GREEN SEAL'S GREEN Case REPORT

JULY 2000

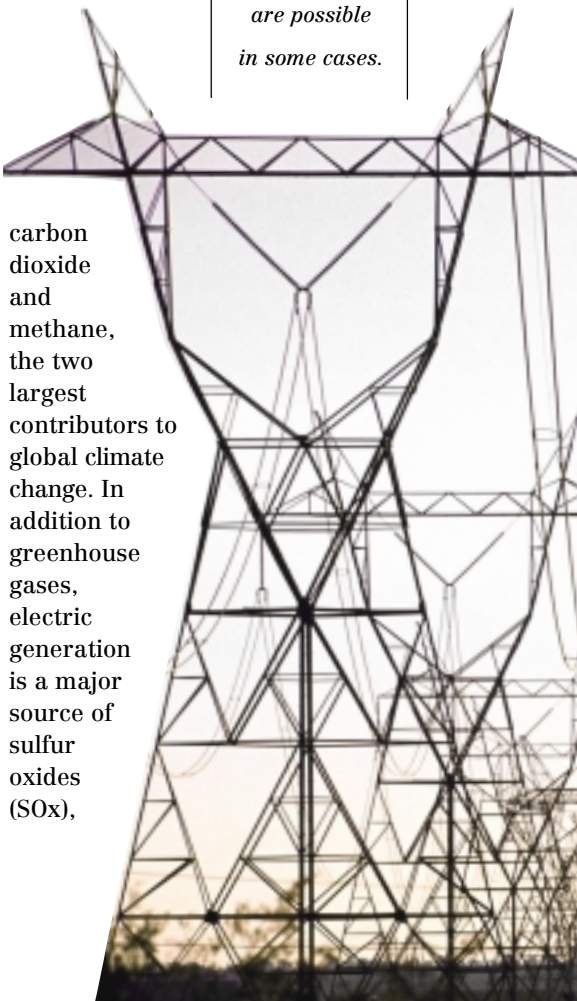
HIGH INTENSITY DISCHARGE LUMINAIRES

Annually, the US commercial and industrial sectors account for close to one trillion kilowatt-hours (kWh) of electricity use. Lighting in offices, hospitals or hotels, hallways and lobbies, factories, large retail stores, and warehouses, combined with outdoor lighting, can account for 25 percent or more of total electricity use by these two sectors, or about $20 billion by one estimate.

Installing the right lighting system can make a significant difference in energy consumption. Energy savings of 50% or more are possible in some cases.

While proper illumination is needed in commercial and industrial settings, the selection of the right lighting system can make a significant difference in energy consumption. Energy savings of up to 50 percent or more are possible in some cases. Less efficient indoor lighting sources often create heat as well as light, and can be a serious source of excess heat in buildings. The additional cooling energy required to counteract this effect increases a building's total energy use. Thus, efficient lighting design not only reduces lighting energy usage and cost, it can also make a difference in other operational areas as well. This Report is the first in a series of three that will focus on commercial and business applications of energy-efficient indoor lighting.

Energy derived from fossil fuels or other non-renewable energy sources can seriously impact the environment—mining and exploration can damage fragile areas; the burning of fossil fuels releases carbon dioxide and methane, the two largest contributors to global climate change. In addition to greenhouse gases, electric generation is a major source of sulfur oxides (SOx),



the leading cause of acid rain, and nitrogen oxides (NOx), the leading cause of urban air pollution. Although energy use is the main environmental issue associated with lighting, another is the use of natural resources required to manufacture fixtures and lamps. Commercial and industrial lamp disposal can be a problem, since they may contain high pressure gases or mercury vapor.

Efficient, well-designed indoor lighting provides safe, effective, working conditions, and results in significant cost savings. It also benefits the environment through reduced energy use and fewer resources needed to manufacture and dispose of lamps and their components.

Commercial & Industrial Lighting Considerations

Because of their high efficiency, high intensity discharge lighting, or HID, should be considered in place of incandescent or even fluorescent lighting for certain indoor commercial and business applications.

HID systems are well suited for many indoor uses. The best HID applications are situations where uniform levels of illumination are required for long periods, and where frequent on/off switching is not required. HID sources can also be alternatives to incandescent and halogen in spot and accent lighting—unlike fluorescent systems, they can give sparkle to polished surfaces and produce shadows for dramatic display effects in the retail environment.

This Report covers HID lamp usage for commercial and industrial applications collectively known as "high-" and "low-bay"—where a high amount of light is needed from a point source, or where uniform general lighting is needed in higher-ceilinged areas (generally, 12 ft or more), and where long periods of illumination with little or no switching control is the norm. Suitable applications of these fixtures can include—

- atriums
- some office spaces
- hallways and lobbies,
- factories,
- loading areas
- indoor parking areas
- large retail areas, and
- warehouses.

For these applications, HID luminaires (or lighting fixtures) generally provide the greatest efficiency and ease of maintenance. Pricing for these products can range from less than $100 per unit with lamp, to over $400, depending on options, ballast selection and quantity.

Generally, choosing luminaires for the above applications involves the selection of the following components—lamp technology, ballast type, reflector type (to focus or direct light output), and housing. Depending on lamp type, some type of shielding may also be required. A luminaire can be selected component by component (lamp, ballast, reflector, and housing), or as a prepackaged fixture for a specific application.

For most of the applications covered above, the selection process is quite simple. The sections below provide an overview of HID lamp and ballast technologies, and suggest criteria for the selection of environmentally responsible HID luminaires.

Overview of HID Luminaire Selection

Available HID luminaires can have lamps that range from as low as 35 watts up to 1,000 or more watts, with lamp lumen output ranging from 1400 to 140,000 or more (see box on page 11 for an explanation of lighting terms). Because of their high lumen capacity and efficiency, replacing incandescents and even fluorescents with HID systems can provide many advantages, including:

- Reduced lighting energy use
- Fewer fixtures and bulbs per square foot
- Less frequent bulb replacement
- Better beam control over fluorescent systems (for displays, for example)
- Highly efficient lamp and bulb packages
- Reduction of excess heat in buildings
- Wide variety of fixture output available

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HID Lamp Technologies and Characteristics

The term "HID" actually covers a large class of lighting products. There are three distinct HID lamp types—mercury vapor (MV), metal halide (MH), and high-pressure sodium (HPS) and low-pressure sodium (lighting experts consider low-pressure sodium, or LPS lamps, to be in a category known as "miscellaneous discharge").

HID lamps all operate on a principle of electric discharge similar to fluorescent lamps—HID lamps emit light when the gases contained inside the envelope (or arc tube) are activated by an electric current, provided by the lamp's ballast. One key difference between HID and fluorescent lamps is that the pressure inside HID lamps is much higher. Each type of HID lamp has its own advantages and disadvantages, briefly outlined below.

■ ***Mercury Vapor***—MV lamps came into widespread use in the 1940s and 1950s in industrial applications, replacing incandescent technology due to their higher lumen output and longer life. These characteristics, plus low initial cost and color stability, remain mercury vapor lamps' best features. However, MV lamps are much less efficient than other lamps in the HID family, have poor color rendering characteristics, and can lose up to 40 % of their light output over their rated life.

■ ***Metal Halide***—MH lamps were designed to improve upon mercury vapor's poor lumen maintenance, color rendering, and relatively low efficacy characteristics. MH lamps function very much like mercury vapor lamps, but the addition of iodides of metals (halides), such as thallium, indium, and sodium, in the envelope produces more and higher quality light than mercury vapor alone. However, MH lamps have their own particular drawbacks, including high UV levels and sensitivity to low temperature. MH light output is also extremely sensitive to lamp position. They can also explode under certain conditions.

■ ***Sodium Lamps***—Sodium lamps work by using a high frequency, high voltage pulse to ionize xenon gas in an enclosed tube, which in turn vaporizes a sodium-mercury amalgam. This mixture is further excited by an electric arc, producing light. Sodium lamp performance is directly related to the gas pressure inside the arc cylinder—high pressure sodium lamps have higher color rendering indices and a wider output spectrum than the almost monochromatic yellow characteristic of low pressure sodium lamps. Long life and high-efficiency are HPS lamps' best features. HPS lamps with higher CRIs trade efficacy and economy for better color rendering.

TABLE 1

LAMP TECHNOLOGY	APPROXIMATE EFFICACY RANGE (LPW)
Standard Incandescent	7 to 15
Tungsten Halogen	15 to 25
Mercury Vapor	25 to 55
White Sodium	35 to 55
Compact Fluorescent	25 to 75
Full-size Fluorescent	65 to 95
Metal Halide	45 to 95
High Pressure Sodium	45 to 110
Low Pressure Sodium	80 to 150

Note: While the calculated efficacy of an LPS lamp is high, it is affected by the way our eyes register its output spectrum. When LPS lumen output is corrected for human eye perception, it can be less than the actual lamp lumen output.

Of the three lamp types, metal halide and high pressure sodium systems are very efficient and provide more lumens per watt (and more light output per fixture) than incandescent and even fluorescent systems; mercury vapor is the oldest and least efficient technology of the three.

In general, MH lamps offer the best compromise between color rendering and efficiency. Recent technological improvements include the ceramic metal halide lamp (CMH). This technology, when widely available, can bring MH color rendering ability in line with good fluorescent lamps. HPS lamps, on the other hand, offer extremely long life and very good economy, and can be well suited for warehouses, loading areas, and other industrial uses.

Table 1 (above) provides a comparison of available efficacy (light output in lumens per input Watt) ranges of different lamp technologies.

HID Ballasts

To operate, HID lamps require a ballast to control the current to the lamp electrodes, and to deliver the starting or restarting voltage. There are three common HID ballast types in use – all are magnetic, employing coils to regulate current, and vary in complexity. They can also be heavy, and are often noisy when not properly packaged.

The three ballast types are—

■ ***Reactor***—these are simple and small units consisting primarily of an inductor coil. They tend to be inexpensive. Reactor ballast designs do not tolerate voltage variations well, and can be the cause of lamp flickering.

■ ***High-reactance Autotransformer***—these are similar in design to reactor ballasts, but with the addition of circuitry capable of boosting line voltage to start lamps. They also are inexpensive.

■ ***Constant-wattage Autotransformer***—the most common ballast type in use. These regulate lamp power better than other ballast designs, controlling flicker and eliminating shutoffs from line voltage variations. They can cost more than reactor or high-reactance ballasts.

Electronic ballasts are now available for some lower wattage (from 150 W to 400 W) metal halide and HPS lamps. They can be more expensive, but offer better operating characteristics such as better color control and starting time, smaller size, and light weight in return. Electronic ballasts do not offer HID lamps the same performance boost as electronically-ballasted fluorescent lamps.

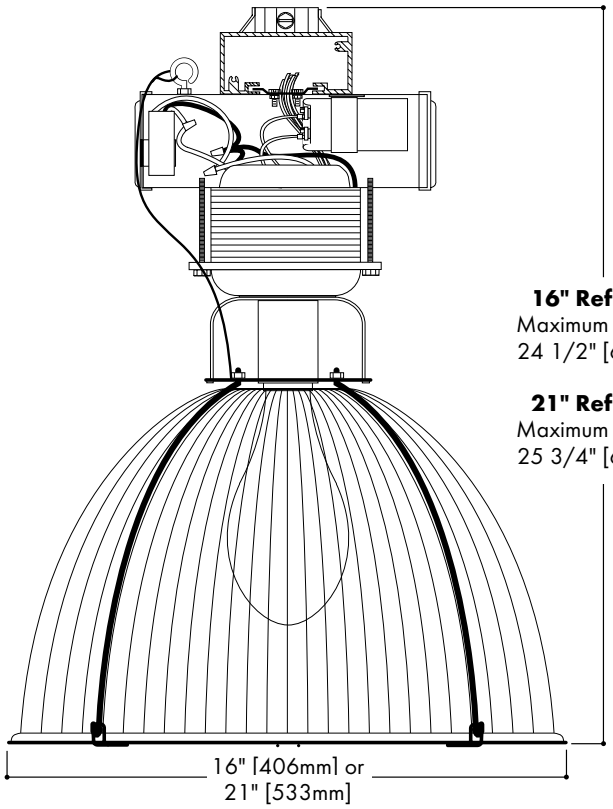
The latest innovation in MH ballast & lamp design is the pulse-start ballast. This design uses an igniter system in the ballast instead of a starting probe. Pulse start is available for a range of lamp wattage. As the name implies, the pulse-start design introduces extremely high-voltage pulses to start the arc and ignite the lamp. This new design improves cold weather starts, efficiency, lumen and color maintenance, and can shorten warm-up and restrike time by up to 60%. The design is available in both electronic and magnetic ballast technologies, and involves reinforcing the lamps and ballasts to withstand extremely high voltages (at higher cost).

Luminaire Selection Criteria

As discussed, the most common commercial and industrial applications of HID, where uniform levels of illumination are required for long periods of time, include some open office spaces, atriums, hallways and lobbies, factories, large retail stores, and warehouses.

These areas are collectively known as “high-” and “low-bay” areas, and luminaires—lamp, ballast and reflector systems—designed for these areas are known as such. Because of the number of products available, the selection process can be as

TYPICAL HIGH-BAY LUMINAIRE



Source: Cooper Lighting

TABLE 2

TYPICAL LUMINAIRE & WATTAGE RANGE	MOUNTING HEIGHT
Low bay - 75 W to 175 W	10 ft. to 14 ft.
Low bay - 200 W	Up to 18ft.
High bay - 200 W to 400 W	18 ft to 30 ft.
High bay - 400 W and above	20 ft to 50 ft

straightforward as determining the required light levels and types based on user needs, and then determining the lamp, fixture type, and number.

■ ***"High bay" luminaires*** are used in high-ceilinged areas (20 ft or more) that require uniform illumination at eye, desk, or shelf level (for example—retail/ superstores, warehouses, atriums, etc.). High bay luminaires are high wattage, high output packages designed to deliver light over long distances. Typical high bay luminaire packages can be quite tall, and most use vertically oriented lamps (as these luminaires are used in areas where package height is not a concern).

■ ***"Low bay" luminaires*** are more compact luminaires, employing both vertical and horizontal lamp orientations, and designed for use in lower- to mid-ceilinged (12 ft to less than 20 ft) areas. They are used for a variety of applications, including general illumination (for example, some offices, retail spaces, or loading docks).

Often, these fixtures are also listed by their "upward efficiency," which provides a measure of how much light they cast upward (from their horizontal plane). Luminaires with higher upward efficiencies can illuminate the ceiling as well as downward, and can be used in combination with a light-colored ceiling to reduce the "dark ceiling" effect.

Table 2 illustrates the wattage range and mounting height for the two types of fixtures.

TABLE 3

TASKS	RECOMMENDED LIGHT LEVELS (footcandles)	APPROXIMATE COLOR RENDERING (CRI) NEEDS	SUITABLE LAMP TYPE
Assembly & Packaging	50 to 70 for Medium Work 75 to 100 for Fine Work	Medium (50+) to High (70+)	MH or MH Pulse start
Engineering & Drafting	70 to 125	High (70+)	MH or MH Pulse start
Food Processing	50 to 75	Medium (50+)	MH
Loading Dock/ Shipping Areas	30 to 50	Low (<50)	HPS
Manufacturing	50 to 75 for Crude Manufacturing 75 to 100 for Average Manufacturing	Medium (50+)	HPS or MH
Office (work area)	60 to 75	High (70+)	MH
Retail	50 to 80 for Average Stores 80 to 100 for "Superstores"	Medium (50+) to High (70+)	MH or MH Pulse start
Sport/Gymnasium	30 to 50 for Recreational 50 to 75 for Professional	Medium (50+) High (70+)	MH or MH Pulse start
Warehouse	20 to 30 for Active Warehouses 15 to 20 for Inactive Warehouses	Low (<50) Medium (50+)	HPS

An important consideration for selecting HID luminaires is whether the fixture will fulfill illumination needs. The luminaire should provide both adequate illumination levels (brightness in footcandles) as well as color quality (CRI) needed for the particular application. Table 3 (page 5) outlines some typical IES (Illuminating Engineering Society) light levels and approximate color rendering index requirements for various tasks. Note that these levels are suggested levels, and can be met with a combination of both ambient (general) and task lighting.

Because of the combinations possible with the components, when evaluating fixtures and comparing one against another, it is important that characteristics such as ballast factor, bulb and reflector design, placement and type are the same across fixtures in order to make a valid comparison (and also light output pattern in the case of some lamps).

Lamp photometric and other testing data provided by manufacturers offer valuable information about their products' efficiency and performance. Manufacturer data can also be used to determine luminaire efficiency, testing information, and economic factors. With few exceptions, care should also be taken to ensure that both lamps and ballasts have matching ANSI (American National Standards Institute) designations to avoid premature lamp failure and possible explosion.

Environmentally Responsible Luminaire Selection

Green Seal has developed a list of criteria below to help you select luminaires that have less overall impact on our environment. These criteria take into account the most obvious resource reduction opportunity—energy efficiency (in the forms of lamp and system efficacy).

We also considered the performance of the luminaire, in terms of lamp longevity and manufacturers' warranty and factors such as safety testing, since these affect how soon a replacement system is needed, and because longer lasting products can reduce the volume of waste entering the waste stream.

Finally, where information is available from manufacturers, we considered the environmental impacts of the luminaire—the metals, plastic and other components used as well as the luminaire production method.

Lamp Color Rendering—Where accurate color perception is needed, or the area to be illuminated will involve high precision work, such as retail or assembly work, a high color rendering index (CRI) HID system is required, and a suitable high CRI system such as metal halide may be necessary. If the area to be lit only requires some degree of illumination (a stock or warehouse area, for example), color perception may not be as critical, and an HPS system may be acceptable.

Lamp type selection—In general, MH lamps offer better CRI and in a wider range, but some medium wattage, high CRI MH can have lamp life of less than 10,000 hours. HPS lamps offer higher efficiency and longer life, but HPS lamps have lower CRI and except for "white sodium" lamps, give out a pinkish light. In summary, MH lamps offer the best compromise between color rendering and efficiency for most indoor applications.

Ballast type selection—Depending on applications and budget, ballast selection involves specifying electronic or magnetic ballast, and the specific type within each category, discussed above. For energy efficiency, choose ballasts with lower losses.

Reflector type selection—HID luminaires come with variety of reflector options. In general, they can be open or enclosed, and are made of transparent, opaque, reflective materials, or a combination.

- Transparent and open reflectors allow some light to be emitted above the horizontal plane of the luminaire, allowing both direct and reflected illumination;

- Opaque reflectors and enclosures are used to direct all or most of the light downward

Luminaire efficiency data (not to be confused with luminaire efficacy rating, or LER) measures the light output in the 0 to 90 degree zone, or the quantity and pattern of light being directed downward. (Note—Luminaires are often grouped by their "upward efficiency" which measures the amount of light a luminaire directs upward.)

Reflectors are used to focus or diffuse light patterns. They are used to ensure even light distribution in high bay units, and also to control glare, especially in low bay units, for example. Enclosed luminaires have baffles or shields, which enclose the lamp/reflector assembly opening, and

Green Seal's Lighting Guidelines

FOR OPEN OFFICE, HALLWAYS, ATRIUMS, MEETING AREAS AND GENERAL LIGHTING

- ❑ Metal halide (MH) lamps with CRI of 60+ are suitable for most indoor general lighting tasks.
- ❑ If low-bay luminaires with horizontally oriented lamps are used, choose lamps capable of universal burning position
- ❑ Look for products that meet or exceed FEMP-recommended LER (if LERs are available from manufacturers), and long life
- ❑ Choose enclosed luminaires for further glare control and shielding
- ❑ MH (and HPS) may not be suitable with occupancy-controlled areas, or where frequent switching is the norm
- ❑ Choose products with recycled content or less harmful production methods, where such information is available

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FOR GENERAL ASSEMBLY, MANUFACTURING AND RETAIL

- ❑ Metal halide (MH) and pulse-start MH lamps with CRI of 70+ are suitable for most general retail and medium assembly work.
- ❑ Choose instant restrike HPS lamps or a backup lighting system for areas where constant illumination (24/7) is needed
- ❑ Look for products that meet or exceed FEMP-recommended LER (if LERs are available from manufacturers) and long life
- ❑ Choose open reflectors if you do not need further glare control or shielding
- ❑ Choose products with recycled content or less harmful production methods, where such information is available

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FOR WAREHOUSES AND LOADING AREAS

- ❑ High pressure sodium (HPS) lamps are suitable for most illumination tasks where color perception is not important.
- ❑ Look for products that meet or exceed FEMP-recommended LER (if LERs are available from manufacturers), and long life
- ❑ Choose open reflectors for maximum light output
- ❑ Choose products with recycled content or less harmful production methods, where such information is available

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FOR SPORT/GYMNASIUM AND SPECIALTY RETAIL

- ❑ Metal halide (MH) and pulse-start MH lamps with CRI of 70+ are suitable for high light output and where good color perception is needed.
- ❑ For specialty retail, low-wattage, white HPS lamps can be used instead of halogen lamps to provide energy-efficient accent lighting
- ❑ Look for products that meet or exceed FEMP-recommended LER (if LERs are available from manufacturers), and long life
- ❑ Choose additional shielding for UV sensitive areas
- ❑ Choose products with recycled content or less harmful production methods, where such information is available

TABLE 4

SELECTION CRITERIA AND RATIONALE FOR RECOMMENDED PRODUCTS

Criteria	*Requirements*	*Benefits*
Luminaire Efficacy Rating (LER)	■ Must meet or exceed FEMP Requirement, or best available	■ Luminaire is more efficient at converting energy into light
Lamp Longevity	■ Minimum of 15,000 hours	■ Reduces lamp use, waste, and manufacturing resources
Electrical Safety	■ UL listing or equivalent	■ Reduces risk of fire and electrical hazards
Warranty	■ Repair or replacement of defective luminaire or parts within 2 years of purchase	■ Consumer confidence and satisfaction

are used to further distribute light, control glare, or protect occupants from UV or lamp fragments in case of lamp explosions.

Energy Efficiency—In this report, the Federal Energy Management Program (FEMP) recommended luminaire efficacy ratings (LER), derived from the National Electrical Manufacturers' Association (NEMA) standard LE-5B, are used as a baseline for identifying energy-efficient luminaires. This is a valid way to evaluate different products, but it must be done with the same ballast, fixture type and bulb type/ wattage ratings in order to make an equal comparison.

The term "luminaire efficiency" is sometimes used interchangeably with "lighting efficiency" where LER is concerned. LER is defined as: LER = (Luminaire efficiency x Total rated lamp lumens x Ballast Factor) ÷ Input Watts

Green Seal recommends that you look for luminaires that meet or exceed FEMP-recommended LER found in Table 5 (page 13), and have been tested by a qualified testing lab for quality and performance.

Lamp Longevity—Although most HID sources are long-lived, various factors can affect system performance and reduce lamp life. The selection of a durable system not only ensures that less solid waste will be introduced into the environment, it also means that the components have been tested to be used as a system, thus ensuring user satisfaction and reducing failure incidents. Green Seal recommends choosing systems with rated lamp life of 15,000 hours or more.

Electrical Safety—To ensure longevity and safety of luminaires, Green Seal recommends that luminaires be tested by an independent laboratory, such as Underwriter's Laboratories (UL), the Canadian Standards Association (CSA) or equivalent.

Warranty—At a minimum, we recommend products should carry a manufacturer's warranty of 2 years or more, to ensure both user satisfaction while reducing failure incidents, replacement costs and waste.

Production Methods and Materials—We also recommend that you consider products that were made using methods and materials that are less damaging to the environment, and products with recycled content, where such information is available.

The products listed in the enclosed product table included available information from manufacturers regarding their product's production method, lamp life, or recycled content. Table 4 summarizes the selection criteria and rationale.

Recommended HID Products

MANUFACTURER	PRODUCT	LER	TOTAL RATED LUMENS	INPUT WATTS	LAMP TYPE	EST. LAMP LIFE	LUMINAIRE PRODUCTION& MATERIALS
ENCLOSED LUMINAIRES WITH UPWARD EFFICIENCY < 0.01							
Lithonia	TE 1000S E22	92.60	140000	1000	HPS	30000 hrs *	B
ENCLOSED LUMINAIRES WITH UPWARD EFFICIENCY FROM 0.01 TO 0.10							
Holophane	Enduralume	83.30	44000	440	MH	15000 hrs	A
Ruud Lighting	CJ1645-M	81.20	50000	508	MH	20000 hrs *	B
Ruud Lighting	CJ1640-M	81.03	44000	448	MH	20000 hrs *	B
Ruud Lighting	CJ1635-M	78.38	38000	400	MH	20000 hrs *	B
Ruud Lighting	CJ1632-M	76.85	34000	365	MH	20000 hrs *	B
ENCLOSED LUMINAIRES WITH UPWARD EFFICIENCY > 0.10							
Cooper	BEVertimark II	98.38	16000	150	HPS	20000 hrs	D
Lithonia	TXR 400M PA25D	84.00	42000	456	MH	20000 hrs *	B
OPEN LUMINAIRES WITH UPWARD EFFICIENCY < 0.01							
Lithonia	THS 400S A16	93.70	50000	465	HPS	30000 hrs *	B
Ruud Lighting	AR1640-M	86.07	40000	448	MH	20000 hrs *	B
Holophane	Prismpack	86.00	44000	440	MH	15000 hrs	A
Ruud Lighting	AR1645-M	85.77	45200	508	MH	20000 hrs *	B
Cooper	SS15 Steeler	85.55	16000	150	HPS	20000 hrs	D
Ruud Lighting	AP1635-M	82.42	34200	400	MH	20000 hrs *	B
Ruud Lighting	AR1632-M	80.82	30600	365	MH	20000 hrs *	B
Lithonia	THS 400M A16	80.37	44000	456	MH	20000 hrs *	B
Spartan	EJ Series	75.81	42000	400	MH/HPS	20000 hrs *	C
Spartan	EC Series	74.19	38000	400	MH/HPS	20000 hrs *	C
Spartan	HC Series	74.19	38000	400	MH/HPS	20000 hrs *	C

NOTES:

LER = Luminaire Efficacy Rating
Total Rated Lumens = Total lamp lumens
Input Watts = System input Watts
Upward Efficiency = Refers to the % light directed upward by a luminaire
* Lamp life is based on 10hrs/start

A = Glass prismatic reflector uses 35% recycled glass product
B = No CFCs or volatile vehicles used in painting process. All fixtures 90% recyclable.
C = 5 Year warranty on products
D = ISO 9000 Certified Facility

All listed products are tested by UL or equivalent. Efficiencies were calculated with Ballast Factor of 1, except for Cooper open luminaires at 0.8

Recommended HID Products (continued)

MANUFACTURER	PRODUCT	LER	TOTAL RATED LUMENS	INPUT WATTS	LAMP TYPE	EST. LAMP LIFE	LUMINAIRE PRODUCTION& MATERIALS
OPEN LUMINAIRES WITH UPWARD EFFICIENCY FROM 0.01 TO 0.10							
Lithonia	THR 400M PA22	85.75	42000	456	MH	20000 hrs *	B
Ruud Lighting	AP1640-M	81.16	40000	448	MH	20000 hrs *	B
Ruud Lighting	AP1645-M	80.88	45200	508	MH	20000 hrs *	B
Ruud Lighting	AP1635-M	77.72	34200	400	MH	20000 hrs *	B
Ruud Lighting	AP1632-M	76.21	30600	365	MH	20000 hrs *	B
Ruud Lighting	A1640-M	72.36	42000	448	MH	20000 hrs *	B
Ruud Lighting	A1646-M	72.17	47500	508	MH	20000 hrs *	B
Ruud Lighting	A1635-M	69.46	36000	400	MH	20000 hrs *	B
Ruud Lighting	A1632-M	68.30	32300	365	MH	20000 hrs *	B
Cooper	SS18 Steeler	67.82	36000	400	MH/HPS	20000 hrs	D
Cooper	SS Series Prismatic	67.82	36000	400	MH/HPS	20000 hrs	D
OPEN LUMINAIRES WITH UPWARD EFFICIENCY > 0.10							
Holophane	Prismalume	92.60	44000	440	MH	15000 hrs	A
Spartan	EL Series	91.58	38000	400	MH/HPS	20000 hrs *	C
Holophane	Centaglo	90.30	44000	440	MH	15000 hrs	A
Lithonia	TPG 400M PG16	89.70	44000	456	MH	20000 hrs *	B
Spartan	HL Series	84.69	22500	250	MH/HPS	20000 hrs *	C

NOTES:

LER = Luminaire Efficacy Rating
Total Rated Lumens = Total lamp lumens
Input Watts = System input Watts
Upward Efficiency = Refers to the % light directed upward by a luminaire
* Lamp life is based on 10hrs/start

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D = ISO 9000 Certified Facility

All listed products are tested by UL or equivalent. Efficiencies were calculated with Ballast Factor of 1, except for Cooper open luminaires at 0.8

MANUFACTURER CONTACT INFORMATION

Cooper 410-517-1401
Holophane 740-345-9631
Lithonia 770-922-9000
Ruud Lighting 800-236-7000
Spartan 800-255-5267

SOME LIGHTING DEFINITIONS

Ballast—The operation of light sources such as fluorescent, high-intensity discharge, and low voltage halogen requires a ballast to control the current. Ballast can be magnetic, hybrid, or electronic. The latter types can be found in better-quality luminaires and permit better control of lamp operations.

Ballast Factor (BF)—BF is the ratio of the light output of lamp(s) operated by a ballast to the light output of the same lamp(s) operated at rated current and voltage.

Brightness—This term refers to the intensity of light striking a surface. Brightness is measured in footcandles. One footcandle is equal to the light of one standard candle striking one square foot of surface located one foot away.

Color Correlated Temperature (CCT)—Also known as ***color temperature,*** and expressed in degrees Kelvin, it measures the color appearance of the light that comes from a light source. Available lamp color temperatures range from 1700 degrees kelvin to 5000 degrees Kelvin, with 2700 to 3500 degrees Kelvin being the comfortable range for most public areas.

Color Rendering Index (CRI)—CRI measures the ability of a light source to render the color of objects. CRI uses a scale of 0 to 100, with 100 representing a color rendering ability similar to sunlight. Light sources with "good" color rendering have indices that range from 70 to 80 CRI. Sources with CRI of 80+ are considered to have "excellent" CRI.

Efficacy—Efficacy measures a light source's ability to convert electric energy into light. It is measured in lumens per watt (lpw). The higher the lpw, the more efficient a light source. Efficacy can be measured for both lamp as well as lamp/fixture combination (system efficacy).

HID Lamps—Lamps are made up of a glass envelope that houses a high voltage arc tube and gases which are activated by an electric current to create light.

Light Output—Also known as ***light quantity,*** is the term used to described the quantity of light from a source. It is measured in lumens. Light quantity measurement is taken directly at the light source and is a calculation of the flow of light. The brighter the light source, the higher its lumen measurement. For example, a typical 60 W incandescent bulb will have the lumen output of approximately 700 to 800 lumens.

Lumen Maintenance—Also known as ***lumen degradation,*** is the term used to describe a light source's ability to maintain a consistent light output over time. Most light sources suffer from reduced output as they age, some more drastic than others. It can be more noticeable in longer-lived sources.

Luminaire—This term is sometimes used interchangeably with "fixture" and refers to a hard-wired, fixed-position apparatus that houses a light source and related components (ballasts, reflector, sockets), and provides illumination in a prescribed manner.

Luminaire Efficacy Rating (LER)—Measures the lumen output of a fixture as a function of input power, enabling comparisons between fixtures. The higher the LER, the more efficient the luminaire. HID system LERs can range from 64-122 depending upon the combination of fixture, bulb type and wattage.

Luminaire Efficiency—Measured as a ratio comparing the lumen output by the luminaire compared to the lumen potential of the lamp alone. HID luminaires are often classified by their ***upward efficiency,*** which refers to the percentage of light directed upward from the luminaire. The higher the ***upward efficiency,*** the more light is directed upward.

HID APPLICATION NOTES

The high efficiency of HID lamps is complicated by a number of characteristics, some common to all HIDs, others affecting only a particular HID type. These characteristics are outlined below, along with some strategies to address them. As with any change in technology, they need to be carefully considered, especially if HIDs are to be retrofitted in place of incandescent sources.

Group Relamping—Some sodium and MV lamps' wattage increase as they reach the end of their useful life. In addition, MH and HPS lamps' ***colors shift*** over their lifetime, particularly after the lamps have reached about 70% of their rated life. Group relamping is an effective way to deal with both of these issues. Ceramic metal halide (CMH) is a new improvement on MH technology, which offers improved efficacy and color temperature stability in lower wattage ranges, but is not yet widely available.

Back-Up and Instant-Restrike Systems—Because of their design, HID lamps require a warm-up period, anywhere from 2 to 10 minutes, before reaching full light output. MH lamps tend to take the longest and sodium lamps take the shortest. In addition, if power is interrupted, an HID's lamp arc will extinguish. When this happens, the lamp must first cool down before the arc can restrike. This cooling period can last anywhere from 1 to 15 minutes or more, depending on lamp design and features. In certain applications, the long starting and restrike time may require a back-up lamp system, or instant restrike lamps in a percentage of the fixtures (at additional cost). In general, HID systems are not recommended for use with occupancy sensors and other areas where frequent switching is the norm.

Dimming—It is possible to dim some type of HID lamps using specialized ballast and electronics. However, the dimmed lamp will result in color shift, and will operate at reduced efficacy.

Lamp Orientation—Some MH lamps and luminaires are designed for lamp operation in a specific position (such as horizontal or vertical), and have specific light output patterns. Operating lamps in positions other than those recommended by manufacturers can seriously affect lamp life and performance.

Output Pattern—Some HID lamp designs can cause the lamps to have highly asymmetric light output. In particular, HID lamps using a double-ended design tend to have very uneven light output patterns. Lamps should be used in the correct orientation and fixture to maximize output.

UV Filters—Both MV and MH lamps can be a source of ultraviolet radiation. While the UV belongs in the less biologically harmful category, emissions still can affect fabrics, papers, and other UV sensitive materials. Optional filters are available from fixture manufacturers to cut UV emissions

Heat—Because of their design, HID lamps operate at extremely high temperature, especially in the higher wattage lamp sizes. Thus, appropriate handling and mounting precautions need to be taken.

Shielding—MH lamps are also available with protective envelopes or coatings to minimize effects in case of envelope breakage. Under certain operating conditions (exceeding safe operation period, or incorrect orientation/ballast) MH lamps can explode (or "extinguish non-passively.") Luminaires are available with protective guards or shielding for use in sensitive areas.

TABLE 5

FEDERAL ENERGY MANAGEMENT PROGRAM: HID EFFICIENCY RECOMMENDATIONS

UPWARD EFFICIENCY	LAMP WATTAGE	CLOSED FIXTURE		OPEN FIXTURE	
		Recommended	Best available	Recommended	Best available
METAL HALIDE					
0	150-399	41	64	insuff data	83
	400-999	53	67	59	89
	1000+	77	83	insuff data	110
1-10	150-399	58	70	insuff data	53
	400-999	62	67	64	70
	1000+	insuff data	99	86	108
11-20	150-399	57	69	insuff data	67
	400-999	55	73	69	75
	1000+	87	87	insuff data	118
20+	150-399	52	73	77	90
	400-999	65	74	insuff data	75
	1000+	96	96	insuff data	96
HIGH PRESSURE SODIUM					
0	150-399	58	76	68	76
	400-999	63	87	84	98
	1000+	insuff data	94	insuff data	95
1-10	150-399	64	73	63	84
	400-999	82	101	89	111
	1000+	insuff data	92	709	121
11-20	150-399	insuff data	89	73	87
	400-999	insuff data	91	94	100
	1000+	insuff data	79	insuff data	122
20+	150-399	75	80	77	90
	400-999	insuff data	102	insuff data	103
	1000+	insuff data	116	insuff data	121

The University Square branch of the Central Carolina Bank in Chapel Hill, NC chose MH lamps to replace incandescents in its lobby. The retrofitted space has 20-foot ceiling and wraparound, high windows, formerly lit by a grid of 28 recessed down-lights, each with a 300-watt incandescent lamp, and 18 90-watt incandescent lamps around the perimeter of the lobby space.

The retrofit consisted of disconnecting the 28 incandescent down-lights and replacing them with eight 460-watt surface-mounted MH luminaires. In addition, the 90-watt incandescent lamps around the perimeter of the lobby were replaced by 16-watt compact fluorescent lamps.

Through the retrofit, the branch was able to reduce its lighting load from over 10 kW to about 4 kW, a 60% drop in lighting energy consumption. The use of the MH luminaires alone was responsible for a reduction of 4.4 kW in lighting energy use (additional kWh reduction from reduced air-conditioning load was not quantified).

Lighting conditions and quality at the bank were improved by the retrofit. Illumination at desk levels improved three fold, from 30 foot-candles to over 90 foot-candles, and the white light produced by the MH blended better with the daylight from the bank's windows.

Source: NC Alternative Energy Center.

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