

The Worldwide Market for LEDs

Market Review and Forecast 2020

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Chapter 1: Executive Summary

- Conversion to USD from original currencies caused around 4%–7% on company original revenues, given the relative stable US Dollar in 2019. Euro, RMB, KRW, and TWD were depreciated against USD.

Figure 1.9 Revenue Growth Rate; US\$ vs. Original Currency, 2019-2019

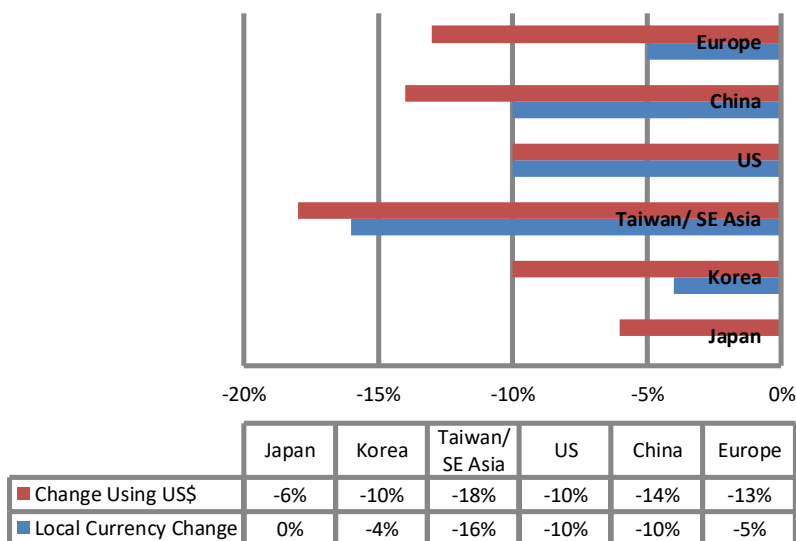


Table 1.1 Ranking of Worldwide LED Companies by LED Revenue

Rank	Company	Location	Revenues	% Share
1	Nichia	Japan	\$2,132	13%
2	Osram Opto	Germany	\$1,411	9%
3	Lumileds	USA	\$1,202	8%
4	Seoul Semiconductor	South Korea	\$867	5%
5	Mulinsen (MLS)	China	\$860	5%
6	Samsung	South Korea	\$749	5%
7	LG Innotek	South Korea	\$572	4%
8	Cree	USA	\$502	3%
9	Everlight	Taiwan	\$441	3%
10	Nationstar	China	\$353	2%

- Nichia leads the industry with US \$2.1 billion in sales.
- Osram Opto stayed at the number two position from 2015 through 2019.
- Lumileds retained its third position from 2016 through 2019.
- Mulinsen (MLS) from China, who made the top ten in 2014, continues to be in the top at number 5 with US \$860 million in revenue and close to Seoul Semiconductor at number 4.

* On June 30th, 2017, Philips completed the sale of an 80.1% stake in the combined Lumileds and Automotive business to a fund managed by affiliates of Apollo Global Management, LLC.



Chapter 2: Applications – Display Backlighting

Figure 2.1.12 Monitor Revenue Growth by Category, 2019-2024 (US\$M)

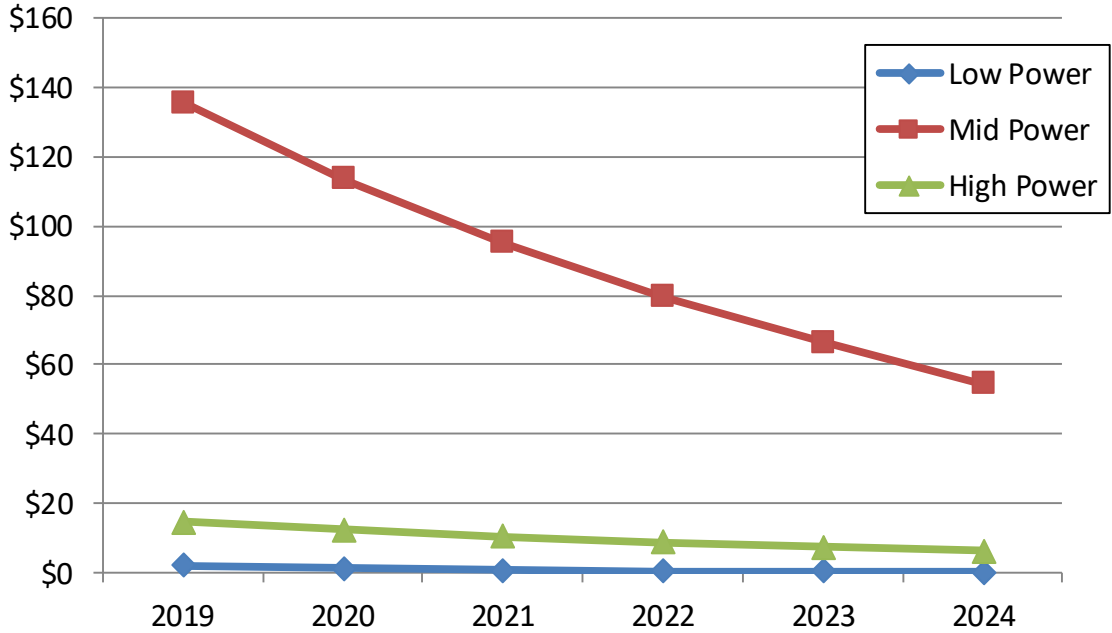


Table 2.1.7 Monitors and AIO PC LED Revenue by Package Type

	2019	2020	2021	2022	2023	2024	5-Year CAGR
Low Power							
Revenues (\$M)	\$2	\$1	\$1	\$0	\$0	\$0	-46.1%
Units (M)	59	34	19	11	6	3	-43.2%
ASP (\$)	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03	\$0.02	-5.0%
Mid Power							
Revenues (\$M)	\$136	\$114	\$95	\$80	\$67	\$55	-16.7%
Units (M)	2,551	2,250	1,983	1,744	1,535	1,324	-12.3%
ASP (\$)	\$0.05	\$0.05	\$0.05	\$0.05	\$0.04	\$0.04	-5.0%
High Power							
Revenues (\$M)	\$15	\$12	\$10	\$9	\$7	\$6	-16.2%
Units (M)	53	47	42	37	32	29	-11.8%
ASP (\$)	\$0.27	\$0.26	\$0.25	\$0.23	\$0.22	\$0.21	-5.0%
Total							
Revenues (\$M)	\$152	\$127	\$106	\$88	\$74	\$61	-16.8%
Units (M)	2,663	2,330	2,044	1,792	1,574	1,356	-12.6%
ASP (\$)	\$0.06	\$0.05	\$0.05	\$0.05	\$0.05	\$0.04	-4.8%



Chapter 2: Applications – Automotive Lighting

DRLs (Daytime Running Lights)

- DRLs are intended to increase the conspicuity of vehicles in motion during the daytime. In the U.S., DRLs may consist of the manual or automatic illumination of the low beams at full or reduced intensity, or the high beams at reduced intensity, or may not involve the headlamps at all.

Standards and Legal Restrictions

- In the European Union, DRLs are now required for all passenger cars, trucks, and buses. Other countries requiring DRLs include Albania, Argentina, Bosnia and Herzegovina, Canada, Colombia, the Czech Republic, Denmark, Estonia, Finland, Hungary, Iceland, Israel, Kosovo, Latvia, Lithuania, Macedonia, Norway, Poland, Republic of Moldova, Romania, Slovenia, Sweden, and Uruguay.
- Penetration of DRLs is still low in Japan since they are not legally allowed in the region. Some high-end Japanese cars and imported European cars have DRLs, but they cannot be used as “DRL” and the light intensity has to be lowered and be used as “clearance lamp”. However, the adoption of Regulation UN-R87 (DRL) is being discussed in the country.
 - In Japan, since motorbikes are mandated to keep their headlights turned on during daytime as well as to prevent traffic accidents, it is of concern that if DRLs are allowed for automobiles as well then the brighter lights of automobiles may take away from the visibility of motorbike’s headlights.



LEDs in DRL

- While the above legislation does not impact the use of LEDs directly, the fact that DRLs are required in Europe means that a larger percentage of cars will use LEDs to accomplish this function.
- DRLs offer a unique opportunity for car manufacturers to establish brand identity. Audi is the first auto company that successfully accomplished such a goal. Conversely, Mercedes will abandon the E-class’s “Zetsche hooks,” as they are derisively called by the competition.
- We have seen two different approaches to implementing DRLs. One is to use a few high power white LEDs on each side. The second is to use a large number of medium white or amber LEDs on each side. Many manufacturers use the first approach; however, like in general lighting, more and more companies are switching to mid power LEDs to reduce cost. We estimate that approximately 7% of all cars with LED DRL lights used mid power LEDs, and that will be close to 15% by 2024.
- In the U.S., DRLs can be either amber or white. If amber is used, it can be combined with the front-turn signal. In Europe, DRLs have to be completely separate from other lamps.
- While the function of the DRL is to be seen and to illuminate, car buyers want the “expensive” LED DRL option they pay for to “look great.” As a result, most LED DRLs are brighter than the legal requirement.



Chapter 2: Applications – Mobile Applications

Figure 2.3.17 Mobile Computing Revenue (US \$M) by Material and Package Type, 2019-2024

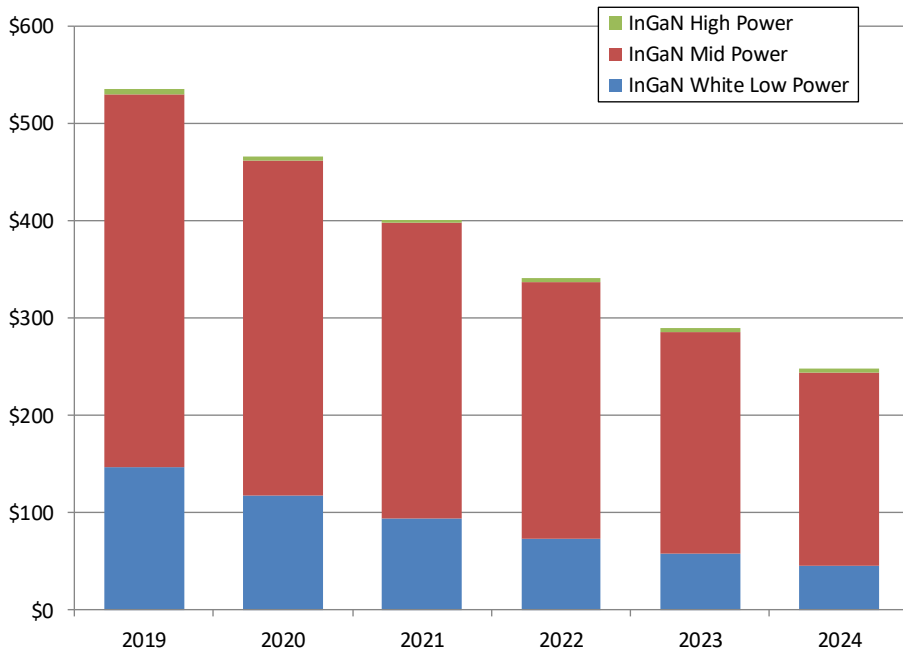
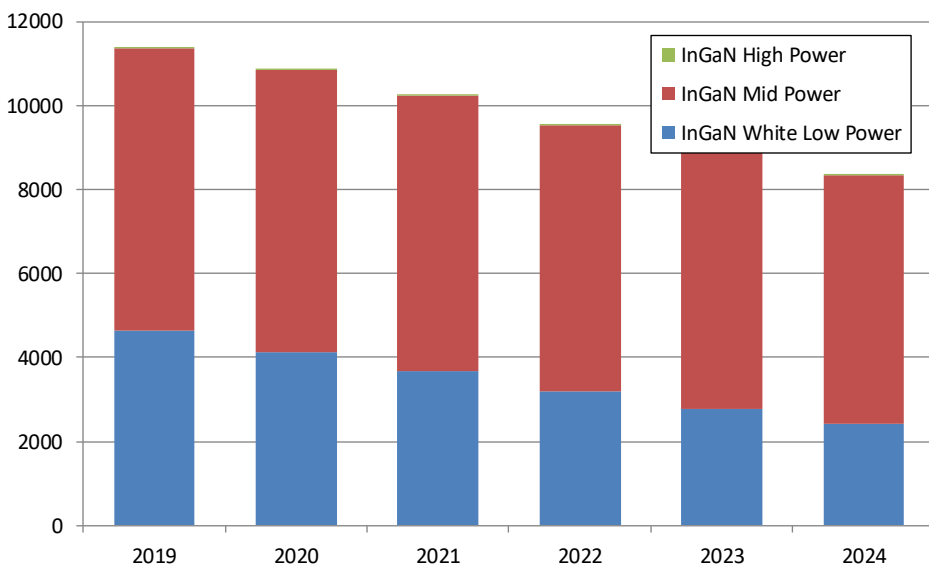


Figure 2.3.18 Mobile Comp. Units (M) by Material and Package Type, 2019-2024





Chapter 2: Applications – Lighting

- In order to further expedite acceptance of LED lighting, a global consortium of manufacturers was formed. Zhaga continues to set standard specifications for physical dimensions, mechanical, thermal, optical interfaces, electrical, and controls between LED modules/light engines and LED luminaires.
- The Department of Energy (DOE) is taking the lead in setting LED standards in the U.S. Although the DOE does not set standards itself, it coordinates standard-setting activities in the interest of expediting the process.
- As of publication, there are 10 Books approved and available that define these standards, and another 5 in development. They range from spot modules, area modules, high-intensity modules, socketable light engines and modules, and - more recently - COB arrays and LED drivers.
- In August 2011, the Illuminating Engineering Society (IES) published the TM-21 document entitled “Lumen degradation lifetime estimation method for LED light sources.” TM-21 is the IES-recommended method for projecting lumen degradation of an LED package, array, or module based on data collected according to LM-80.
- Other regions and countries outside the U.S. are also working toward setting LED standards. Many of them are based on LM-79 and LM-80. CIE in Europe is working on quality of light and biological safety. China is also attempting to set its own standards.
- IEA 4E SSL Annex is an effort to harmonize global standards around the world. The International Energy Agency (IEA) has begun the process. The status of this process is available at: <http://ssl.iea-4e.org>
- The three main tasks of the SSL Annex are to:
 - Develop SSL quality assurance by working to clarify the SSL market worldwide.
 - Harmonize SSL performance testing by working with global testing laboratories.
 - Develop a standards and accreditation infrastructure by working with existing accreditation bodies.





Chapter 2: Lighting – Commercial

Characteristic and Definition

- **Downlight:** Technique to illuminate a space. A lighting fixture that is inserted in the aperture of the ceiling. Size is measured from the internal diameter of the fixture and does not include the trim.
- **Troffers:** Replacements for wraparound and parabolic troffers, which are used with linear fluorescent tubes. Anything that has a tube in it will be classified under troffers unless it is installed where the ceiling height is more than 20', in which case it is classified under high bay. Strategies Unlimited confines their research by only looking at 2x2, 2x4, and other. This category also includes suspended linear office fixtures.
- **High Bay:** High bay lights are typically used when ceiling heights are 20 – 45'. They typically have an aluminum reflector. Other high bay lights have prismatic reflectors that illuminate shelves. Suspended troffers that are installed in ceiling heights of greater than 20' will be classified as high bay fixtures.
- **Street Lights:** Cobra heads and decorative street lights.
- **Suspended Pendants:** A fixture suspended via a rod, chain, or cord that has only one light bulb in it. If the suspended fixture includes multiple light bulbs, it is a chandelier. If the fixture is a suspended linear troffer, it will be classified under the troffers form factor in this report.
- **Track Lights:** Track lights or track heads could be used in isolation or could be mounted on rails. They are used as "spot lights" to highlight merchandise in retail/commercial setting. These are also spotlights on a track.



Market Overview and Background

LED lighting first started to make inroads into the commercial sector due to specific circumstances that created opportunities for it to provide advantages over conventional light sources. Some of these circumstances were (and still are today):

- Difficult-to-access locations with high lamp replacement costs
- Replacement of low-efficiency, short-lifetime (incandescent, especially halogen) sources
- Hazardous environments (mines, chemical plants, refineries)
- Environments with multiple light sources that have high ongoing maintenance costs (e.g., hotels)

In addition to the reasons listed above, LED lighting continues to provide energy savings and, with the introduction of connected lighting, having full control over your lights will provide even more energy savings and cost advantages over conventional lighting.



Chapter 2: Lighting – Residential

Figure 2.5.31 LEDs in Residential by Package Type 2019-2024 (\$M)

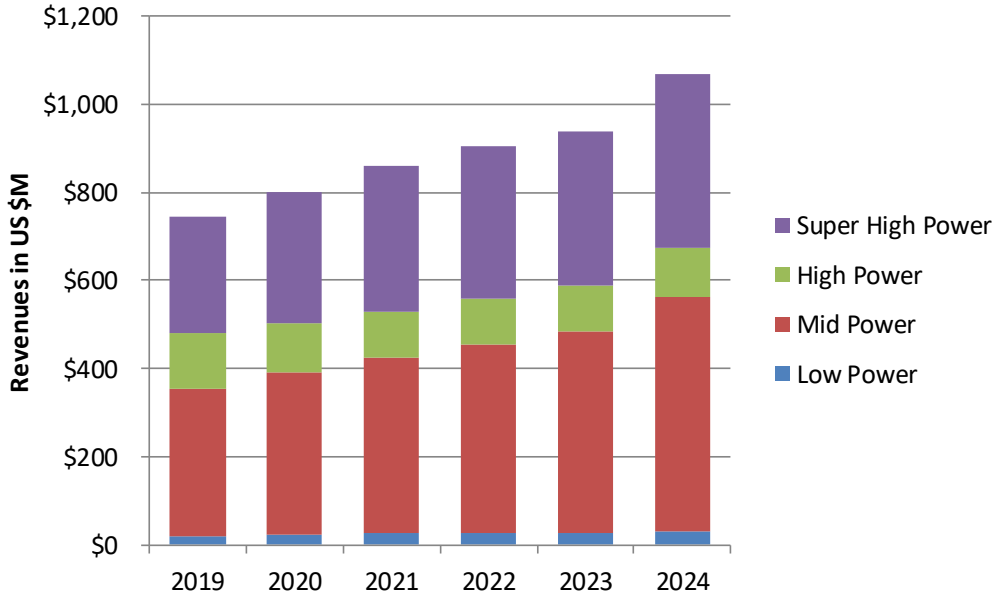


Table 2.5.15 LEDs in Residential by Region 2019-2024 (\$M)

		2019	2020	2021	2022	2023	2024	5-Year CAGR
North America	Revenues (\$M)	\$40	\$41	\$42	\$43	\$44	\$48	4.0%
Europe	Revenues (\$M)	\$79	\$83	\$90	\$92	\$93	\$100	4.9%
China	Revenues (\$M)	\$536	\$575	\$618	\$648	\$674	\$790	8.1%
Rest of World	Revenues (\$M)	\$90	\$100	\$112	\$121	\$128	\$131	7.9%
Total	Revenues (\$M)	\$744	\$800	\$861	\$904	\$939	\$1,070	7.5%