Lighting, LEDs and Smart Lighting Market Overview

Philip Smallwood
Research Director
Strategies Unlimited
Who is PennWell?

Market Research
World leader in LED, laser and photonics market research and custom Research

- North America – Nearly 5,000 registrants
- Europe – Nearly 1,000 registrants
- Las Vegas—2,300+ attendees, 90 exhibitors

- Global circulation 63,800
- 9 issues annually including the Suppliers Directory

- Page views: 349,667
- Visits: 133,580
- Unique: 82,787
Reports from Strategies Unlimited

http://www.strategies-u.com/leds-lighting.html
PACKAGED LED, COB, CSP AND MODULES MARKETS
Lighting Revenues

Revenues ($M)

$0 $5,000 $10,000 $15,000 $20,000 $25,000


12% CAGR

$9,109

$5,263

$9,109

Others
Lighting
Automotive
Signs
Mobile
Display

12% CAGR
Revenues for LEDs in Lighting – by Application

12% CAGR

<table>
<thead>
<tr>
<th>Year</th>
<th>Replacement Lamps</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Outdoor</th>
<th>Residential</th>
<th>Architectural</th>
<th>Consumer Portable</th>
<th>Entertainment</th>
<th>Off-grid</th>
<th>Retail Display</th>
<th>Safety and Security</th>
<th>Strips and Strings</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>$5,263</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>$9,109</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2013 to 2019, 12% CAGR
COB Revenue Forecast in Lighting

15% CAGR

Graph showing revenues increasing from 2014 to 2020 with a 15% CAGR.

Pie chart showing revenue shares for 2014:
- Downlights, 17%
- Street Lights, 11%
- MR-16/Reflectors, 11%
- Other Replacement Lamps, 28%
- Others, 33%
Module and Light Engine Definition

LED Module
- A number of packaged LEDs mounted onto a printed circuit board (PCB) that has NO driver electronics.
- The module can have any level of integration including optics, thermal management, housing enclosures, etc., as long as it does not have the driver electronics on board.

LED Light Engine
- An LED module with the added driver electronics, whether on board, integrated, or separate, as long as it’s sold as a complete unit.
- AC light engines will also be included under this definition. An AC light engine connects directly to the AC mains while delivering photometric and electrical performance similar to that of DC-driven designs.
Total Market by Product Type

Figure 2: Total Market for LED Modules & Light Engines
By Product Type

World

Revenues ($M)


Modules
Light Engines

Revenues (SM)

$0 $1,000 $2,000 $3,000 $4,000 $5,000 $6,000 $7,000


Modules
Light Engines
Total Module and LE by End Application

![Graph showing total module and LE by end application for various categories over the years 2014 to 2020.](image)

**Figure 5 Total Market for LED Modules & Light Engines By Luminaire Form Factor**

- **World**
- **Revenues ($M)**
  - Troffers
  - Downlights
  - Roadway Fixtures
  - Outdoor Area Lights
  - Other Luminaires
  - $3,000
  - $0

**Figure 6 Total Market for LED Modules & Light Engines By Lamp Form Factor**

- **World**
- **Revenues ($M)**
  - Reflectors
  - Tubes
  - Other Lamps
  - $1,000
  - $0
Chip-Scale Package (CSP)

- CSP is done at the wafer level, eliminating the separate step of having manufactured LEDs go through a packaging line (packaging can sometimes be 60% of the total cost).
- The CSP LEDs can have the exact same footprint as the LED die, a wider beam angle, more design flexibility, and it can be overdriven.
- However, CSP LEDs are not as efficient as high-power LEDs and low yields result in much higher prices, currently.
- Many large LED chip and packagers are investing in this technology including Samsung, Lumileds, LG Innotek, Seoul Semiconductor, Epistar and Lextar.
LAMP AND LUMINAIRE MARKETS
# LEDs in Lamps and Luminaires

<table>
<thead>
<tr>
<th>Replacement Lamps</th>
<th>Commercial &amp; Industrial Luminaires</th>
<th>Outdoor Luminaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-Lamps</td>
<td>Downlights</td>
<td>Street Lights</td>
</tr>
<tr>
<td>MR-16</td>
<td>Troffers</td>
<td>Tunnel Lights</td>
</tr>
<tr>
<td>Reflectors</td>
<td>Suspended Pendants</td>
<td>Parking Garages</td>
</tr>
<tr>
<td>T-Lamps</td>
<td>Track Lights</td>
<td>Parking Lots</td>
</tr>
<tr>
<td>Others</td>
<td>High Bays</td>
<td>Canopies</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>Wall Packs, Soffits, and Floodlights</td>
</tr>
</tbody>
</table>
Global Lamp Installed Base

![Bar chart showing the installed base of various types of lamps from 2014 to 2022. The chart compares LED Replacement, Incandescent, Halogen, Fluorescent, and CFL.]
Global Lamp Revenue by Technology

<table>
<thead>
<tr>
<th>Year</th>
<th>CFL</th>
<th>Fluorescent</th>
<th>Halogen</th>
<th>Incandescent</th>
<th>LED Replacement</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>3465</td>
<td>3434</td>
<td>2724</td>
<td>1241</td>
<td>7025</td>
<td>17889</td>
</tr>
<tr>
<td>2015</td>
<td>3319</td>
<td>3297</td>
<td>2533</td>
<td>992</td>
<td>10157</td>
<td>20298</td>
</tr>
<tr>
<td>2016</td>
<td>2960</td>
<td>3139</td>
<td>2395</td>
<td>801</td>
<td>11237</td>
<td>20532</td>
</tr>
<tr>
<td>2017</td>
<td>2515</td>
<td>2959</td>
<td>2032</td>
<td>661</td>
<td>12632</td>
<td>20799</td>
</tr>
<tr>
<td>2018</td>
<td>2022</td>
<td>2770</td>
<td>1611</td>
<td>521</td>
<td>14272</td>
<td>21195</td>
</tr>
<tr>
<td>2019</td>
<td>1522</td>
<td>2577</td>
<td>1229</td>
<td>408</td>
<td>14980</td>
<td>20716</td>
</tr>
<tr>
<td>2020</td>
<td>1107</td>
<td>2376</td>
<td>965</td>
<td>316</td>
<td>14484</td>
<td>19249</td>
</tr>
<tr>
<td>2021</td>
<td>781</td>
<td>2174</td>
<td>783</td>
<td>244</td>
<td>13605</td>
<td>17588</td>
</tr>
<tr>
<td>2022</td>
<td>566</td>
<td>1975</td>
<td>649</td>
<td>186</td>
<td>12595</td>
<td>15972</td>
</tr>
<tr>
<td>Grand Total</td>
<td>18257</td>
<td>24702</td>
<td>14920</td>
<td>5370</td>
<td>110988</td>
<td>174237</td>
</tr>
</tbody>
</table>

- LED Replacement
- Incandescent
- Halogen
- Fluorescent
- CFL
## LEDs in Lamps and Luminaires

<table>
<thead>
<tr>
<th>Replacement Lamps</th>
<th>Commercial &amp; Industrial Luminaires</th>
<th>Outdoor Luminaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-Lamps</td>
<td>Downlights</td>
<td>Street Lights</td>
</tr>
<tr>
<td>MR-16</td>
<td>Troffers</td>
<td>Tunnel Lights</td>
</tr>
<tr>
<td>Reflectors</td>
<td>Suspended Pendants</td>
<td>Parking Garages</td>
</tr>
<tr>
<td>T-Lamps</td>
<td>Track Lights</td>
<td>Parking Lots</td>
</tr>
<tr>
<td>Others</td>
<td>High Bays</td>
<td>Canopies</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>Wall Packs, Soffits, and Floodlights</td>
</tr>
</tbody>
</table>
Global Luminaire Unit Shipments

- LED Replacement
- LED Integrated
- Incandescent
- HID
- Halogen
- Fluorescent
- CFL

Unit Shipments (M)

Years: 2014 to 2022
Global LED Luminaire Revenue Forecast

2014 LED Revenues = $19,751 M

- Downlights: 21%
- High Bay: 9%
- Others: 38%
- Suspended Pendants: 6%
- Track Lights: 6%
- Troffers: 7%
- Street Lights: 13%
- Others: 38%

2022 LED Revenues = $45,548 M

- Downlights: 17%
- High Bay: 11%
- Others: 29%
- Suspended Pendants: 7%
- Track Lights: 7%
- Troffers: 21%
- Street Lights: 8%
# Connected Lighting

## Connected LED Reflector & A-Lamps

<table>
<thead>
<tr>
<th>Features</th>
<th>Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Tunable White</td>
<td>ZigBee</td>
</tr>
<tr>
<td>Complex Tunable White</td>
<td>Bluetooth</td>
</tr>
<tr>
<td>Simple Dimming</td>
<td>Wi-Fi</td>
</tr>
<tr>
<td>Color Changing</td>
<td>6LoWPAN</td>
</tr>
<tr>
<td>Hybrid</td>
<td>Hybrid</td>
</tr>
</tbody>
</table>

## Connected Outdoor Luminaires

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programmable Scheduling/Switches</td>
<td>Power Line Communication</td>
</tr>
<tr>
<td>Photocells/Photo Sensors</td>
<td>ZigBee</td>
</tr>
<tr>
<td>Occupancy Sensors</td>
<td>6LoWPAN</td>
</tr>
<tr>
<td>Dimmers</td>
<td>Other 802.15.4 based protocols</td>
</tr>
<tr>
<td>Hybrid</td>
<td>Proprietary/Other</td>
</tr>
</tbody>
</table>

## Connected Indoor Controls

<table>
<thead>
<tr>
<th>Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Line Communication</td>
</tr>
<tr>
<td>Bluetooth</td>
</tr>
<tr>
<td>Power Over Ethernet</td>
</tr>
<tr>
<td>EnOcean</td>
</tr>
<tr>
<td>DALI</td>
</tr>
<tr>
<td>Wi-Fi</td>
</tr>
<tr>
<td>ZigBee</td>
</tr>
<tr>
<td>Proprietary/Other</td>
</tr>
<tr>
<td>6LoWPAN</td>
</tr>
<tr>
<td>Hybrid</td>
</tr>
</tbody>
</table>

---

*Note: The above table is a simplified representation of the connected lighting protocols and features.*
CONNECTED REFLECTOR AND A-LAMPS
Global Installed Base by Lamp Shape

- Total Installed Base = 44 billion lamps
- Reflector and A-lamps comprise 55% of this (24 billion)
Definitions

- **Simple Dimming Connected Lamp** – LED lamps that are wirelessly controlled to dim, with no control over the color temperature or CRI of the light emitted by the lamp.

- **Basic Tunable White Connected Lamp** – LED lamps that are wirelessly controlled to dim using a linear tuning mechanism. Linear tuning products cannot track the blackbody curve (i.e., they cannot maintain a constant Duv as CCT is adjusted).

- **Complex Tunable White Connected Lamp** – LED lamps that are wirelessly controlled to dim by using a non-linear mechanism, that are effective at following the blackbody curve. Some products can be adjusted over a range of CCTs and can be dimmed at a constant CCT.

- **Color Tunable Lamp** – Wirelessly controlled LED lamps that can be adjusted to create white or colored light.
Connected LED A and Reflector Lamps
Installed Units Forecast

2014 Total A and Reflector Installed Base = 23.8 Billion Units
- Non-Connected LED: 3%
- Connected LED: 0.002%
- Other: 97%

2020 Total A and Reflector Installed Base = 25.0 Billion Units
- Non-Connected LED: 56.88%
- Connected LED <0.4%
- Other: 42.21%
Connected LED A and Reflector Lamp

Unit Shipments & Revenues

- Basic Tunable White
- Color Changing
- Complex Tunable White
- Simple Dimming
CONNECTED OUTDOOR MARKET
Connected Outdoor Luminaire Unit Shipments

2014 Connected Outdoor Luminaire Shipments = 1.66 Million Units

2022 Connected Outdoor Luminaire Shipments = 30.0 Million Units

<table>
<thead>
<tr>
<th>Year</th>
<th>LED (%)</th>
<th>Non-LED (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>2022</td>
<td>73%</td>
<td>27%</td>
</tr>
</tbody>
</table>
Total Connected Outdoor Luminaire Shipments

- Rest Of the World
- Western Europe
- North America
- Eastern Europe
Connected LED Outdoor Luminaire Unit Shipments

2014 Connected LED Outdoor Luminaire Shipments = 0.74 Million Units

- Zigbee 12%
- Power line Communication 52%
- Proprietary/Other 30%
- Other 802.15.4 based protocol 1%
- 6LoWPAN 5%

2022 Connected LED Outdoor Luminaire Shipments = 21.75 Million Units

- Zigbee 41%
- Power line Communication 13%
- Proprietary/Other 35%
- Other 802.15.4 based protocol 1%
- 6LoWPAN 10%
CONNECTED INDOOR MARKET
Connected Indoor Square Feet Installations

- **2014 Square ft. using connected controls = 1,256 Million Sq. Ft.**
  - LED: 56%
  - Non-LED: 44%

- **2022 Square Ft. using connected controls = 16,464 Million Sq. Ft.**
  - LED: 82%
  - Non-LED: 18%
Overview of Connected Indoor Lighting Market

Total Revenue Forecast

- Rest of the World
- Western Europe
- North America
2014 Connected Indoor Lighting Market

- DALI: 43%
- EnOcean: 2%
- Hybrid: 18%
- Power over Ethernet: 2%
- Power Line: 3%
- Proprietary: 19%
- ZigBee: 6%
- Bluetooth: 3%
- Wi-Fi: 4%
Connected LED Indoor Controls

- DALI: 39%
- Hybrid: 18%
- Power Line: 4%
- Power over Ethernet: 4%
- Proprietary: 19%
- Wi-Fi: 5%
- ZigBee: 6%
- Bluetooth: 3%
- EnOcean: 2%
Thank You!

Philip Smallwood
Research Director
Strategies Unlimited
Philips@pennwell.com