

Pacific Gas and Electric Company

Emerging Technologies Program

Application Assessment Report #0905

HID Electronic Ballast

Overall Summary Report 3 Site Assessment

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Section 1: Introduction/Site Comparisons

The purpose of this report is to summarize findings of three separate tests on emerging electronic ballast technology. Although strides in the overall efficiency of lighting technology are made continuously, there had been little progress made in the High-Intensity Discharge (HID) lighting field before the last few years. HID lighting is generally used for large bay (high ceiling type) environments where adequate lighting is required at “standard surface heights” (i.e. 3 to 4 feet above finished floor) from lighting fixtures mounted 20 to 30 feet above finished floor. In the lighting industry, there are only a handful of manufacturers with electronic ballast options available for HID lighting. Because electronic ballast technology is relatively new, most existing buildings utilize magnetic ballast technology. In general, all types of lighting with electronic ballasts use less energy, burn brighter, last longer, and start up faster. Therefore, with the advent of electronic HID ballast technology, a new level of energy efficiency in lighting is possible. However, lighting with electronic ballasts has also generally cost more historically, and is not always compatible with existing light fixtures – thus making retrofit solutions more difficult (and more expensive). As with any potentially large project, it is very important to thoroughly evaluate all economic considerations of an electronic ballast retrofit on a case-by-case basis.

Project Hypothesis/Objectives: For the purposes of this report, tests were performed on three different electronic ballasts (produced by three different companies) at three different locations. The main objectives of these tests were to evaluate energy use of the emerging technology as compared to the existing technology; and to characterize the lighting system performance of the emerging technology as compared to the existing technology. Specifically, tests were carried out by (1) measuring pre-selected criteria within a determined lighting area under existing conditions for a period of 7 days, (2) changing out the ballasts of the lighting fixtures serving that specific area, (3) re-measuring the same criteria, and (4) comparing and analyze the difference in values.

In order to fully appreciate the findings of these tests, it is first necessary to differentiate each testing facility, since facility type and facility purpose will undoubtedly influence testing results of lighting products. For instance, comparing lighting tests at a supermarket and a school will only be valuable if those tests take into account the differing lighting needs at each facility.

Site #1, Aurora: The first testing site was a large manufacturing plant in the San Francisco Bay area. The plant hosts a wide variety of operations, and HID lighting is used throughout the entire building. The area selected for testing is used mainly as a staff break area/storage area and is not enclosed by any walls. The area is surrounded by several manufacturing processing areas, making for a noisy and active



environment. Ceiling height in the area is approximately 24-feet and existing HID fixtures hang at approximately 20-feet.

The HID electronic ballasts tested at this facility were manufactured by the *Aurora Ballast Company* (Knoxville, TN). In addition to operating at lower energy inputs, these ballasts are designed to: fit into standard HID fixtures with no audible hum; have continuous and smooth dimmability; be of a significantly lighter weight, and; generate a “perfect” sine wave.

Site #2, MetroLight: The second testing site was an educational facility located in the San Francisco Bay area. The specific room selected is primarily used for practice of self-defense tactics by a local law-enforcement academy. The assessment team inspected several test room options at the educational facility and found that the room selected would be the best candidate to perform product evaluation testing. The room has a T-bar ceiling at a height of 12 feet high. The existing, indirect HID fixtures hang from the ceiling at 7’-11” high, and are full, indirect types with opaque lenses. The associated, existing magnetic ballasts are remotely installed in the ceiling area above the T-bar ceiling (examples of which can be seen in the adjacent photos). Wires in conduit connect the hidden ballast to the exposed HID hung from the ceiling grid.



The HID electronic ballast tested at this facility was manufactured by the *MetroLight Corporation* (Netanya, Israel). According to the manufacturer, these electronic ballasts, a product named “Smart Electronic Ballasts”, offer “...improved energy efficiency, light output and reliability”. Further, they claim that by using their product, lamps can be dimmed from 50-100% of full power without flickering and without any damage to the lamp.

Site #3, ROM Light: The host site participating in this study is a 24-hour grocery store in the Stockton/Central Valley Area. HID lighting is used throughout the entire facility. The area selected as a test area for the store is used mainly to display packaged and bottled dry goods. It is located in the corner of the store (enclosed by 2 walls), and there are also some frozen food freezer display cases and refrigerated/non-refrigerated beverages on display. Surrounding the area, there are continuations of aisles of more dry goods with availability to consumers at all times of the day and night, making for a noisy and active environment. An example of these existing fixtures is shown in the adjacent photo.



Ceiling height in this area is approximately 24 feet high. Existing HID fixtures hang from the ceiling at about 20 feet high.

The HID electronic ballast tested at this facility was manufactured by *ROMLight International, Inc. (ROMLight)*. *ROMLight* has designed and manufactured a new type of HID electronic ballast that claims to operate HID lamps with lower energy losses and superior lumen maintenance than magnetic ballast technology. This claim results in savings in the “cost of light” as a result of either: (1) requiring fewer fixtures in new installations; or, (2) reducing the wattage per fixture in retrofit applications. *ROMLight* claims that their ballasts operate at 97% efficiency compared with 75% to 85% efficiency of magnetic ballasts. The improvement in lumen maintenance reduces excessive “re-lamping” costs also.

Section 2: Installation Costs & Considerations

There are three basic cost components that will be discussed in this section: electronic ballast cost; installation cost; and, additional costs. Electronic ballast cost is quite simply the “per unit” cost of the electronic ballast being tested; installation costs include labor (adjusted per location) and incidentals (basic installation parts, etc.), and; additional costs are those costs not anticipated before installation was performed, but nonetheless essential to proper installation (i.e. unknown costs). Also in this section, there will be a discussion on overall installation procedure, with emphasis on compatibility with existing equipment and installation time. Finally, all costs will be tallied and broken down per foot (tested area square footage) for final comparison purposes.

Site #1, Aurora: In total, five (5) HID fixtures were retrofitted from existing high-bay fixtures using 360W metal halide lamps and magnetic ballasts to new high-bay fixtures using 320W metal halide lamps and electronic ballasts.

Because of the manufacturer’s claim that their product would be compatible with any existing fixture (“drop-in replacement”), the original scope of this retrofit project included replacement of the ballast only, leaving the lamp and luminaire in place, and the test plan was developed accordingly. However, installation issues arose during initial change-out which required modification to the plan. As can be seen in the following photo (top, next page), the new HID electronic ballasts would not fit in the housing of the existing ballasts. *Aurora Ballast* was consulted to develop a satisfactory solution. Options for “bracketing” the housing were explored with no success.



The option to replace the ballast housing in its entirety was also explored, but could not fit comfortably with the existing lens, bulb and adjacent mounting assembly. In the end, the retrofit included complete retrofit with new luminaire, ballast, and lamp. It should be noted that after the initial compatibility issue, overall installation of the new ballasts went smoothly.

Because of this scope change, results from this assessment provide useful information and lessons learned for future testing, but are not entirely conclusive for this product. Further testing of these HID electronic ballasts is planned where the impacts of retrofit of the *Aurora* ballast *alone* can be evaluated. Additional Assessments of the HID electronic ballasts are also planned to more thoroughly evaluate various lamp and ballast combinations and other issues, such as performance at high temperatures, operation with photocell and dimming controls, and lumen matching.

Costs:

Cost of <i>Aurora</i> electronic ballast (only):	\$200/each
Installation Cost:	\$217.50/each
Additional Cost(s) – new HID fixture	\$375/each
Total Installed Cost for this project:	\$792.50/each

Overall, after the initial issue of incompatibility was discovered and the installation plan was adequately modified, installation proceeded without issue. When compared to other similar products, the *Aurora Ballast* product is of similar price for both the ballast and fixture.

***For the purposes of cost comparisons across all three (3) products, the *Aurora* product will be priced at \$417.50 (installed cost/each); this price includes the cost of the *Aurora* electronic ballast (\$200/each) and installation (\$217.50/each).

Site #2, MetroLight: For this assessment, the original nine (9) indirect HID fixtures using 400W metal halide lamps and magnetic ballasts were replaced with new 400W metal halide lamps and electronic ballasts. As stated in most recent publications from *MetroLight*, new configurations of different ballasts and lamps are continuously tested at their facilities. As new combinations of ballast + lamp configurations are tested and approved for use with the Smart Electronic Ballast, they are published by *MetroLight* as “acceptable for use.” In planning for this case study, we verified that all ballast and lamp configurations used within this assessment have been tested and are compliant with *MetroLight’s* current documentation.



Next, with assistance from our in-house electrician, the old Magnetek magnetic ballasts were removed from each fixture and were replaced with new *MetroLight* electronic ballasts. Overall, the installation went smoothly. There was only one slight modification determined just prior to installation – a metal enclosure was purchased and installed to house the new electronic ballast and keep all conductor connections contained. This eliminated any electrical components from being exposed to the environment (safety hazard), as well as provided for a clean, professional installation.

Costs:

Cost of <i>MetroLight</i> electronic ballast (only):	\$170/each
Cost of new 400W metal halide lamp:	\$34/each
Installation Cost:	\$113/each
Total installed cost for this product:	\$317/each

In comparison to similar products from other manufacturers, the *MetroLight* electronic ballast is substantially lower in price.

Site #3, ROM Light: The project retrofitted 18 HID fixtures with electronic ballasts in a testing area of a 24-hour grocery store. The original (18) high bay fixtures using 360W metal halide lamps and 400W magnetic ballasts were retrofitted with new 320W metal halide lamps and 320W electronic ballasts.

Prior to baseline monitoring, the bulbs of existing fixtures were changed out to new 360W bulbs and allowed to burn-in for at least 200 continuous hours. This was done so that baseline test results would not be skewed by any long-term lumen depreciation, or any other uncertainties of age and/or quality of the existing bulbs. These same, “broken-in” bulbs would then be used to test the new electronic ballasts, as well.



However, at the time of the new electronic ballast installation, the existing bulbs would not make contact with the ceramic sockets provided with the new electronic ballasts. Prior to this, *ROMLight* was certain that the socket would fit the lamp. As a result, retrofit work was put on hold, and a work-around was explored. Eventually, it was requested by Facilities staff that a new electrical socket compatible with the existing electrical socket on site be included and installed on the power cord ‘whips’ of the new ballasts. This would make for an easy power connection for each



fixture during retrofit. An example of this socket is shown in the adjacent photo.

Furthermore, *ROMLight* contacted us about two more challenges surrounding the lamp socket compatibility issue. It was discovered that the replacement of the existing core and coil magnetic ballast to electronic ballast was more complicated than originally planned because:

1. The existing condition that was created for baseline testing was: existing 400W magnetic ballast with 'newly burned-in' 360W pulse start lamps. (The use of 400W ballasts with 360W lamps was typical throughout the rest of the grocery store.) In this scenario, the magnetic ballast draws only 360W to operate. However, when the 400W magnetic ballast is replaced with a 400W electronic ballast, the settings in the *ROMLight* electronic ballast will cause it to deliver 400W to the lamp, regardless of the rating of the lamp. This will cause a post-installation scenario that is not compatible with existing conditions; and,
2. Furthermore, when a *ROMLight* electronic ballast is used with the existing lamp chosen (360W probe/pulse start lamp), a lamp socket that is 'closed-rated' (i.e. requires a lens cover) is required. In the existing baseline condition, the existing 360W probe/pulse start lamp was coupled with an 'open-rated' socket (i.e. no lens cover), as that is the existing conditions of the other fixtures at the site. This is not an issue with magnetic ballasts. However, retrofitted with electronic ballasts, a potential safety hazard is created, should the probe/pulse start lamps rupture.

In order to alleviate this issue, the following steps were taken:

1. The electronic ballasts were to be sent back to the factory (in Ontario, Canada) to be 're-tuned' to deliver 320W; and,
2. Lamp sockets will be factory-replaced with ones compatible with new 320W lamps, also supplied at no additional cost to the owner or project. (The 320W rating was chosen as a satisfactory replacement to the existing 360W lamp/400W magnetic ballast condition as it resulted in similar light levels at measurable heights, according to the manufacturer's representative).

In addition, replacement parts for the original electrical power socket 'whips' were not found, as they were discovered to be discontinued. Resulting work-around was to re-use the existing socket connectors and splice them into the power cord connectors of the new ballasts.

All ballasts were eventually re-tuned and shipped back for installation. In addition, new 320W lamps were sent with delivery. Finally, installation of all ballasts and lamps were completed. However, because of the new lamps



in the modified scenario, an additional burn-in time of 200 continuous hours was required prior to post-installation monitoring & measurements.

Costs:

Cost of <i>ROMLight</i> electronic ballast (only):	\$163.64/each
Cost of new 320W luminaire:	\$ 40.00/each
Cost of labor to install:	\$417.50/each
Total Installed Cost for this product:	\$621.14/each

In comparison to other manufacturers of similar products, the *ROMLight* ballast is comparable in price.

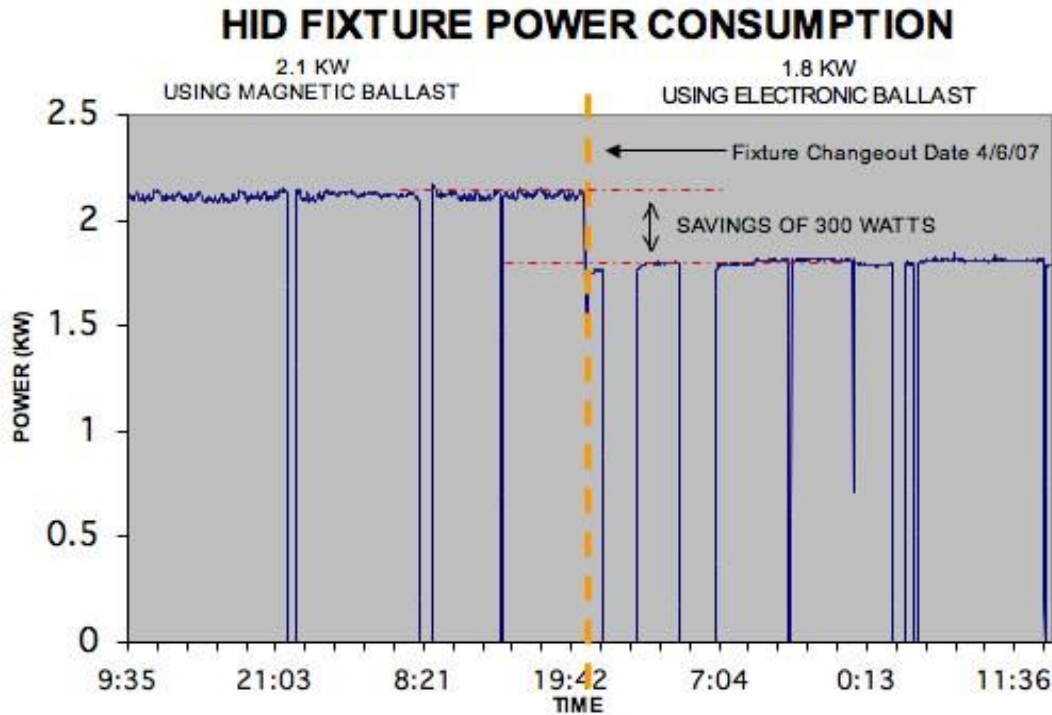
Section 3: Technical/Testing Criteria

In this section, technical aspects of the electronic ballasts will be compared. Noise, light and temperature findings for all electronic ballasts tested will be summarized and compared. Testing criteria, such as amps, volts, kilowatts, kilowatt-hours, power factors, and harmonics will also be compared in this section.

Site #1, Aurora: Selected criteria was discussed with the evaluation team and determined after discussion with staff at the test site, evaluation of the product, and after pre-monitoring inspection of the specific test area. For this site, testing criteria included electrical power consumption, light output, temperature output, and sound output.

Power - For testing purposes, a current transducer was connected to the electrical circuit that provides power to the five (5) HID fixtures that were part of this assessment project – a power meter data recorder was also connected to the current transducer to record a number of electrical properties, including amps, volts, kW, kWh, power factor, and harmonics. Recorded data spanned a period of seven (7) days each for pre- and post-installation phases.





Test results showed that total power demand pre-installation was about 2.1 kW, and total power demand post-installation was about 1.8 kW, resulting in a savings of about 0.3 kW, or 0.06 kW per fixture. The new HID fixtures therefore operate at a lower demand (kW) and a resulting lower energy usage (kWh) over time.

Light - Light level readings (measured in foot-candles) were taken at various points at standard surface height (3 to 4 feet above finished floor) during pre- and post-installation. Readings were evaluated to determine whether the new HID fixture yielded more, less, or the same amount of light output at this height. A portable light meter was used to measure light in a grid pattern at measured intervals.

The post-installation measurements revealed a *significant* increase in light levels throughout the test area – in fact, *all* points tested showed an increase in light output with the new HID fixtures. Percent (%) increase ranged from 50% to as much as 400% - the average increase across the entire test area was between 150-200%. It is important to note that the results of the relative light level testing are not conclusive because the new HID fixtures were installed with new bulbs, which will inherently provide higher light levels than a bulb that has been in operation for many hours. However, the collected data reveals that *it is likely* that the new fixtures will provide a higher level of light output even after “burn-in” time and lamp depreciation to the equivalent life of the existing lamps. Also, due to the “mid-stream” change in project scope, the opportunity to



thoroughly evaluate and measure the energy savings afforded by the lumen matching capability of the electronic ballasts was lost – this is a very important feature of the *Aurora* electronic ballast design, as it allows the tuning (dimming) of the ballast to match existing light levels, while inherently providing a higher lumen output. Future assessments should include this testing.

Temperature – The temperature at two (2) randomly selected fixtures was monitored pre- and post-installation to explore whether the new HID fixtures operated “cooler” at a lower ambient temperature. For this test, temperature sensors were placed 12” below the center of the bulb, taking into account how much overhang the fixture lens protruded below the bulb position.

Pre-installation ambient air temperature readings were between 110 and 130 degrees Fahrenheit (degF), while post-installation ambient air temperature readings were between 95 and 115 degF. This proved, that in operation, the new HID fixtures ran approximately 15 degF cooler than the existing HID fixtures. It should be noted that during post-installation testing, one of the fixtures previously tested for temperature was not available because stacks of pallets in the area made it impossible to set-up the sensor monitor in the same position. As a result, the sensor was moved to another fixture – this action should have negligible affects on the overall results of this test.

Sound Levels – Sound level readings were taken on four (4) equidistant sides of each of the five (5) HID fixtures during pre- and post-installation. This test was aimed at determining if the new HID fixtures were more, or less, noisy than the existing HID fixtures.

Findings for this test proved to be inconclusive, as it was determined during post-installation testing that the noise level generated by surrounding manufacturing equipment was a heavily influential factor in overall readings, and as such, accurate data could not be collected.

Harmonics – For harmonic analysis, instantaneous readings were taken during pre- and post-installation testing phases. Electrical harmonics are built up “stray” currents that transpire heat in the power system. A build-up of harmonics causes sensitive equipment to fail as well as introduces a significant amount of heat that eventually needs to be dissipated.

Pre-installation harmonic distortion measured at 20%, while post-installation harmonic distortion measured at 11%, showing that the new HID fixtures operate at a lower harmonic distortion than the existing HID fixtures.

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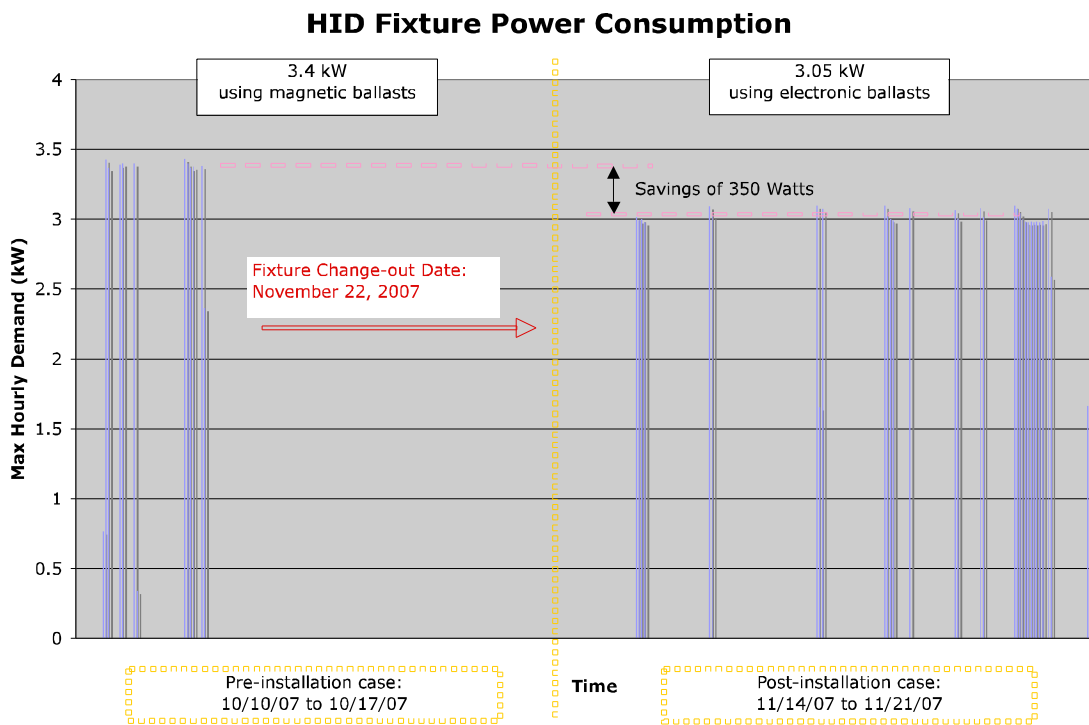
**Site #2, MetroLight:** Selected criteria were created by the assessment team through discussions with the evaluation team, test site representative, and PG&E representative. The final implementation plan was documented and agreed upon after further evaluation of the



product to be installed and after a pre-monitoring inspection of the test site by both the assessment team and the PG&E representative. Testing criteria, selected for evaluation of the product, included electrical power consumption, light output, and temperature output and sound output.

Testing criteria for this product attempted to take into account the effect of lumen depreciation by allowing a burn-in period of at least 200 hrs for all installed lamps. Also, tuning adjustments (“dim-down”) were made to the new HID fixtures so as to provide light output “as-equal” to the existing fixtures. Following the criteria identified in the pre- and post-installation Monitoring Procedure, the key findings from this lighting demonstration project are summarized as follows.

**Power** – With approval from Site Facilities staff, our in-house electrician connected a current transducer to the electrical circuit providing power to the nine (9) HID fixtures within the test space. A power meter data recorder was subsequently connected to the current transducer in order to record a number of electrical properties: *amps, volts, kW, kWh, power factor and harmonics*. Unless otherwise stated, recorded data spanned over a period of at least 7 days each for all pre- and post-installation phases.



Test results showed that total power demand pre-installation was about 3.4 kW, and total power demand post-installation was about 3.05 kW, resulting in a savings of about 0.35 kW, or 0.039



kW per fixture. The new HID fixtures therefore operate at a lower demand (kW) and a resulting lower energy usage (kWh) over time.

**Light** – Light level readings (measured in foot-candles) were taken at various points – underneath and between fixture locations - at standard surface height (i.e. 42” above finished floor) during pre- and post-installation phases to explore whether the new HID fixture yielded more, less or the same amount of light output at this height. For this test, the evaluation team used a portable light meter to measure light in a grid pattern at measured intervals. In addition, all windows within the room were covered to prevent any influence from outdoor light onto the light level readings.

The post-installation measurements revealed that light levels throughout the testing area *remained the same* or *slightly lower* than pre-installation conditions. The majority of measured points showed equal, or slightly lower, light output values with the new HID fixtures. Only a handful of measured points revealed an increase in light output with the new HID fixtures. The average percent (%) change across the entire testing area was a decrease of about 1% .

As a result, our test procedure was adjusted to *exclude* the secondary step of dimming down for lumen matching that is historically completed to maintain a light level equal to existing conditions. It is unclear why light levels did not change. We speculate that the type of lens used and the direction of luminance (i.e. 100% indirect) on the tested fixtures provided too much light filtering to the ambient space to show a significant change in light levels. Regardless, this surprising result will be adjusted for in future lighting assessments.

**\* Lumen Matching better explained:**

Lumen matching is a term used by electronic HID ballast manufacturers. It means that the electronic HID ballast brightness can be adjusted to a lumen value where the lumen output matches that of a typical magnetic HID ballast. The electronic HID ballast can be adjusted either through dimming or installing a ballast that will produce the equivalent of the mean lumen output of a magnetic HID ballast. The lumen matching adjustment of an electronic HID ballast results in the electronic HID ballast providing the equivalent brightness as the magnetic ballast's mean lumen while consuming less power. For example, electronic HID manufacturers claim that a 320W electronic HID ballast can produce the equivalent lumens as a 400W magnetic ballast. How does this impact power? A 400W magnetic ballast requires 469W to operate a 400W HID lamp. A 400W electronic HID ballast requires 421W to operate a 400W lamp. Initial expected energy savings are 48W or 11%. However, the electronic HID is suppose to deliver significantly more lumens than that of a magnetic ballast. Based upon the known lumen depreciation curves for magnetic ballast and those of electronic HID ballast, we can extrapolate to determine the appropriate wattage of an electronic HID ballast which can deliver the same mean lumen output as the magnetic ballast. Continuing with the example, a 320W electronic HID ballast requires 337W to operate a 320W HID lamp produces the equivalent lumens of the 400W lamp operating with a magnetic ballast resulting in energy savings of 132W or 28%.

**Temperature** – The temperature of one randomly selected fixture of the nine (9) HID fixtures was monitored during pre- and post-installation phases to explore whether the new electronic HID fixtures operated “cooler” at the lamp, or rather at a lower ambient temperature. For this test, a temperature sensor was installed 4” away from the bulb and temperature readings were taken throughout the monitoring phases.



When the existing 400W bulb was replaced with a new like-kind 400W bulb, the average fixture temperature dropped from 108 degF to 104 degF. However, when the magnetic ballasts were replaced with the *MetroLight* electronic ballasts, there was a noticeable increase in fixture temperature past the existing pre-installation condition up to 117 degF, a change of almost 12% in increased fixture temperature.

Therefore, in this indirect lighting application in which the lamp was in a vertical down position, it can be concluded that HID bulbs with new electronic ballasts ran “hotter” by a significant 12% average increase. Why this is the case is still uncertain. It is possible that this single selection of 9 fixtures was a measurement anomaly. It is also possible that the output voltage from the electronic ballast to the lamp socket is actually higher than that of the output voltage from the magnetic ballast to the lamp socket, even though the input voltage to the electronic ballast is clearly documented as lower than that of the magnetic ballast. Whatever the explanation, this aspect of HID lighting is one that should be considered for exploration in future lighting assessments.

**Sound Levels** – Sound level readings were taken on at least 4 equidistant sides of one randomly selected fixture of the nine (9) HID fixtures during pre- and post-installation phases. This test was performed to determine if the new HID fixtures were more/less or equally noisy than their existing counterparts.

Our testing of sound levels found an average 7% drop in overall ambient noise surrounding the ballasts just by changing the existing 400 W bulbs with new like-kind bulbs. Subsequently, when the magnetic ballasts were replaced with the *MetroLight* electronic ballasts, sound levels dropped an average 21% more. Overall, with bulb and ballast change-out, ambient noise dropped an average 26% in total. With the most significant portion of this 26% drop attributed to the ballast change-out, it can be concluded that the *MetroLight* electronic ballasts run quieter providing the same service as its predecessor.

**Harmonics** – For harmonic analysis, instantaneous readings were taken during pre- and post-installation testing phases. In the existing pre-installation case, THD (Total Harmonic Distortion) values for volts and amps are at about 5% (volts) and 19% (amps), respectively. When the 400W bulbs were replaced with new like-kind 400W bulbs, the THD change was minimal, at about the same value with no more than 0.2% deviation. Then, when the existing magnetic ballasts were changed with electronic ballasts, subsequent monitoring during this post-installation phase showed that THD voltage dropped about 1% (from 4.6% to 3.7%), and THD current dropped about 5% (from 19.0% to 13.7%).

Therefore, it can be concluded from this testing that the HID fixtures with new electronic ballasts operate at a lower total harmonic distortion than the existing HID fixtures, and suppress the effects of THD at a faster rate.

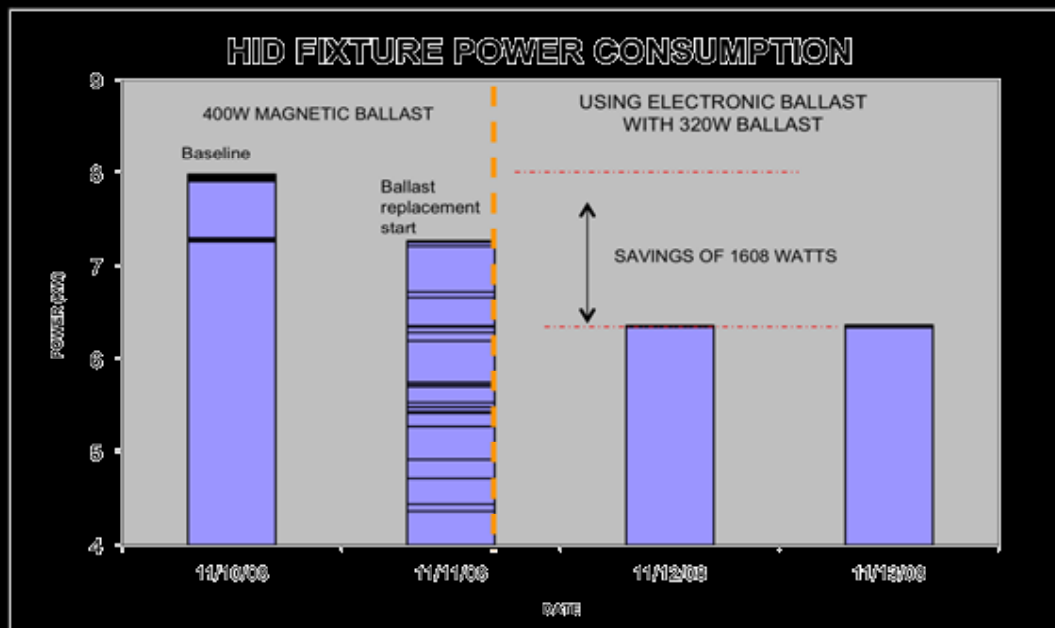




**Site #3, ROM Light:** Selected criteria were discussed with the evaluation team and determined after discussion with staff at the test site, evaluation of the product, and after a pre-monitoring inspection of the testing area by the assessment team and the PG&E representative. Testing criteria, selected for evaluation of the product, included electrical power consumption, light output, and temperature output and sound output.

Testing criteria for this product attempted to take into account lumen depreciation by including a “burn-in” period of 200 hours for all newly installed bulbs. Also, adjustments (i.e. tune-down, or dim-down) were made to newly installed electronic ballasts in order to attempt to match original, baseline light output levels. Following the criteria identified in the pre- and post-installation Monitoring Procedure, the key findings from this lighting demonstration project are summarized as follows.

**Power** – With the assistance of the Facilities staff, a current transducer was connected to the electrical circuit that provides power to the (18) HID fixtures that were a part of this assessment project. A power meter data recorder was subsequently connected to the current transducer to record a number of electrical properties: amps, volts, kW, kWh, power factor and harmonics. Because of the nature of the testing facility (i.e. 24-hour grocery store), kW readings were only



This graph shows that the power demand prior to change-out is about 8.0 kW and after the change-out the power demand is about 6.4 kW, a savings of about 1.6 kW (20%), or 0.0893 kW per fixture. The new HID fixtures operate at a lower demand (kW) and a resulting lower energy usage (kWh) over time.

**Light** – Light level readings (measured in foot-candles ~ fc) were taken at various points at standard surface height (i.e. 3 to 4 feet above finished floor) during pre- and post-installation to explore whether the new HID fixture yielded more/less or the same amount of light output at this height. For this test, the evaluation team used a portable light meter to measure light in a grid pattern at measured intervals. Measurements were taken at 42 inches above finished floor.

The post-installation measurements revealed an overall slight decrease in light levels throughout the testing area. Overall foot-candle readings dropped from an average of 85.1 fc to 75.8 fc (11% decrease) – still an adequate level for the requirements of the grocery store.

It is important to note that the results of the relative light level testing are from 2 sets of newly burned-in bulbs (360W in pre-installation conditions and 320W in post-installation conditions), which will inherently provide higher light levels than a bulb that has been in operation for a longer period of time. In this particular study, due to the mid-stream change in scope, we did not have the opportunity to thoroughly evaluate the effect of the electronic ballast *solely* on the overall fixture, though that was the goal at the initial onset. Future assessments should include this testing.

This data shows that it is likely that the new HID fixtures will provide a comparable level of light output, with lower wattage bulbs, even after lamp depreciation over time. Taking into account that this occurs while using less wattage is a significant point of note and describes a key feature of the *ROMLight* electronic ballast technology design: the ballast inherently provides higher lumen output, yet can be “tuned” (or dimmed) to match existing light levels. This has the potential to provide higher energy and cost savings.

Because of the dimming control system that was installed as part of the electronic ballast system package, light levels could be conceptually tuned down even further to achieve even greater energy savings. Industry-standard light level values for environments like this 24-hour grocery store typically fall between 60-70 fc. This scenario was explored briefly during post-installation monitoring, but was not maintained, as permanent changes to light levels to the site would require prior approval from Facilities management. Using the dimming feature, light levels were dropped to approximately 70 fc (18% decrease), at a dimmed setting of 80%. Measurements were taken, and then dimming was raised to 100% levels again.

**Temperature** – The temperatures of 8 randomly selected HID fixtures were monitored pre- and post-installation to explore whether the new HID fixtures operated “cooler” at a lower ambient



temperature. For this test, temperature sensors were placed 12” below the center of the bulb, taking into account how much overhang the fixture lens protruded below the bulb position.

*Temperature Readings:*

|                                                               |                    |
|---------------------------------------------------------------|--------------------|
| Overall Average Ballast Temperature – Pre-Installation (*F):  | 114.8 deg F        |
| Overall Average Ballast Temperature – Post-Installation (*F): | 103.9 deg F        |
|                                                               | <i>9% decrease</i> |

Results conclude that ballast temperatures run slightly cooler with electronic ballasts when compared to magnetic ballasts.

**Sound Levels** – Sound level readings were taken on 4 equidistant sides of 8 randomly selected HID fixtures during pre- and post-installation. This test was to determine if the new HID fixtures were more/less noisy than the existing counterparts. Sound level readings for both pre- and post-installation phases are included in the Appendix of this report.

*Sound Readings:*

|                                                       |                        |
|-------------------------------------------------------|------------------------|
| Overall Average Sound Level – Pre-Installation (dB):  | 58.2 dB                |
| Overall Average Sound Level – Post-Installation (dB): | 58.6 dB                |
|                                                       | <i>&lt;1% increase</i> |

Results conclude that sound levels do not significantly change between magnetic and electronic ballast operation.

**Harmonics** – For harmonic analysis, instantaneous readings were taken during pre- and post-installation testing phases. Electrical harmonics are built-up “stray” currents that transpire as heat in the power system. A build-up of harmonics causes sensitive equipment to fail as well as introduces a significant amount of heat that eventually needs to be dissipated.

It can be concluded from this testing that the new HID fixtures operate at a slightly higher harmonic distortion than the existing HID fixtures. Though harmonic distortion is at a higher level (22% increase), the overall harmonic distortion levels in both pre- and post-installation cases are insignificant to the overall power system.

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## **Section 4: Savings & Payback**

Comparing overall savings is one of the most important factors to consider when trying to determine overall comparative product performance. However, simple comparisons can be



problematic, as they might not take into consideration site differences, use differences, and other factors. “Savings” is defined here as the amount of money (in dollars) and energy (in kWh) that is not expended due to the installation of a more efficient product. “Payback” is defined here as the amount of time (in years) it takes to recapture the cost of an upgrade through the savings (in dollars) that are realized by that same upgrade.

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**Site #1, Aurora:** As noted earlier in this report, total installed cost, per/fixture was \$417.50. Based on monitoring and information obtained during the testing phase, the average annual hours of operation for the lights is roughly 85%, or 20.4 hours/day – 7446 hours of yearly operation. Also, as noted before, each new HID fixture presented a savings of 0.06 kW. Given the operating conditions of the testing area, hours of operation, and current utility electrical rates (\$0.084/kWh) for this manufacturing plant, the operational cost savings associated with this drop in energy usage is:

\$36 per fixture per year, and  
424 kWh per fixture per year

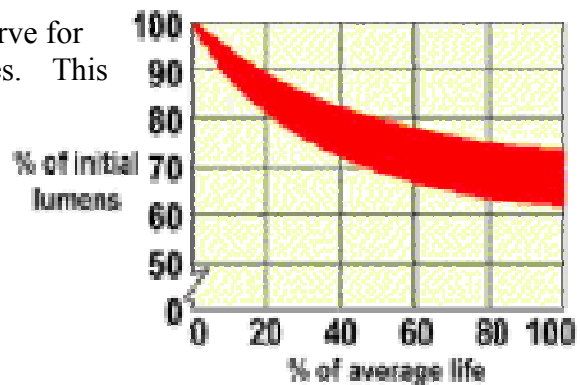
**Simple Payback (installed cost/yearly savings) = 11.6 years**

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**Site #2, MetroLight:** As noted earlier in this report, total installed cost, per fixture was \$317. Based on typical hours of operation for this type of facility, the average daily hours of operation of the lights, excluding weekends, was estimated at roughly 16 hours per day, 5 days per week – 4000 hours of yearly operation (50 weeks). Also, as noted before, each new HID fixture presented a savings of 0.039 kW. Taking into account the average daily hours of operation of this facility, operational cost savings could be calculated. However, in order to obtain the most accurate representation of savings, the effect from lumen depreciation would also need to be factored in.

*Effect of Lumen Depreciation:*

The adjacent graph is a typical lumen depreciation curve for typical HID magnetic “core and coil” lamp fixtures. This graph shows that over the average life of a typical magnetic HID fixture, lumens will depreciate approximately 32% (dropping mean lumens from 100% at 0% avg. life to an average of 68% at 100% avg. life.)



In contrast, HID fixtures with electronic ballasts are generally published with a depreciation of only 10% over the average life of the fixture.

*(Note: MetroLight documentation claims “lamps operated with Smart Ballasts maintain almost constant Lumen output throughout their lifetime.” Outside of this claim, no other chart or quantitative documentation was found to substantiate this. Therefore, without proper documentation from MetroLight, we are assuming generally published lumen depreciation values, which is conservative in comparison to this claim.)*

The electronic ballasts by *MetroLight* installed at this test site have the capability to be “dimmed down” to a lower output wattage matching the expected mean lumen level of the core and coil ballast performance, in order to be matched up in overall lumen intensity throughout the illuminated test space. Though this scenario was not *considered* during this analysis (because overall light levels were relatively the same between existing and proposed scenarios), the effect of lumen depreciation was still taken into account in the energy savings calculations, based upon typical operational hours of 16 hours per day, 5 days per week.

The Power Consumption data shows that it is likely that the new HID fixtures are capable of providing “like-kind” performance (as measured in light level output) while using less energy in the process. In addition, taking into account lumen depreciation (and the ability to “tune down” electronic ballast output wattage), ***energy savings can be more than doubled.*** In this assessment, taking into account the effects of lumen depreciation, a savings of 34% (vs. the original 11.5% based on straight electrical power demand reduction) would have been realized.

Therefore, taking into account typical operating hours, the difference in Power Consumption readings, and the effect of Lumen Depreciation energy savings, the overall effect of converting to HID electronic ballasts is a savings of:

\$48 per fixture per year

404 kWh per fixture per year

**Simple Payback (installed cost/yearly savings) = 6.6 years**

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Site #3, ROM Light: As noted earlier in this report, total installed cost, per fixture was \$621.14. Based on information from Facilities staff and also verified during site work, the annual hours of operation of the lights are 8,760 for the 24-hour facility (24-hrs per day, 365-days per year). According to testing results, each newly installed electronic ballast resulted in a savings of 0.0893 kW per fixture. Given the operating conditions of the testing area, hours of operation, and current utility electrical rates (\$0.15/kWh) for this manufacturing plant, the operational cost savings associated with this drop in energy usage is:

\$102 per fixture per year



680 kWh per fixture per year

Simple Payback (installed cost/yearly savings) = 6.09 years

Section 5: Conclusions

Site #1, Aurora: Preliminary evaluation of the relative light levels between the existing and retrofit fixtures is overall positive, as the new HID fixtures have proven to operate at:

- lower energy input;
- lower temperatures;
- with less harmonic distortion;
- higher light levels, and;
- lower sound levels (although this test proved overall to be inconclusive).

However, conclusive results are not, at this time, possible due to the change in original testing design scope that was necessitated midway through this project. Additional testing of the electronic HID ballasts are planned to more thoroughly evaluate the relevant light levels – these studies will be aimed at verifying the manufacturer’s claims that additional energy savings can be achieved by tuning ballasts to match existing light levels. Additional assessments of the ballasts are also planned to more thoroughly evaluate various lamp and ballast combinations and other issues, such as performance at high temperatures, operation with photocell and dimming controls, and lumen matching.

Results of testing revealed potential reduction in both electrical demand and energy consumption from a retrofit to the HID electronic ballast; however, the installed cost was significant, resulting in a long payback period (11.6 years at current electrical rates). As such, a retrofit project from a base case with 360W metal halide lamps and magnetic ballasts to a proposed case with 320W metal halide lamps with electronic ballasts is not economically attractive at this particular host site. The economics could improve by modifying several parameters during testing, including:

- If the blasts were tuned to adjust light levels to base case conditions, which would lower energy input, and;

- If the retrofit project were at a facility where the utility electricity rate was higher (*\$0.084/kWh is considered to be low compared to other similar facilities*)

Overall, the results of this assessment suggest that PG&E consider this product for future utility-administered programs. However, to provide conclusive results on the performance of the



Aurora Electronic Ballasts, it is our recommendation that further testing be done on this product at different testing sties with different operating conditions and retrofit scenarios, such as:

- Assess retrofit of ballast change-out only;
- Asses lumen matching capabilities;
- Assess electronic ballast operation with photocell control, and;
- Assess ballast operation with dimming (tuning) control.

Site #2, MetroLight: Results of our evaluation revealed potential reductions in both electrical demand and electrical consumption due to the HID electronic ballast retrofit. The installed cost was economical and associated cost savings were significant - especially since lumen depreciation (which represented for lumen matching to the mean lumen level) was taken into account within the savings calculation. This combination resulted in a payback period that was satisfactory (6.6 years).

Results of the various performance testing of the electronic ballasts were “as-expected” in many of the categories tested, yet surprisingly unexpected in others. The electronic ballasts used less energy than their magnetic counterparts, with less harmonic distortion and quieter operation. However, surprisingly, lamp temperatures ran significantly hotter when powered by electronic ballasts than when powered with existing magnetic ballasts. Furthermore, bulbs driven by the retrofit did not produce more light level output to the test space, as expected, at standard surface heights. Only equivalent light levels were found (albeit using less energy demand and consumption in the process.)

Results from this assessment, though slightly varied from its original intent, are still solid and quite conclusive indicating the following – *MetroLight's* “Smart Electronic Ballast” has:

- Energy savings due to ballast change-out
- Energy savings due to the ability to “lumen match” (to the equivalent of the core and coil ballast mean lumen light levels)
- Equivalent light levels at lower energy usage
- Quieter operation with lower sound levels
- Hotter operation with higher ambient temperatures
- Operation with less harmonic contribution to the overall power system, and ability to suppress the effects of THD at a faster rate

Overall, the results of this assessment provide conclusive results on the performance of the electronic ballasts, and it is our recommendation that this ballast be recommended for consideration in PG&E’s future utility-administered programs. Also, because of its significant



contribution to the overall energy savings potential, it is our recommendation that further testing be done on this (or similar) product to assess the effects of dimming capabilities and further investigate the phenomenon of hotter lamp temperatures with electronic ballast operation.

Site #3, ROM Light: Although there were mid-project scope changes necessitated by installation and compatibility issues, performance results from this assessment still do indicate potential benefits from the HID electronic ballast technology, including:

- Energy and demand savings (20%)
- Comparable light levels at higher energy savings
- Operation with comparable sound levels
- Operation with comparable temperature levels
- Operation with little harmonic contribution to the overall power system

Overall, the results of this assessment suggest that PG&E consider this product for future utility-administered programs. However, to provide conclusive results on the performance of the electronic ballasts *alone*, it is our recommendation that further testing be done on this product at a site with existing HID light fixtures that will allow only a complete electronic ballast change-out without any additional modifications, or replacements. It is only under that condition that monitoring and measurements can solely be attributed to the effect of the electronic ballast alone.

Section 6: Final Observations

Included below is a summary table of the findings of the investigations into the three electronic ballasts tested for this report. Included here are the raw values observed for each category that may be expected in other applications. For example as noted previously, payback periods may differ from site to site based on hours of operation and rate charges; the figures below can be used for evaluating a ballast type for varying applications.

Ballast	Cost	Energy Savings/ Unit	Lumen Output	Temperature Change	Harmonic Disturbance	Sound
Aurora Ballast	\$417.50	0.06 kW	Inconclusive	-15 ⁰ F	-9%	Inconclusive
MetroLight	\$283.00	0.039 kW	-1% Average	+9 ⁰ F	-6%	-21%
ROMLight	\$581.14	0.0893 kW	Inconclusive	-10.9 ⁰ F	+22%	- <1%



All values above should be taken in the context provided in their respective sections above. Overall there are a number of indications that the use of electronic ballasts for energy saving should be further studied. Most importantly, determining the likelihood of incompatibility issues between the ballast and fixture in other circumstances will determine if the suitability of ballast replacement retrofits for widespread adoption in any energy saving portfolio. Unexpected results observed above may be found to be unique to these studies and more robust figures for all measures can be determined with larger sample sizes. Thus, further study of all three tested ballasts is recommended.

