FIXING THE BILLION-DOLLAR HOLE IN THE ROOF
THE END OF INEFFICIENT HIGH-BAY LIGHTING
REVOLUTION IN THE AIR

They number in the millions. They light our indoor gymnasiums, swimming pools and basketball courts, and hang above the merchandise in our big box stores and supermarkets. They illuminate aircraft hangars, truck depots, train stations and subway concourses. And in manufacturing plants, industrial complexes, storage facilities and warehouses across the country, they cast down the light needed by workers to stay productive and safe.

Making the wrong choice in new high-bay lighting can mean paying hundreds of dollars more each year per fixture in added energy costs and maintenance.

They are the high-bay fixtures, so called because they’re found wherever lights are mounted 15 feet or higher above the floor. But while high-bay fixtures may be everywhere, they are not all the same. Making the wrong choice in new high-bay lighting can mean paying hundreds of dollars more each year per fixture in added energy costs and maintenance. Failure to upgrade outdated fixtures or making the wrong retrofit can cost even more. As a result, businesses in the U.S. waste billions of dollars in energy and maintenance costs for obsolete high-bay lighting that delivers sub-optimal lighting in return.

The right choice in high-bay fixtures can cut lighting costs by 65% OR MORE.

Lighting typically accounts for more than a quarter of a commercial building’s electricity use,¹ and that figure can be even higher for intensive-use and 24/7 facilities. The right choice in high-bay fixtures can cut lighting costs by 65% or more while virtually eliminating less obvious bottom-line penalties like maintenance costs, relamping, lighting-associated work stoppages and disposal concerns.

What’s the right choice? LED technology, hands down. The LED high-bay fixture has come into its own. Any excuse for not converting metal halide [MH] fixtures has winked out like a bad bulb, and the fluorescent lighting alternative is little better.
THE TIPPING POINT ARRIVES

The LED lighting revolution was slow to reach the high-bay category. LED high-bay fixtures initially cost several times more than metal halide or fluorescent fixtures, and though these pricey first-gen fixtures were indisputably the winner in terms of total cost of ownership, payback often required three to five years, making them a tough sell. Not today. The last decade has seen phenomenal advances in LED energy efficiency, while prices have dropped. When facilities convert a 400-watt metal halide to a 324-watt fluorescent fixture, they realize an energy savings of about 19%. Converting the same fixture to a new ultra-efficient LED high-bay instead can generate energy savings of 65% or more, with three times the useful life, no disposal worries and vastly greater options for lighting controls, environmental sensors and Internet of Things networking. That’s why the U.S. Department of Energy reports the early adopter status of LED high-bay luminaires will soon surge to an early majority.

The only challenge left is determining which LED high-bay is right for you. First, let’s dispel any lingering notions that the other options might work for you.

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NO PLACE LEFT TO HID: RETIRING THE METAL HALIDE HIGH-BAY

Metal halide fixtures have been the mainstay of high-bay lighting. A type of high-intensity discharge (HID) lighting, a metal halide lamp uses electricity to vaporize a strip of metal inside a sealed, pressurized bulb, giving off light. It’s always been a love-hate relationship. Metal halide lamps produce a bright, white light with fairly good color rendering. That’s the love, and that’s where it ends. To quote the Lighting Controls Association, “service life, light output and efficacy severely degrade over time. As a result of its lumen maintenance and typical fixture efficiencies, this standard MH system appears low-cost but in fact is not very economical relative to the best alternatives.”
Any facility manager using MH high-bay fixtures can list all the ways the relationship goes sour, but may run out of fingers counting them:

**They’re energy hogs.** A typical 400-watt MH high-bay fixture consumes 450 watts of power (more about that below). At the national average commercial price of a kilowatt-hour of electricity (about 11 cents), running that fixture 16 hours a day will cost $289 in electricity every year—even though the fixture’s light output falls off dramatically over the first year (more about that below, too).

**They generate a lot of heat.** The materials inside the bulb may be heated up to 6000°F, with 10-15% of the lamp’s energy lost as heat. That puts extra strain on the HVAC, indirectly adding to the total energy cost of the fixture.

**They waste light.** “Total lumens” isn’t the same as delivered light. A MH lamp is an omnidirectional light source, throwing light in every direction. When that light is redirected with reflectors, photons lose energy with every bounce and some light stays trapped in the fixture, dropping illuminating power by 25% or more.³

**Their effective illumination drops off quickly.** Metal halide lamps lose their lighting efficiency quickly and dramatically. In one test, a 400-watt MH lamp rated to produce 65% of initial lumens at 40% of its useful life in fact produced only 49%. That means a metal halide lamp with a rated life of 15,000 hours burning 16 hours a day would produce less than half its initial lumens only 18 months after you installed it. But it would still cost you as much for electrical power as it did on day one. If you compensate by installing more fixtures than you need, you’ll add to your energy costs and initially over-light your space.

**They use more power than their wattage designation.** Most metal halides use magnetic ballasts that consume another 10-15% of the fixture’s rated wattage, hence the 50-watt penalty on a 400-watt metal halide fixture. Some older ballasts continue to use power even if the lamp has failed, or there’s no lamp in the fixture at all, and burned-out or failing lamps can cause ballasts to overheat and fail prematurely.⁴ The worst offenders were banned by the U.S. Department of Energy as of February 2017, taking many metal halide fixtures off the market (but not the millions that are still in use). The newer ballasts are more expensive and less durable than their predecessors, further hastening the category’s decline.

**They contain heavy metals requiring regulated disposal.** Used lamps must be disposed of according to strict regulations for handling mercury, lead and other heavy metals. Federal guidelines always apply, while some state guidelines are stricter.

**The arc tubes can rupture.** MH lamps should be relamped at or before the end of their rated lives. Operating them until they fail increases the likelihood of the arc tube rupturing, causing the pressurized bulb to explode, known as “catastrophic failure” and potentially exposing users to ultraviolet (UV) radiation.⁷ [Not likely a problem, since you’ll need to relamp long before then.]

**They’re dirt magnets.** The heat and electrostatic charge of metal halide lamps attract dirt and bake it, further dimming the lamp and reflector and making cleaning difficult.

**They’re prone to color shift.** Many MH fixtures have a low CRI in the 60s and color may vary from fixture to fixture, especially over time.
They’re high maintenance... Cleaning, relamping and reballasting is expensive and time-consuming. You may need special lift equipment to reach the lamps and you’ll pay $60 to $98 an hour per commercial electrician. You’ll also need an inventory of replacement lamps and ballasts, especially if you’re trying to maintain adequate light levels as lumen output rapidly declines.

... which means they kill productivity. The biggest problem is that you can’t simply flip a switch to turn MH fixtures off and on. If a MH lamp is turned off, or power is interrupted even briefly, it requires up to a 15-minute cooling-off period to restart, and can take another 15 minutes to reach 90% of its full light output. In industrial and manufacturing facilities, that irretrievable downtime means lost production and idled workers. In consumer-facing environments, it means inconvenienced customers and lost sales. And in the case of Super Bowl 2013 in New Orleans, it meant a long delay of game after a second-half power outage at the Mercedes Benz Superdome. Those stadium lights have since been replaced with LEDs.

Lighting controls are impractical. There are schemes for dimming metal halide lamps, but they come at a high cost: more expensive ballasts or transformers, degraded lighting efficiency, color shift, loss of lighting stability and lamp life shortened by up to 90%. And occupancy sensors clearly won’t be much use for a lamp that takes 15 minutes to turn back on.

They can sound like a nest of angry hornets. In case that’s not enough to convince you, metal halide ballasts often emit a loud, annoying buzz as they age.

T5 FLUORESCENT HIGH-BAY FIXTURES: THE T STANDS FOR TRADE-OFF

Given the headaches of MH high-bay fixtures, it’s no wonder that fluorescent high-bay fixtures became a popular alternative. There are a wide variety out there, from T12 fixtures (the T officially stands for “tube”) now considered dinosaurs, to more recent and energy-efficient T8 and T5 fixtures. We’ll use the best case to compare. If you replace a 400W metal halide high-bay with a 6-tube T5 54-watt high-output (HO) fixture, your energy consumption drops about 19%, from 450 watts to 365 watts. What’s more, T5 fixtures and replacement tubes are generally inexpensive.

T5 HO lamps provide good color rendering and much better lifetime lumen maintenance than metal halide lamps: at the end of its rated life, a T5 HO fluorescent tube may still produce 90% of its initial lumen levels.
Now for the trade-offs:

They still use a lot of energy. At the average price of 11 cents per kilowatt-hour, running that 6-tube high-output fixture 16 hours a day will still cost $234 a year.

They waste a lot of light. Like a MH lamp, a fluorescent tube is an omnidirectional light source, meaning light is trapped in the fixture and must be redirected with reflectors. Optical control is possible, but not precise, and only at a high cost in lost lumens that never reach the environment you’re trying to light.

They’re fickle about operating temperature. This is a big one: most fluorescent lamps (T12, T8) are designed to provide their maximum light output at an ambient temperature of about 77°F, and T5 HO lamps provide maximum light at about 95°F. These lamps quickly lose efficiency in cooler and hotter environments, which is most any unconditioned or partially conditioned space. Lamp manufacturers assert that an enclosed luminaire will keep the lamps warm and near peak efficiency, but that means even more optical barriers between the light source and the space you want to light, and in hot environments, an enclosed luminaire only adds to the lumen-robbing heat. “Extreme temperature” T5 HO lamps work well in hot spaces, but their efficiency nose dives when temperatures drop below 65°F, losing more than 35% of their lumens at 50°F—a typical chilly day at the truck depot.

They require regulated disposal. Like metal halide lamps, used fluorescent tubes contain mercury and must be disposed of according to strict regulations. Tubes break easily if mishandled, compounding disposal problems with site cleanup—especially problematic when fixtures are suspended above food, food processing equipment, sophisticated machinery or retail merchandise.

They’re dirt magnets. Even in a clean environment, dirt buildup can reduce light output by 10% in 18 months, and that loss can be much higher in dirty environments. Properly cleaning fixtures, especially reflectors, is a time-consuming, labor-intensive chore.

Bottom line—fluorescent fixtures offer modest improvements over MH in lighting efficacy and lamp life. But the world can do better, and already is.

Lighting controls may shorten lamp life. While special dimming ballasts (at a special price) are available to dim T5 HO lamps without affecting lamp life, the same can’t be said for occupancy sensors. Fluorescent lamps perform best when never shut off, and continuous on-off-on cycles can drastically reduce a lamp’s useful life. In one study, T8 lamps set to cycle off after 10 minutes of “no occupancy” lasted less than 4,000 hours.

Cleaning, relamping and re-ballasting means expense and downtime. It’s the metal halide story all over again—special lift equipment, pricey labor and the need to store and manage an inventory of replacement lamps and ballasts. In 24x7 environments where you can’t schedule after-hours service, you’ll be forced to disrupt activities on the floor.
THE LED HIGH-BAY FIXTURE: YOUR NEW FRIENDS IN HIGH PLACES

On appearance only, LED high-bay fixtures may not look like a 50-year leap in technology. Many have the same familiar inverted cup shape, and they hang overhead, making light. That’s where the resemblance ends. LEDs are light-emitting diodes, essentially silicon chips. They use much less power to create a lumen of light, and that light is highly directional and easily controlled. Their useful life is measured in decades and they require little if any maintenance. They turn ON/OFF instantly without impacting lamp life. The LED silicon chip is a natural for intelligent lighting controls, and like the smartphone in your pocket, provides a ready-made platform for any number of environmental sensors, as well as Wi-Fi and networking capabilities. In short, LED lighting offers pain relief for every headache created by MH and fluorescent fixtures.
What does all this look like in the real world? We’ll use the Cree® KBL Series and HXB Series LED luminaires as examples of what’s available for today’s high-bay fixture buyer.

THE KBL SERIES: EXCELLENCE FOR EVERYWHERE.
Designed as the ideal solution for mainstream high-bay environments, the KBL Series is that rare breed of product both eminently affordable and engineered to deliver stellar performance across diverse categories. Available in both 18,000 and 24,000 nominal lumen packages, it’s tough enough for the rigors of industrial, manufacturing and warehouse environments, but offers the clean styling sought for big-box stores, supermarkets, athletic venues and concourses.

THE HXB SERIES: A BIG BROTHER WHO’S INTO EXTREMES.
At 70,000 lumens, the HXB Series offers a one-for-one replacement of 1000-watt MH fixtures with a tough-as-nails fixture that can master even the most extreme and hostile conditions without compromising on light quality, durability or energy savings.

Here’s the rundown:
They’re energy misers right out of the box.... Under our 16-hour-day, 11-cents-per-kilowatt scenario, the KBL luminaire’s annual energy cost could be as low as $77 before any lighting controls are applied, while the HXB Series can cut the energy costs of a 1000-watt MH by 60%.

... and many utilities will pay you to buy them. LED lighting conversions save so much energy that utilities can avoid or delay the billion-dollar expense of building new generating plants. That’s why many utilities offer hefty rebates on fixtures that qualify under the DesignLights Consortium® [DLC®] certification program. DLC Standard certification indicates a fixture with very good efficacy, while DLC Premium certification tells you a product meets exceptional efficiency standards for its category. Both the KBL and HXB Series fixtures qualify for DLC Premium status, which can mean generous rebates that lower your initial cost, accelerate payback and ensure you’ll be reaping maximum savings for years to come.

They last much longer than MH or T5 lamps. Both the KBL and HXB Series luminaires have a useful life of more than 100,000 hours—five to 10 times the actual life of the typical MH and T5 lamps. That means a child entering the first grade on the day you install your Cree® high-bay fixture will start her first job after college before you need to think about a replacement.
They’re low maintenance and don’t require careful handling. In a clean environment, the KBL and HXB fixtures may be virtually maintenance-free. In dirty environments, you’ll want to periodically clean the luminaire’s reflector and body. There are no bulbs or ballasts to replace, no pressurized gas lamps or tubes to shatter and release contaminants, and no heavy metals requiring regulated disposal.

Even without reflectors, they throw most of their light toward the work plane. Both the KBL and HXB Series offer excellent optical control with distributions to light either aisles or open areas. LEDs are directional point light sources, emitting a much greater share of their light energy toward the workplane and requiring fewer light-robbing optics for precise control. With fewer reflectors required to bounce light, there’s a much smaller difference between total lumens and useful lumens. (That’s why many facilities can retrofit with fewer LED high-bay fixtures of lower total lumens and still see a vast improvement in the illumination of the environment.)

They maintain useful light levels even as they age out. The gradual and imperceptible loss of an LED’s light output is called lumen depreciation. A common industry yardstick for the rated life of an LED is “L70”—the point at which 50% of the LEDs in a luminaire drop to 70% of their initial lumen levels. The human eye generally doesn’t detect a decrease in light until it exceeds 30%—hence the use of L70. Both the KBL and HXB Series are rated >100,000 hours L70. That means half of the fixture’s LEDs will have dropped to 70% of initial lumen levels after 17 years of 16-hour-a-day use, while half will still produce 70+%.

Their lifetimes are rated for extremes, not ideals. The KBL Series’ useful life is >100,000 hours L70 at maximum operating temperature. The HXB Series’ rating is >100,000 hours L70 at 65°C. Unpacked, that means you can run the KBL fixture 24x7 in temperatures up to 131°F for more than 100,000 blistering hours, or do the same with the HXB fixture at up to 149°F.

They turn ON and OFF without all the drama... You can cycle the KBL and HBX high-bay fixtures without worrying about temperamental lamps and ballasts, cooling off periods, strike times, warm-ups or slow climbs to maximum output. Just instant ON and OFF, whenever you want.

...so they’re a natural for lighting controls. Both the KBL and HXB fixtures feature standard 0-10V dimming that can be enhanced with occupancy sensors for additional energy savings.

They dress up well.
Despite their brawny engineering, these fixtures look right at home shining down on organic produce, new cars and sporting goods. As industrial décor continues to grow in popularity for upscale establishments, the KBL Series’ tight fit and finish and clean lines make an industrial-strength statement.
They’re versatile. The KBL and HXB Series come standard in multiple color temperatures to complement environments from the warmly lit ambiance of performance venues to the alert-and-awake energy of the factory floor. The KBL luminaire also offers 80+ CRI for places like food markets and retail stores where accurate color rendering is essential. A choice of aluminum, prismatic or polycarbonate reflectors and a variety of bottom lenses and wire guards let you customize the KBL Series’ appearance. There are optics for both narrow aisle lighting and broad area illumination, as well as an optional “gym-friendly” impact-resistant reflector that shrugs off errant balls and hockey pucks.

MORE THAN AN UPGRADE. A TRANSFORMATION.

To recap: LED high-bay fixtures use a fraction of the energy of metal halide and fluorescent fixtures. They are virtually maintenance-free and eliminate other hidden costs. They offer payback measured in months and lifespans measured in generations. And they produce better light—responsive, precisely controllable light. And they produce better light—precisely targeted and highly controllable.

Yet an even bigger story continues to unfold as companies vie for competitive advantage and sustainability. While energy economics are driving the mass migration to LED high-bay lighting, LED high-bay fixtures can be part of a strategic approach to lighting that creates a new asset for the enterprise.

Safer, more efficient and responsive lighting plays a prominent role in sustainability mandates and third-party certifications such as LEED and the WELL Building programs. As online competitors put more pressure on brick-and-mortar retailers, beautiful, responsive LED lighting can enhance the customer experience and create more memorable brand associations. In the manufacturing segment, the emergence of big data and increased automation are shaping lighting decisions as facilities explore LED lighting’s ability to help achieve process improvements and create safer, more productive environments for workers. And every LED chip is a ready-made platform for the Internet of Things.

The right LED high-bay lighting doesn’t just replace what was there before. It signals to customers, workers, investors and visitors that you’re headed in the right direction—toward a green and sustainable future of lower costs, safer, more productive spaces and better light for all.

Footnotes
1 Lawrence Berkley National Laboratory, July 2013
2 A 400-watt metal halide fixture actually draws 450 watts or more, and a 6-lamp 324-watt fluorescent fixture actually draws 365 watts.
3 SSL Market Adoption: Status and Trends, DOE SSL Technology Development Workshop, Denver, CO, November 17, 2016
4 Fluorescent Retrofits for High/Low-Bay Applications, May 2009; Lighting Controls Association
5 Fluorescent Retrofits for High/Low-Bay Applications, May 2009; Lighting Controls Association
6 Troubleshooting & Maintenance for HID Lighting, Universal Lighting Technologies
7 Mid-wattage metal halide Lamps, NLPIP Volume 7, Issue 1, Lighting Research Center
8 Electricians Costs & Prices, ProMatcher Cost Report
9 Electrician Rates, Top Electricians
10 HID Lamp Dimming, 2011; Lighting Controls Association
11 Fluorescent Retrofits for High/Low-Bay Applications, 2009; Lighting Controls Association
12 Light Output Declines with Time, Madison Gas and Electric
13 Cleaning Your Fluorescent Lights, Lampsrecycling.com
14 The Effect of Occupancy Sensors on T8 Lamp Life, H.E. Williams, Inc.
15 https://www.designlights.org/
Visit lighting.cree.com or contact a Cree lighting representative to learn more.