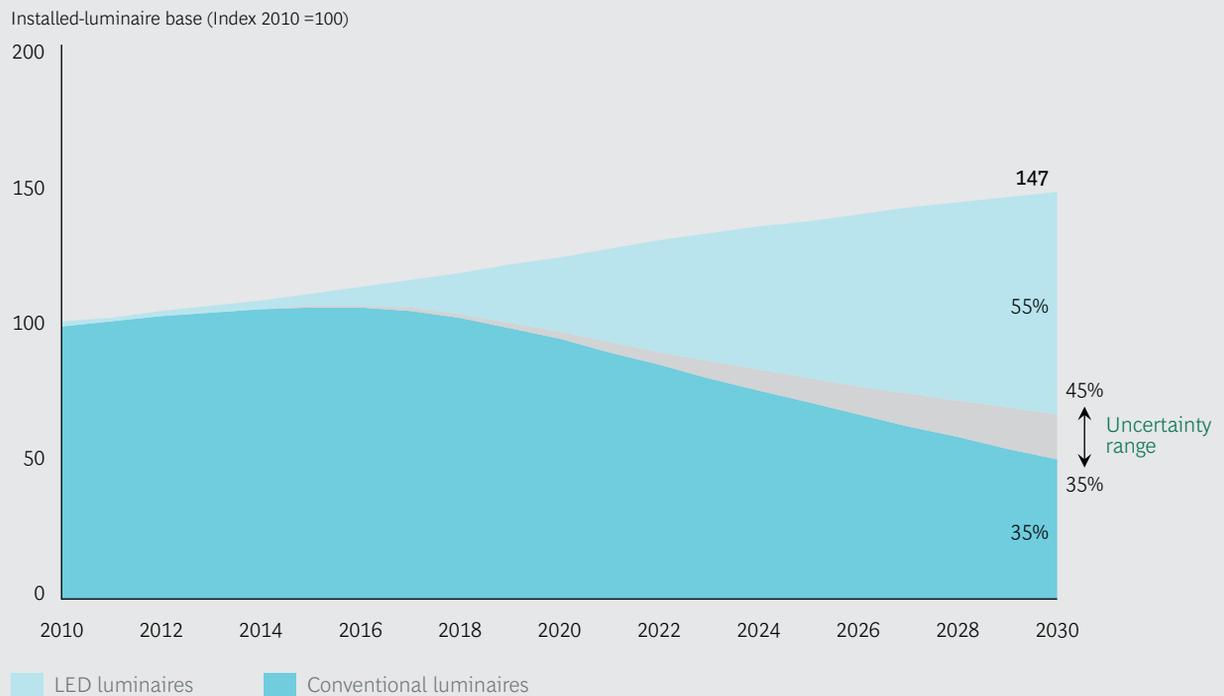


Source: BCG 2020 Lighting-Market Model.

Note: These figures are based on current technology efficiency and the assumption of a (slowed) price decline for LED luminaires (electronics) and LED lamps from 2020 through 2030 (for example, the average sales price of an LED lamp point in 2030 will be approximately \$1.35), numbers are highly dependent on the price outlook for 2030. CFL = compact fluorescent lamp; HID = high-intensity discharge; LED = light-emitting diode; LFL = linear fluorescent lamp.

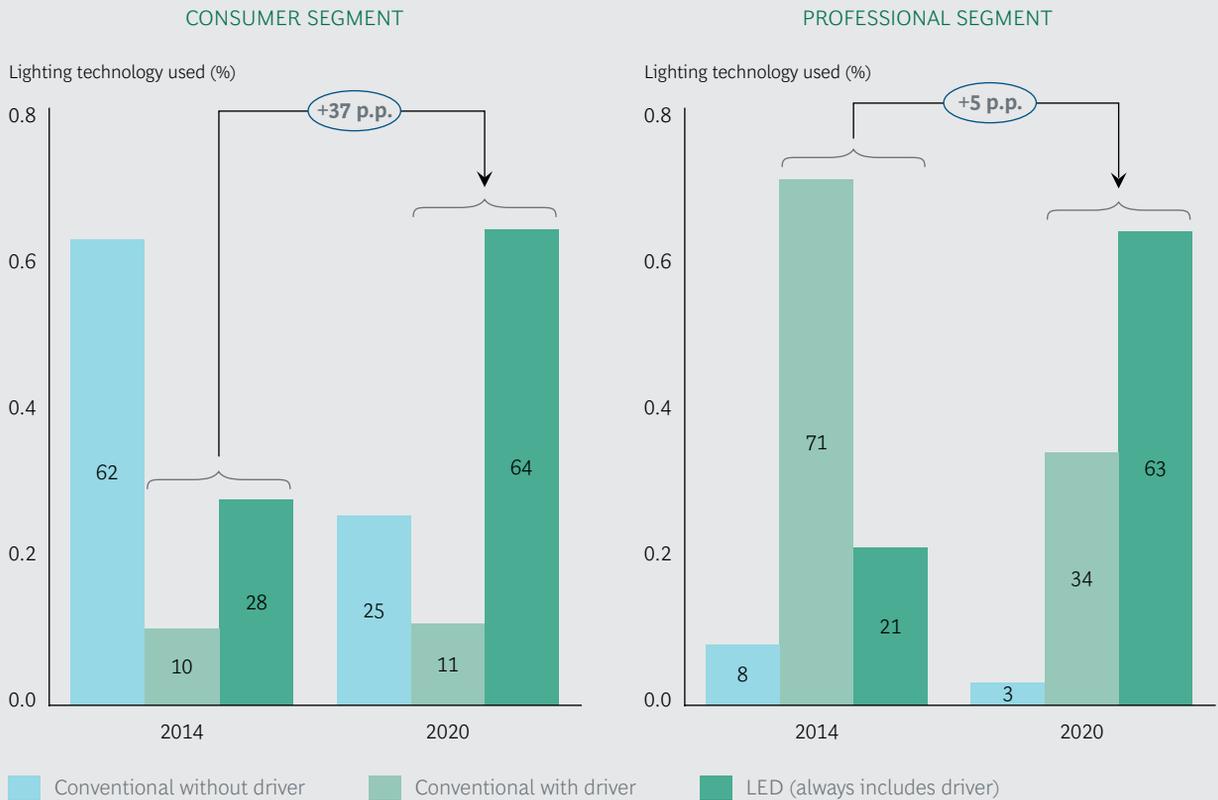
¹This is the light source in an LED luminaire. Technically, it is not part of the lamps market, but electronics cannibalize lamps demand.

EXHIBIT 7 | The Market for Conventional Luminaires Will Remain Sizable Beyond 2030



Source: BCG 2020 Lighting-Market Model.

EXHIBIT 8 | The Shift to LED Luminaires Will Fuel Driver Sales



Sources: BCG 2020 Lighting-Market Model; expert interviews.

overlap of production technology, R&D, and the client base between conventional and LED drivers as well as the strong customer loyalty to luminaire manufacturers (customers are hesitant to switch suppliers for critically important electronics, especially while they are transitioning to LED technology).

The low-end market for both LED drivers and modules—about 50 percent of the electronics market, concentrated largely in the consumer segment—is more fragmented than the high-end market. In the low-end market, many small, low-cost Asian players dominate, making products that do not have extremely high quality standards, are easy to assemble, and require less R&D.

Overall, the electronics market—both professional and consumer—will double in size from the end of 2014 through 2020. Sales will grow from roughly \$8.2 billion to about \$16 billion. Module revenues will jump from about \$2.9 billion to \$5.7 billion and driver revenues will increase from \$5.3 billion to

\$10.3 billion. Electronics profits, meanwhile, will increase from about \$550 million to \$950 million as margins hold relatively stable.

Professional Market: Systems and Services Take Off. The professional market—which includes luminaires, systems, and services used in professional settings—will change dramatically owing to the rise of LED and connected lighting.

LED luminaires are rapidly replacing conventional luminaires across just about every professional customer segment and geography. As a result, in 2020, 80 percent of professional luminaires sold (measured in volume) will be LED luminaires. At the same time, the percentage of all luminaires (measured in revenues) that are sold as part of a connected lighting system is expected to be 25 percent, up from 5 percent in 2014. Much of that shift will occur in the professional market.

The capabilities of these smart systems create new opportunities to sell professional ser-

vices. The greater functionality of LED—including the ability of a single LED point (or lamp) to project light in a variety of changing colors—sparks demand for consulting and design services, for example. In addition, the IT and software components of connected lighting are increasing the need for systems integrators. New opportunities will also emerge for service companies that can harness data from the systems—everything from tracking lamp breakdowns and energy usage in a commercial space to occupancy and foot traffic in retail shops. In some cases, professional customers will opt to hand off management of these systems to a third party, much as companies do with software today through software-as-a-service offerings. (See the sidebar “Lighting as a Service.”)

Overall, the professional market is expected to show accelerated compound annual growth of about 4 to 5 percent through 2020, up from the 3 to 4 percent rate seen from 2010 through 2014. Total revenues should top \$65 billion in 2020, with margins holding steady. Luminaire sales will grow by about 3 percent annually. Systems and services will grow more dramatically but will remain a small portion of the total professional market, only about 20 percent in 2020. (See Exhibit 9.)

Consumer Market: Stable Growth Ahead. As in the professional market, the shift to LED

luminaires for home systems in the consumer market will be rapid. However, the takeoff of home systems in the consumer segment will be more modest than the growth of smart systems used in professional settings.

In 2020, LED luminaires will account for about 60 percent of volume in the consumer luminaire market. This market is likely to remain as fragmented as it is today, with success in both conventional and LED luminaires continuing to hinge on understanding local consumer tastes and having a strong local distribution network.

On the connected-lighting front, the move to LED opens the door to wider adoption of home systems. However, we expect the home system market to remain relatively small through 2020, with buyers limited largely to affluent, technology-oriented early adopters. We believe the expansion of the market for home systems will be limited by high prices, the relatively low cost savings made possible by these systems, and the fact that functions such as lighting color and intensity changes are unlikely to be a huge selling point for consumers. That projection, however, could prove to be conservative if home system prices—which are currently much higher than those of standard LED lights—fall more quickly than expected or if consumer perception of the value of such systems improves significantly.

LIGHTING AS A SERVICE

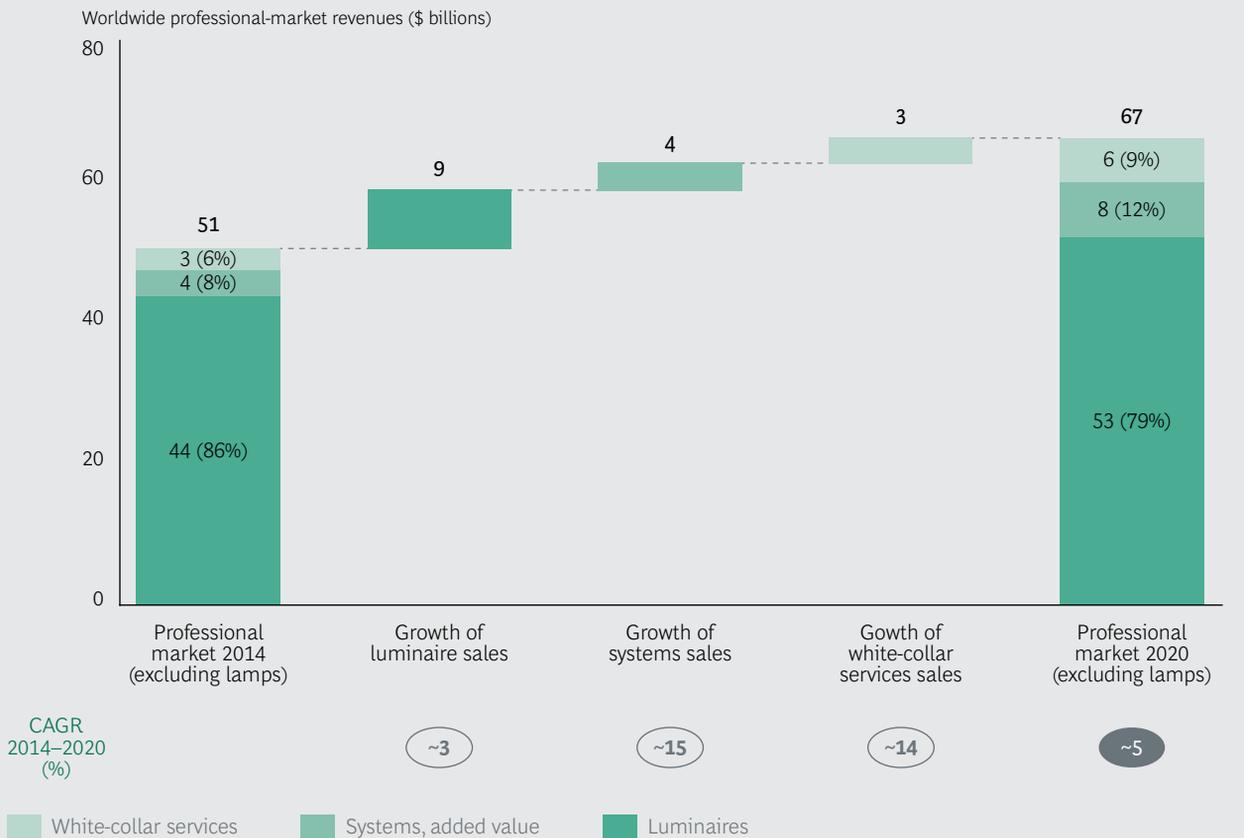
Lighting customers are increasingly looking to buy an integrated solution—the entire package including lamps, luminaires, controls, software, and services. This is spawning a new category: lighting as a service.

In this model, a customer does not buy its own lighting equipment; rather, it enters a multiyear contract that stipulates a flat fee for all its lighting needs. The lighting player provides the lamps, luminaires, and controls—and in some cases can also offer additional services such as data analysis and financing arrangements. Separate

installation companies install the lighting system and receive a fee from the lighting company for maintaining that equipment over the life of the contract.

The upside for customers is predictable—and even reduced—capital expenditures as well as guaranteed and improved lighting performance. And for lighting companies and installers, these services offer a powerful way to differentiate their offerings while generating ongoing revenue streams.

EXHIBIT 9 | Professional Systems and Services Are Growing



Source: BCG 2020 Lighting-Market Model.

Overall, we expect the consumer market to grow in line with the historical 3 percent compound annual rate and to reach \$24 billion in 2020. Home systems will make a modest contribution to sales and profitability within the consumer segment, and consumer luminaire volume growth will continue to run at about 2 percent compounded annually from the end of 2014 through 2020. Average prices for consumer luminaires will increase with the shift to LED luminaires, which sell for about 1.8 times the price of conventional luminaires.

Profitability within the consumer luminaire business will get a boost over the next few years from the shift toward higher-margin LED luminaires. That will be a welcome improvement in a business in which fragmentation, little impact from brand marketing, and complex distribution combine to yield tight margins. But the profitability improvement will be temporary thanks to the expected rapid decline in LED-luminaire prices that is ex-

pected to accompany manufacturing improvements. As a result, the improvement in consumer luminaire margins will be temporary; these margins are expected to fall back to 2015 levels by 2020.

An Automotive-Market Shakeout Looms

Like general lighting, the \$21 billion automotive-lighting segment—about 20 percent of the total lighting market—is being transformed by LED technology.

At the moment, only three main technologies—LED, halogen, and HID—are bright, robust, and cost-effective enough to be used for automotive-lighting systems on a large scale. And LED—even though it is more expensive than the other two technologies—is garnering an ever larger slice of the market. That's because LED not only offers improved energy efficiency but also can be used to create different light effects, such as dots and stripes.

Car manufacturers use LED lights to, for example, generate different images, which become a central feature of individual brands. The growing use of LED is also driving a shift toward sophisticated, dynamic lighting systems that can, among other things, automatically adjust to weather conditions.

The uptake of automotive LED is most rapid in the developed world, where LED's share of the automotive market will increase from about 3 percent in 2014 to about 20 percent in 2020. In emerging countries, LED's share of the automotive-lighting market will increase from nearly zero in 2014 to 4 percent in 2020.

Already, the rise of LED has altered the automotive-lighting landscape. Three major lighting players—Philips, Osram, and General Electric—have traditionally dominated the market for conventional automotive lamps. But the LED automotive market is more fragmented; those big lighting players and a number of Asian companies are vying for share. The number of competitors is likely to shrink in the years ahead, however, as those unable to achieve a decent margin exit the business.

OLED has already nabbed 5 percent of the backlight market for mobile phones.

Although the move to LED systems gives a boost to total segment revenues, tempering forces are at work as well. Light sources—LED as well as other technologies—are becoming more and more bright, which means that fewer lights per car are needed. And LED lights have a longer life than conventional lights—in some cases even longer than the life of the vehicle itself. So as LEDs gain favor for use in automotive lighting, the market for replacement lights will slowly erode.

Amid these shifts, the automotive-lighting market is expected to grow by about 3 percent compounded annually from the end of 2014 through 2020 to reach \$25 billion, thanks in part to underlying demand for cars (a demand that is particularly robust in

emerging markets). Beyond 2020, however, the outlook is less clear. Laser lighting—the next big thing in automotive lighting—is already being used in Audi and BMW headlights. The key selling point: laser lighting is stronger and brighter than all other options. Through 2020, the steep prices for laser lighting are likely to limit uptake, but the technology could become more price competitive down the road.

Revenues Will Decline in the Backlight Market

The \$3.8 billion backlight market—which is already largely dominated by LED—will decline in the years ahead as LED prices plummet. That price decline will erode total revenues, cutting the average backlight revenue per screen by about 70 to 90 percent by 2020. In addition, as LEDs increase in brightness, fewer are needed per screen. Even considering the increase in the number of screens being manufactured every year and the shift toward larger screens, backlight volumes will drop overall. We expect total revenues for the backlight segment to slip to about \$2.6 billion in 2020.

Amid declining revenues, backlight companies must also navigate the transition to a new technology: organic light-emitting diode (OLED). OLED is a light source in which a thin film of organic material emits light when an electric current is sent through it. The technology has already nabbed about 5 percent of the backlight market for mobile phones and is increasingly being used in large-screen televisions. However, OLED is unlikely to see widespread adoption in other areas because of limitations including the technology's higher energy consumption when used continuously.

Expect Healthy Returns Despite Change

A look at all six segments together reveals a lighting market that will produce relatively stable financial results through 2020. Profit, as measured by earnings before interest and taxes, will grow about 3 to 4 percent per year. The increase will be driven by top-line growth (most notably in LED luminaires) as

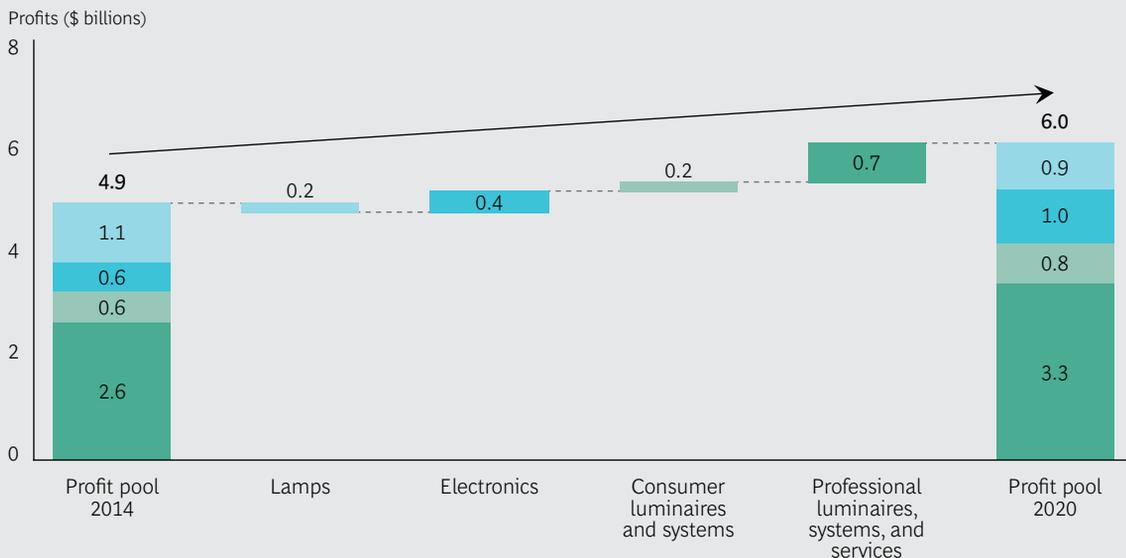
margins hold steady in most categories. The major exception: lamps, where the shift to lower-margin LED lamps will be a drag on profitability in the near term.¹

NOTE

1. Within any segment, margins can differ significantly by company (depending on such factors as a company's business model, brand, and access to distribution channels).

Return on invested capital (ROIC)—which reflects the asset level required to produce profits—is healthy across all segments of the industry, even within the low-margin LED-lamp segment. (See Exhibit 10.) In lamps and electronics, for example, ROIC is approximately 15 to 40 percent; for luminaires, systems, and services, it is about 15 to 20 percent.

EXHIBIT 10 | Margin Improvement Will Increase Lighting Profits



PROFIT MARGIN 2014 (%)	~6.7	~6.6	~3.2	~6.1	~5.6
PROFIT MARGIN 2020 (%)	~6.3	~5.9	~3.5	~6.4	~5.7
RETURN ON INVESTED CAPITAL 2020 (%)	~37	~33	~15	~19	~23

Sources: BCG 2020 Lighting-Market Model; expert interviews.

HOW TO WIN IN THE FUTURE

THE CHANGES SWEEPING THE lighting industry have fundamentally altered competitive dynamics. The overall lighting market is now much more fragmented than in the past despite consolidation in certain segments. In the expanding LED-lamp segment, for example, the number of competitors is quite large relative to the number in conventional lamps. At the same time, luminaires, systems, and services—all of which are highly fragmented segments—account for an increasing share of the total lighting market. Furthermore, various players are moving to adjacent parts of the value chain, thus upping the number of competitors in those segments.

The chance to shape the future lighting market is a major opportunity.

Consequently, success will require new strategies. Local and customer-specific expertise, for example, will become more critical. And lighting players must change their mind-set, from one that focuses on selling products to one that centers on delivering integrated lighting solutions.

With these new dynamics in mind, companies competing in our six segments must de-

velop new strategies. For some, this will be a matter of zeroing in on one segment. For others—companies that compete across the value chain—it will mean addressing the unique opportunities and challenges conferred by their broad reach. (See the sidebar “Competing Across the Value Chain.”)

But whether a company is competing in one or multiple segments, it must look for ways to influence the market’s development over time. In a rapidly changing industry, the chance to shape the future market is a major opportunity.

In General Lighting, Adopt New Strategies

Within general lighting, winning strategies will need to be tailored to match the customer base. In some areas, that will require innovative R&D; in others, it will call for a close understanding of consumers and a new approach to sales and marketing. Across all segments, a relentless focus on cost containment will be necessary.

The Lamp Market: Compete on Cost or Differentiation. Dynamics within the consumer and professional lamp market will differ substantially.

Within the consumer category, the LED lamp market will become segmented, with premi-

COMPETING ACROSS THE VALUE CHAIN

Some leading companies—a group we dub “universal lighting players”—compete in all segments of the general-lighting market. For these companies, success will hinge on successfully managing the decline in one segment of their business while leveraging their strengths to gain ground in other parts of the value chain.

In lamps, universal players must use the cash flow generated by their conventional-lamp business—the “golden tail”—to fund investments and expansion in the LED business. To maximize the cash flow from the conventional operation, they will need to manage their manufacturing footprint in a smart way, shutting down high-cost facilities over time, for example, while focusing on the remaining strong

pockets of demand in that market, including in developing economies.

At the same time, these companies can harness their enviable expertise and connections. They should use their strong existing relationships with wholesalers, for example, to maximize shelf space for their conventional products. In addition, their strength in the professional market puts them in a good position to shape the standards for smart-system controls and software as well as to partner with specialized providers to offer systems and services aimed at specific customer segments.

um brands at one end of the market and private labels at the other. In both price segments, the key to success will be winning shelf space by ensuring that retailers earn a healthy margin. But the way in which lamp manufacturers deliver that retailer margin will differ on the basis of their price level.

Premium-lamp manufacturers in the consumer category can offer a range of differentiated products with strong brands. These products will carry a relatively high retail price, giving the retailer room to earn a decent margin. Innovative R&D will be central to building out that broad, differentiated portfolio—and will protect against commoditization of the product line. At the same time, premium players must build a reliable supply chain to ensure that retail shelves are always fully stocked with their products.

Private-label-lamp manufacturers can offer that margin by keeping their costs—and therefore the price they charge to retailers—as low as possible. They need to put an emphasis on a few products that will sell quickly rather than a comprehensive portfolio of products. And they need to hone an R&D process that can quickly copy popular new offerings in the market.

In the professional segment, LED-lamp manufacturers need strategies that offer buyers a compelling offering in terms of the total cost of ownership of LED lights. Success will stem in part from continued R&D investments to drive down manufacturing costs (thus allowing lamp manufacturers to cut prices) and to improve the efficiency and longevity of the lamp. Lamp players in the professional segment must also train the wholesalers that market their products to deliver the message about the lower TCO afforded by LED.

Electronics Market: Rapid Innovation and Customer Insight Drive Success. The rapidly expanding electronics market in lighting is attractive, but its technology requirements pose a significant barrier to entry.

For those with the technical know-how to compete in the high-end, largely professional segment, developing a broad portfolio is crucial. That’s because of the large number of luminaire types in the professional market, which creates the need for a variety of drivers and modules. At the same time, customers are demanding continuous quality improvements in electronics. Electronics makers that can manage a large, complex portfolio and rapid R&D innovation will win.

At the low end, there is little room for differentiation. As a result, the key to success will be keeping costs low. Electronics players in this end of the market should focus on building a narrow product portfolio of fast-selling items.

Professional Market: Managing Customer Relationships Will Be Critical. Tapping the emerging opportunities in the professional segment (luminaires, systems, and services) will require new strategies.

One is a sales strategy. Lighting players must understand the three types of sales approaches common in this market. These approaches are defined by the level of interaction the end user seeks with the lighting player:

- *The Wholesale Approach.* This approach is appropriate for transactions that are not large enough to warrant a formal tender process and that involve products or systems that professional customers purchase directly from wholesalers. To make this approach effective, the lighting company must train wholesalers' staff to sell the lighting company's products—that wholesaler team acts as an extended sales force for the lighting company. Lighting companies must also invest in marketing to build strong brands that will help boost sales and increase shelf space.
- *The Respond Approach.* This approach is best when the customer spells out lighting requirements in a well-defined tender process. In these cases, lighting companies can indirectly influence those requirements, the key being to ensure that the customer setting the specifications understands new offerings and systems. Lighting players need to also keep strict control of their costs so that they are able to offer competitive prices.
- *The Shape Approach.* In this approach, the lighting player is directly involved in shaping specifications with the end-user and driving the sale. This involves a direct sale by the lighting company to the end user.

In the coming years, this third approach will become more important in the professional

lighting segment as sophisticated lighting systems and options, whose benefits are not always obvious to customers, become more prevalent. Educating and managing stakeholders including customers, contractors, architects, installers, and distributors will be increasingly important. Strong customer relationship management and a more direct sales effort can help providers make those benefits clear while also addressing customer concerns about the risks of shifting to new technologies.

Tapping opportunities in the professional market requires a new sales strategy.

The shift toward the shape approach creates challenges, however. In particular, professional players need to strike a delicate balance between building direct relationships with end users while also preserving their relationships with distributors.

At the same time, the increasing sophistication of lighting solutions will allow lighting players to develop specialized offerings for particular customer segments—thus requiring companies in the professional systems and services markets to gain a deep understanding of those customer segments. (See the sidebar “Know Your Customer.”)

The scale that providers must build in any customer segment, however, will vary. Significant scale will be critical in the sports segment, for example, where the number of projects within one region will be limited and where systems are relatively complex and quite similar across markets. But providers targeting small retail chains will find that an effective local sales network—not large national or global scale—is the key to success.

Regardless of the sales approach, the increasing complexity of lighting in the professional sector will also require the development of new capabilities. Local sales support, for example, will become increasingly important. Lighting providers in some cases will arrange deals

KNOW YOUR CUSTOMER

No doubt the shift toward LED and the growing attractiveness of connected lighting systems are evident across most professional customer segments. But the speed of that transition—and therefore the size of the near-term opportunity—is often quite different across customer segments:

- *Office, Health Care, and Industrial.* The move to LED and smart systems will be rapid in these segments because LED's lower total cost of ownership will be popular for both newly built space and renovated locations. Nonsmart systems such as sensors allow for energy savings by switching off or dimming lights when rooms are not occupied or when there is a lot of daylight. And smart systems will gain in popularity not only because of the energy savings they offer but also because of additional capabilities including occupancy monitoring and automatic notification regarding lighting problems.
- *Retail and Hospitality.* These segments will likely be a bit slower than other groups to adopt LED. Retail and hospitality players seem hesitant to make radical changes to their lighting setup, such as switching to LED, because lighting is critical to the customer experience. As a result, retail and hospitality players are less focused on the TCO associated with lighting than they are on the atmosphere that

lighting creates. However, when a critical mass of players in these categories becomes comfortable that LED does not compromise the overall customer experience, the switch to LED is likely to be swift, in part because of the relatively short renovation cycles in retail (six to eight years). The embrace of smart systems in both segments may be a bit quicker than LED adoption in general given that these systems combine both improved functionality and reduced energy costs in an industry plagued by low margins.

- *Road and Street and Sports.* These segments are expected to show a strong shift to LED and smart systems—although at a slower pace than with some other customer groups owing to long renovation cycles. LED lighting offers major financial advantages courtesy of both reduced energy usage and lower maintenance costs. Smart systems will also be embraced because of the cost savings and nonfinancial benefits (including increased safety due to better light controllability) that they offer.
- *Architectural.* This niche segment, which includes the illumination of large structures such as buildings and bridges, will make a strong shift toward LED and smart systems given the high importance of light functionality.

whereby installers or wholesalers provide that sales support to lighting customers. In addition, partnerships between systems and services players and luminaire makers will become more common. Those arrangements will give luminaire makers the chance to create integrated solutions for their customers and provide companies from outside the lighting systems and services industry with an opportunity to build a solid position in lighting.

Consumer Market: Different Strategies Are Required for the High and Low Ends of the

Market. The consumer luminaire market is fragmented; many players boast broad portfolios aimed at addressing different consumer preferences across regions and applications. The key to success here is matching the right strategy to each particular segment of the market that a company seeks to serve.

In both the value segment (where customers focus heavily on price) and the mass-market functional segment (where customers focus more on function than aesthetics), companies

must develop standardized designs to minimize complexity and costs. Meanwhile, in both the premium segment (where prices are higher) and the mass-market decorative segment (where customers put more emphasis on visual style and appeal than on function), players can create some level of differentiation through unique designs with winning aesthetics, through superior technical specifications, and through strong branding.

Dynamics in the emerging home-systems market, meanwhile, are more difficult to predict, in part because of the variety of players competing in that space. Lighting players, for example, typically offer connected lamps and luminaires as well as lighting controls and software. Meanwhile, others—known as smart-home players—take a broader view, offering controls and software to manage lighting as well as other appliances for heating, security, and entertainment. Which will grab the biggest share—and in turn have the most influence on the setting of standards in home systems—remains to be seen. For lighting players, success will hinge on offering compelling pricing and functionality and ensuring compatibility with smart-home controls and software.

In Automotive Lighting, Innovate Rapidly

As lighting becomes a more distinguishing, brand-oriented feature in automobiles, players in this segment will need to offer innovative, advanced, high-quality lighting products.

But cutting-edge technology will not be enough. Amid intense competition, the winners in this segment will be those that foster strong partnerships with automakers as well as with their tier-one component suppliers. Certainly, the level of collaboration between vehicle and lighting manufacturers has always been strong. And as dynamic lighting systems gain ground and lighting increasingly becomes a “signature” feature, this collaboration will only become more important.

In addition, the long automotive-design cycles—about seven years on average—make establishing long-term relationships even more imperative. A lighting company operating in this sector needs to position itself as a

strategic supplier in order to be among the handful of players even invited into the contract-bidding process.

Furthermore, automotive-lighting companies must offer robust warranty and after-service capabilities. That’s because vehicle owners may be dissatisfied—or worse—when they are hit with a higher-than-expected bill to replace lamps in complex auto-lighting systems. If managed correctly, these services can be a solid source of profits for lighting suppliers.

In the Backlight Market, Shift to OLED

The key challenge for players in the backlight segment will be to manage the transition to OLED. In this environment, scale will become increasingly valuable. Scale will allow backlight companies to fund the large R&D investments required to improve the functionality of OLED (especially enhancing its brightness) and to cut manufacturing costs. Those lower manufacturing costs, in turn, will create room to lower OLED prices—a crucial source of competitive advantage because the customer base in the backlight segment is relatively small and competition is intense.

TECHNOLOGY is transforming lighting more rapidly than at any time since the invention of the incandescent bulb. As LED technology changes the basic economics in lighting and as connected lighting systems create new opportunities, lighting players across the value chain must rewrite their playbooks.

Long-established companies face a challenge in maximizing returns from their existing conventional business while making the leap to develop products based on newer technology. Reliable profits from that existing business can provide a critical funding source for investing in these newer LED products and services. And established players and new entrants alike must make sure that they understand customer demands and build operations that reflect an understanding of rapidly changing sources of advantage.

APPENDIX

APPROACH AND METHODOLOGY

This report is based on BCG's 2020 Lighting-Market Model, which has been developed to forecast the future of the worldwide lighting market. The model covers eight key technologies, nine major application segments across all parts of the value chain, and six regions. (See the exhibit "Streamlined Market-Model Structure.")

Sizing of the market has been conducted from the bottom up on the basis of existing market reports, investor reports, BCG expertise, and close to 100 interviews with external experts. We have modeled market growth projections taking into consideration likely future volume growth, technology mix, and price. The logic is consistent throughout the model, for all technologies, application segments, and geographies.

The model includes the new, renovation, and replacement markets for lamps. In the new and renovation markets, both the lamp and luminaire are sold, whereas in the replacement market, only the lamp is being replaced. The value of components is included in the value of the lamp:

- The new-lamp market covers light sources that are added to the installed base because of increased demand for light points, as new buildings are constructed or as access to electricity increases (mainly in developing countries).

- The renovation-lamp market covers the installed area that is being renovated; during renovation cycles, both lamp and luminaire are replaced.
- The replacement-lamp market covers the replacement of lamps in existing sockets.

The automotive-lighting market consists of lamps and luminaires in five lighting categories: front lights, rear lights, daytime running lamps and fog lights, side lights, and inside lights.

The backlight market covers four key applications: smartphones, TVs, tablets, and computers and peripherals.

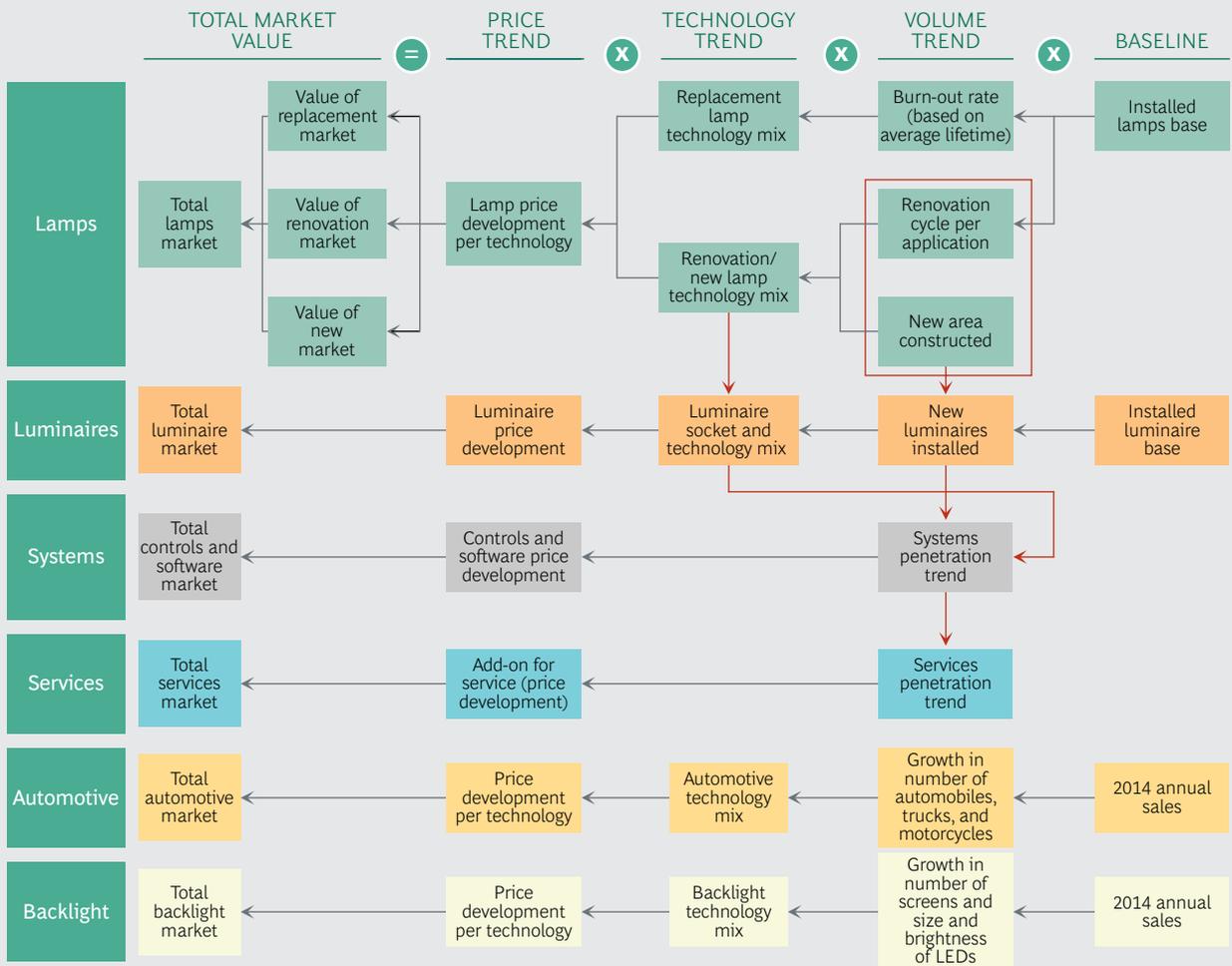
Specialty lighting is excluded.

The market value is based on average manufacturer's sales price, does not include inflation, and assumes constant 2014 exchange rates (EUR1 to USD1.3269) for the projections through 2020. Product value is allocated to the region in which the product is ultimately sold.

Application Segments

The general-lighting market has been categorized into nine key application segments in order to incorporate the different drivers of each application into the market model.

Streamlined Market-Model Structure



Source: BCG 2020 Lighting-Market Model.

The report covers one consumer application segment (residential) and eight professional application segments, as follows:

- **Residential.** The consumer application includes all lighting used at home, such as permanently installed fixtures and portable corded fixtures.
- **Road and Street.** This professional application includes road and street lighting (such as highways and tunnels) and other outdoor areas such as parking lots (public and private).
- **Sports.** This professional application covers lighting of areas such as sports stadiums and playing fields that require high-intensity lamps to cover large areas from a distance.
- **Architectural.** This professional application consists of the illumination of large buildings and other large construction projects such as bridges.
- **Office.** This professional application includes lighting for office buildings and educational buildings as well as other public and commercial buildings that are used for similar purposes.
- **Industrial.** This professional application consists of general lighting used in industrial environments, such as production, assembly, and storage spaces in factories and workplaces.
- **Retail.** This professional application covers general shop-floor area lighting, display lighting, and decorative lighting.

- *Hospitality.* This professional application includes general lighting for hotels, bars, and restaurants.
- *Health Care.* This professional application comprises lighting for health care institutions but does not include specific lighting components for medical equipment.
- *North America:* the U.S. and Canada
- *Latin America:* Central America (including Mexico) and South America
- *China, Taiwan, and Hong Kong*
- *Japan*

Geographies

On a geographical level, we distinguish six regions for which we have modeled separate regional markets:

- *Europe:* DACH (Germany, Austria, Switzerland), CEE (Central and Eastern Europe), France, the UK and Ireland, the Benelux countries, the Nordic countries, Italy, Israel, Greece, and Iberia
- *Rest of the World:* RCA (Russia and Central Asia), the Indian subcontinent, the ASEAN countries, Australia, New Zealand, the Middle East, Turkey, and Africa

NOTE TO THE READER

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If you would like to discuss this report and our lighting-industry model in greater detail, please contact one of the authors.

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