

Shedding Light on Unexpected Market Response to High Bay Retrofits

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ABSTRACT

The high intensity discharge (HID) fixture has provided a combination of low quality light, high energy consumption, and operational inconveniences for many decades. Fortunately, exceptional results from HID retrofits including replacing them with T5 or T8 fixtures offer new opportunities to provide improved lighting using less energy. Retrofits also provide an added benefit of allowing lighting controls, which prevents re-strike delays. To date, the market response to utility-offered incentives for HID retrofits has far-exceeded initial projections and the energy savings produced has comprised a surprisingly significant portion of total portfolio savings.

This paper assesses various HID replacement measures and incentives offered by utilities across the country. It compares the actual measure up-take rates to initial plans. In some markets, HID conversions are providing more than twice the measure savings initially proposed in the portfolio plans. This review of HID retrofit programs improves measure design and evaluation efforts by highlighting measure benefits and discussing the potential for receiving utility incentives to reduce implementation costs. Program designers can use this information to help set better targets for this popular energy efficiency measure.

Background

Electric utility companies had demand side management (DSM) programs in place 15 to 20 years ago. When the push for deregulation came about in the 1990s, many utilities prepared to compete in the electric market by splitting their companies into separate entities focused on providing services to different segments of the market. As part of that divestiture, most states eliminated DSM programs and down sized engineering and account management groups. After California's challenges with deregulation, many utilities and states chose to suspend their deregulation activities; however, some utility companies had already lost their engineering talent and cancelled DSM programs. These utilities were forced to slowly rebuild their DSM programs, which today, are in some cases just starting up again, while others are operational and growing rapidly. In the commercial and industrial sectors, DSM programs typically include incentives for reducing energy use. These programs often include both a portfolio of prescriptive energy efficiency measures for common measures and custom measures to allow greater flexibility in assessing the energy savings associated with more complex projects.

One prescriptive measure commonly offered by utilities across the country is replacement of high intensity discharge (HID) fixtures with T5HO (High Output) fixtures. Utilities offer incentives for this measure in a range of formats as summarized in Table 1.

Table 1. Sample Incentive Levels for High Bay Fixture Retrofits

State	Utility	Incentive and Units	Caps or other considerations
AZ	Arizona Public Service	\$75 per fixture for standard 400W HID to 4 lamp T5HO retrofits	Cannot exceed 100% of measure cost
AZ	Arizona Public Service	\$0.11 per kWh reduced for other types of fixtures	Cannot exceed 100% of measure cost and 50% of incremental measure cost
IL	Commonwealth Edison	\$0.40/watt reduced (this was reduced in year 2 to \$0.30/watt reduced)	Cannot exceed 100% of measure cost
NV	NV Energy	\$0.35/watt reduced	Cap at \$100 per fixture; Cannot exceed 100% of incremental cost.
WI	Focus on Energy	\$60 per fixture for standard 400W HID to 4 lamp T5HO retrofits	Cannot exceed 100% of measure cost

Source: Utility incentive program literature – available on program websites

The energy savings for these fixture retrofits are significant even when considering only the direct fixture retrofit savings. In many cases, customers can reduce the number of fixtures required if the original design over lit the area or if the new equipment is more efficient at lighting the same space with fewer fixtures. Adding occupancy sensors also reduces energy use. Replacing HID fixtures can save 20 to 45% of the lighting energy used for the space with a higher quality and more consistent quality of light. While the retrofit results in great energy (i.e., cost) savings, the newer technology also offers greater user flexibility since T5HO are quick-start fixtures that do not require the warm up and cool down times that forced many users to keep HID fixtures on continuously. Restart times on HID fixtures can be as much as 1 - 15 minutes after shut down.

HID High Bay and Low Bay Lighting

Existing high-bay and low-bay lighting is predominantly comprised of high pressure sodium (HPS) or metal halide (MH) HID fixtures often found in school gymnasiums, school cafeterias, warehouses, industrial facilities, big box retail stores, and grocery stores. Although mercury vapor fixtures still exist in the market, this technology has largely been replaced by MH or HPS. Low-bay lighting is similar to high-bay lighting, but with lower wattage lamps and corresponding lower lumens of light output. The high bay terminology generally applies for areas with fixtures that are placed 20 feet or higher off the floor.

One of the main reasons for using an HID fixture to light a large open area is the amount of light obtainable from a single point source. The quantity of light made HID the leading technology despite the fact that the light quality was poor. Many HIDs did not provide a consistently colored light from one fixture to the next; the color also changed over the fixture's life. Although re-strike times for some older HID fixtures can be 1 to 15 minutes, newer HID lamps are instant start or nearly instant start.

The following is a summary (New Buildings Institute, Inc., 2003) of various HID technologies:

- Mercury lamps are one of the oldest and most inefficient of the HID technologies. Their relative efficacy is around 50 lumens per watt. Mercury lamps have a long life but slow lamp lumen depreciation so they last a long time despite producing very low light levels.
- Metal halide lamps were designed as a replacement for mercury lamps. Metal halide lamps provide 50 to over 100 lumens per watt depending on the lamp selection and their application. Metal halide lamps come in a large variety of lamp wattages ranging from 32 to 2,000 watts. Metal halide lamps also come in a variety of lamp bases, color temperatures, and orientations (e.g., vertical, horizontal, universal). Metal halide lamps have a color rendering index (CRI) of 65 to 70.
- High pressure sodium lamps are generally designed for outdoor and roadway lighting. These lamps have higher lumen output and longer life than MH lamps but have a lower CRI and emit a gold colored light. The efficacy of HPS technology is 70 to 120 lumens per watt.

New T5HO and T8 High Bay and Low Bay Lighting

The newest trend in lighting retrofits is to replace high bay and low bay HID fixtures with suspended four-foot and eight-foot luminaires containing 54 watt T5HO lamps with electronic ballasts or T8 lamps with high ballast factor electronic ballasts. Figure 1 depicts new T8 fixtures in a Big Box retail store.

Figure 1. High Bay T8 Fixtures



Source: APS Solutions for Business Incentive Program, Bill Biesemeyer

The advantages of the new T5HO and T8 fixtures are:

- Energy Savings – 25% to 45%

- Instant on and off – No re-strike time
- Better quality light

Both technologies (T5HO & T8) use a similar type of fixture with highly reflective silver or white reflectors. The T5HO fixture is slightly different than the T8 because it does not use the standard four foot lamp. The shorter T5HO lamp requires correct fixtures and lamp holders to handle the size difference. The T5HO fixture requires a ballast designed for the 54 watt T5HO lamp, while the T8 fixture requires one with a ballast factor (BF) greater than 1.0. Generally, the BF is 1.15 to 1.20, meaning that the lamp produces 15 to 20 percent more mean lumens as compared to a “reference” ballast having a BF of 1.0.

Table 2 shows a comparison of T5HO fixtures and T8 fixtures.

Table 2. Comparison of Fixture Specifications

Fixture	4-Lamp T5HO 54W	6-Lamp T5HO 54W	6-Lamp T8 32W HBF
Fixture Wattage	236	354	220
Initial Lumens	20,000	30,000	21,948
Mean Lumens	18,600	27,900	20,851
Mean Lumens/Watt	78.8	78.8	94.8

Source: Osram Sylvania, 2008

Incentive Program Results

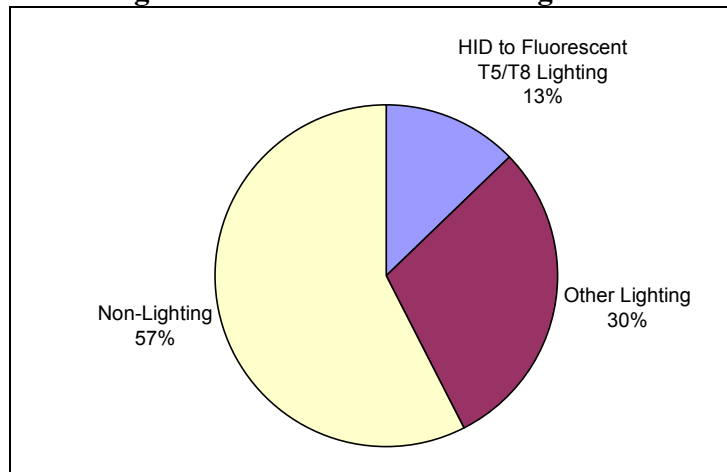
A number of major commercial and industrial (C&I) programs including programs in Arizona, Illinois, and Nevada, among others, offer incentives for the replacement of HID fixtures with T8 or T5 fixture. Replacements can be accomplished using either a prescriptive or custom program, or in some cases, both. Incentive programs vary in age across utilities. Programs in Nevada have been operating for 5 years or longer while the Illinois program is only completing its first year. Market maturity influences the resulting measure mix of each program as does the mix of C&I customers in the utility service territory. Industrial sectors dominate the Illinois program but comprise a lower percentage in the Arizona program. Despite these differences, replacement of HID with fluorescent fixtures creates a significant impact on the total program savings.

Arizona Public Service

The Arizona Public Services Solutions for Business program, a large C&I incentive program in the Phoenix area, projected that lighting would represent 48% of the total incentives paid over a 3 year period (\$5 million out of \$10.5 million). The 4-lamp T5HO incentive of \$75 per fixture was projected to be 2.4% of the lighting incentives and 1.1% of all incentives paid over the 3 year period. An allocation of 2.4% of lighting incentives amounted to approximately 1,600 T5HO fixtures over the 3 year period. Additionally, custom incentives, which would include some types of high bay fixtures, were projected at 4.2% of all incentives paid for the 3 year period.

Analysis of 2.5 years worth of data for the APS program show that over 4,000 T5HO fixtures were installed under the prescriptive measure incentive program and approximately 12,000 T5HO and T8 fixtures were installed under the custom measure incentive program. The amount of incentive dollars paid for T5HO fixtures under the prescriptive measure program was more than 2.5 times the projected number. Combining the prescriptive and custom incentives paid for T5HO and T8 fixtures results in this measure (HID to linear fluorescent) being over 13 times the projected installation quantity. Figure 2 shows the annual savings results over the 2.5 year period. Savings as a result of HID to fluorescent T5 or T8 measures comprise 13% of all savings in that period.

Figure 2. Percentage Breakdown of Gross Savings for APS C&I Retrofit



Source: APS Solutions for Business Program
Notes: Total Savings = 136.5 GWh

Table 3 shows the breakout of the prescriptive T5HO fixtures installed and the custom T5HO and T8 fixtures installed in the 2.5 year period. The row showing prescriptive T5HO only includes 400W HID to 4-lamp T5 fixtures. Other retrofit types are included in custom T5HO and custom T8 categories.

Table 3. High Bay Lighting Incentive Results for APS

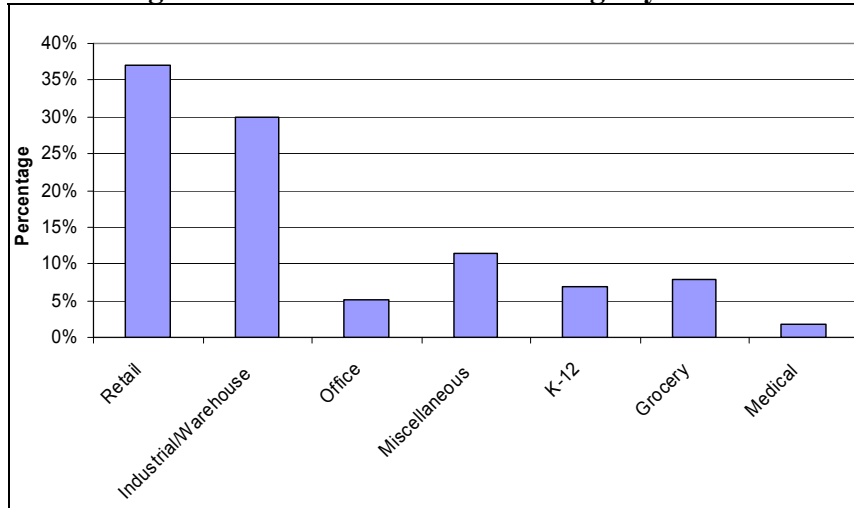
Measure	No. of Fixtures	Incentives Paid	kW Saved	kWh Saved	Increment Cost	Incentive \$/kWh	Incentive per Fixt.	Incr. Cost per Fixt.
Prescriptive T5HO	4023	\$301,725	1062	4,638,519	\$438,507	\$0.065	\$75	\$109
Custom T5HO	5399	\$485,883	618	4,448,005	\$1,591,160	\$0.109	\$90	\$295
Custom T8	6871	\$784,187	1479	8,434,613	\$1,809,695	\$0.093	\$114	\$263

Source: APS Solutions for Business Program

Many customers transitioned from a 400 watt MH fixture to a 6-lamp T5HO fixture because the light output of the 6-lamp is similar. Some customers moved to a 2-lamp or 3-lamp T5HO if they did not need as much light so while there are many fixtures, there is also a range of solutions being implemented in the APS market.

Figure 3 below depicts percentage of total T5HO savings across various sectors.

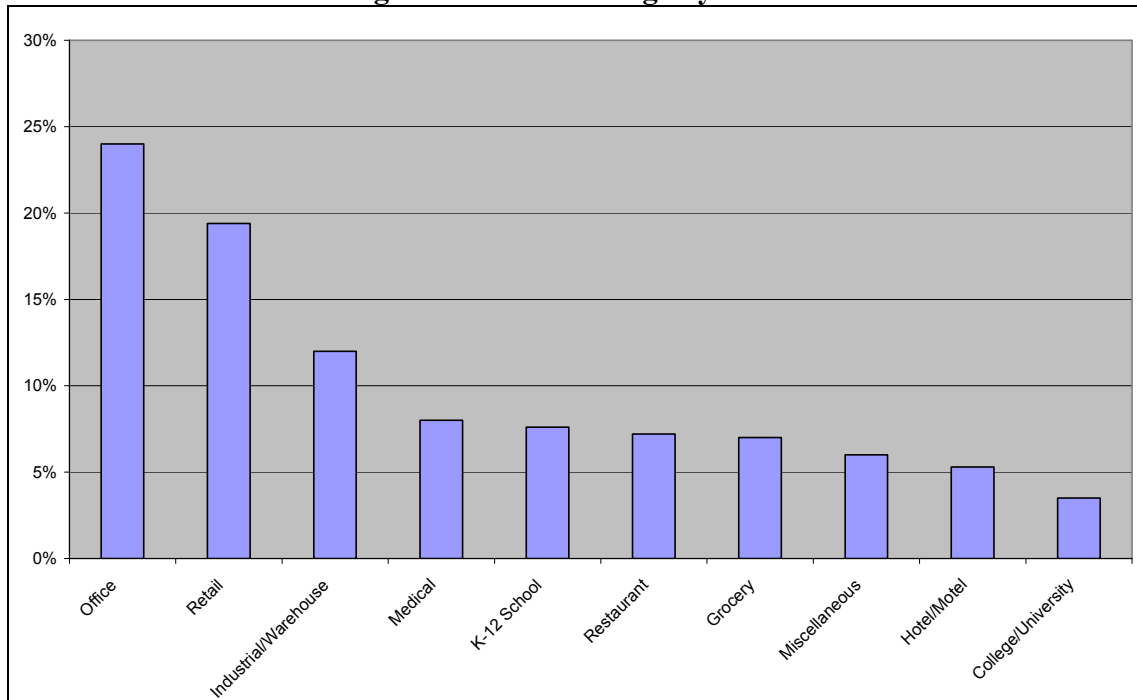
Figure 3. Normalized T5HO Savings by Sector



Source: APS Solutions for Business Program

These numbers are normalized by each sector's usage and show the expected savings breakdown if all sectors have the same usage. The actual electric usage of each sector is shown in Figure 4. As expected, the largest prevalence of these lighting solutions comes from the retail, industrial, and warehouse sectors.

Figure 4. Electric Usage by Sector



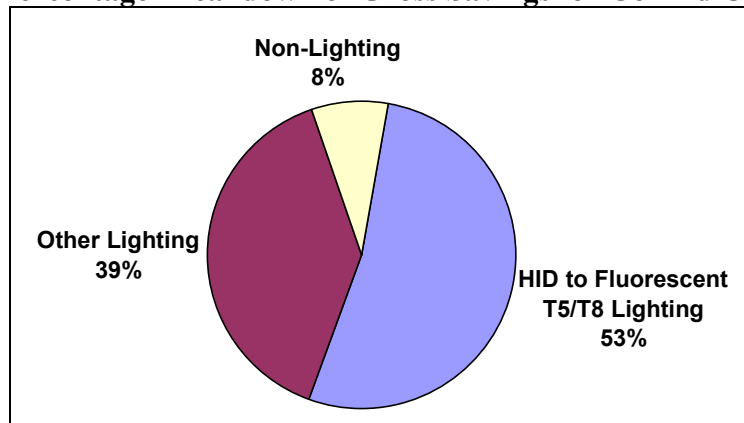
Source: APS Solutions for Business Program

Commonwealth Edison

The Commonwealth Edison (ComEd) Smart Ideas for your Business Program, a large C&I project in northern Illinois, also maintains high interest in the high bay portion of their rebate program. The program operates in a market with a significant number of warehouses and multiple industries. While initial projections expected roughly 15-20% of the program savings to come from the high bay retrofits, the program received just over half of its savings (53%) from these new T5/T8 fixtures in the first program year.

Figure 5 depicts savings by lighting type in the first year of the program. Lighting comprises 92% of all savings as it is a relatively inexpensive and easy measure for both customers and contractors. In addition, the program interest was extremely high so short term lighting projects tended to be the ones that participated in the first year due to their relatively shorter planning and installation time. As shown, the majority of ComEd lighting savings come from HID to fluorescent T8 or T5 retrofits.

Figure 5. Percentage Breakdown of Gross Savings for ComEd C&I Retrofit

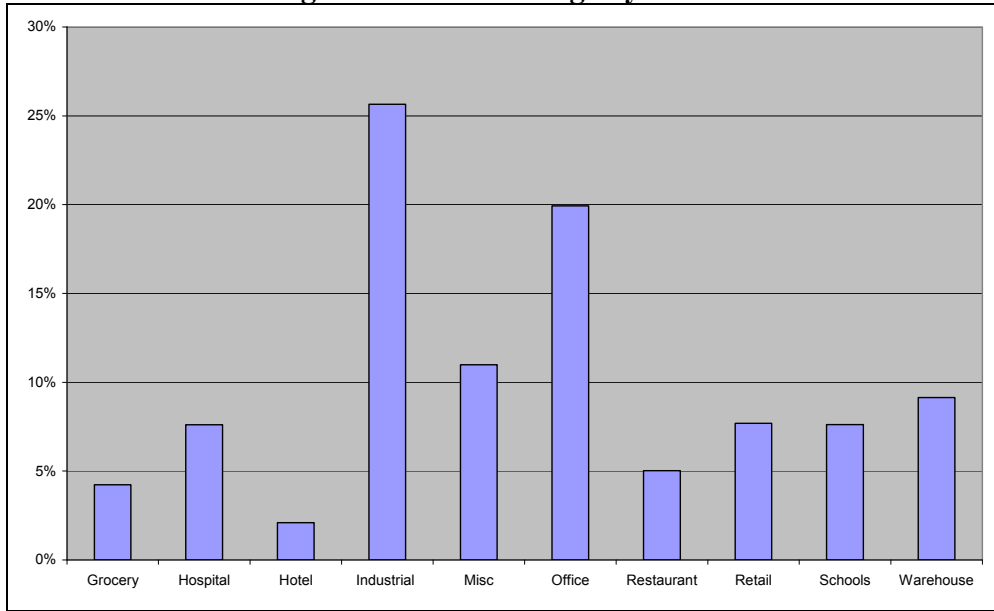


Source: ComEd Smart Ideas for Your Business Program

Notes: Total Savings = 82.5 GWh

This measure's prevalence in the region partly reflects the high percentage of industrial facilities and warehouses as shown in Figure 6.

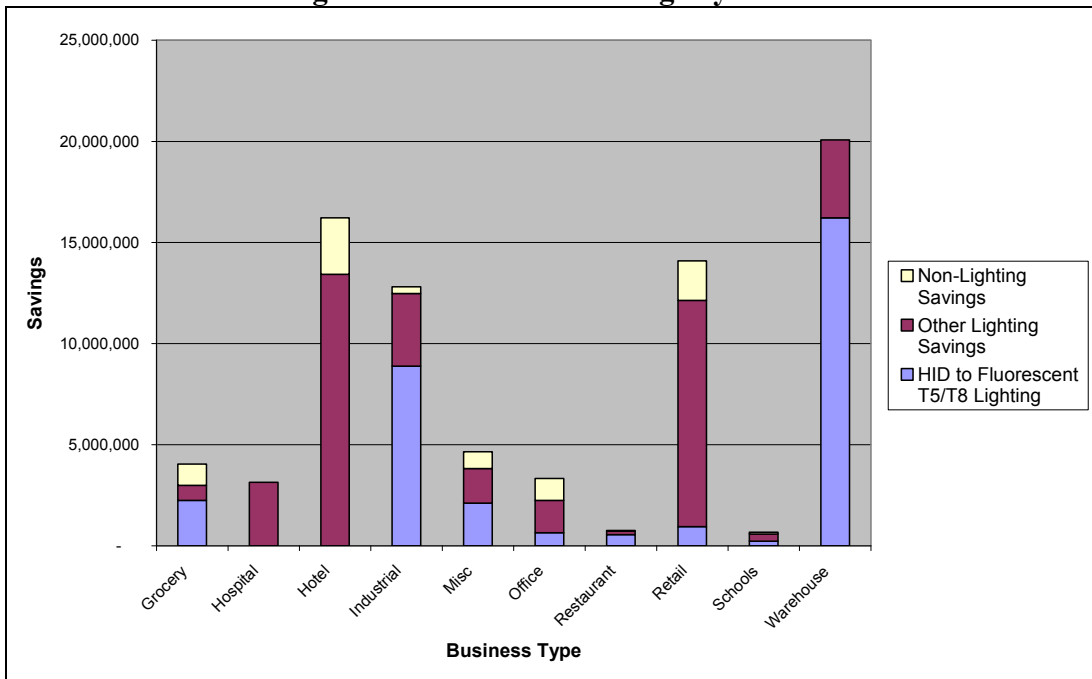
Figure 6. Electric Usage by Sector



Source: ComEd Smart Ideas for Your Business Program

Not only do the industrial and warehouse sectors comprise a large portion of the total electric usage, but they disproportionately account for a large amount of HID to fluorescent savings. To better understand the impact that HID to fluorescent measures have on these two particular sectors, Figure 7 depicts savings by business type normalized by usage.

Figure 7. Normalized Savings by Sector



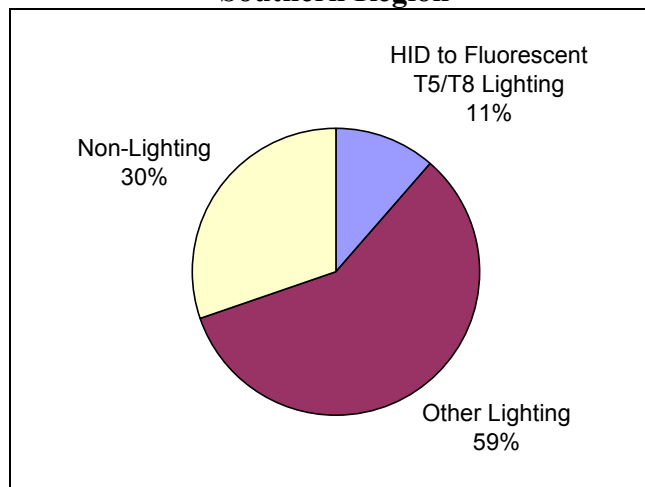
Source: ComEd Smart Ideas for Your Business Program

The normalized savings used above represents real savings values, taking into account the usage differences of each sector. These numbers represent expected savings values if all sectors had the same usage. It is apparent that the program's savings have come disproportionately from warehouses due to the HID to fluorescent measures. The measure is also a large component of the industrial sector savings. With the first year of the ComEd program showing such a large interest in this measure, the program team opted to reduce the program incentive from \$0.40/watt reduced to \$0.30/watt reduced to help spread out the incentives across more customers and technologies. Initial interest is strong for the year two program and this measure in particular.

NV Energy

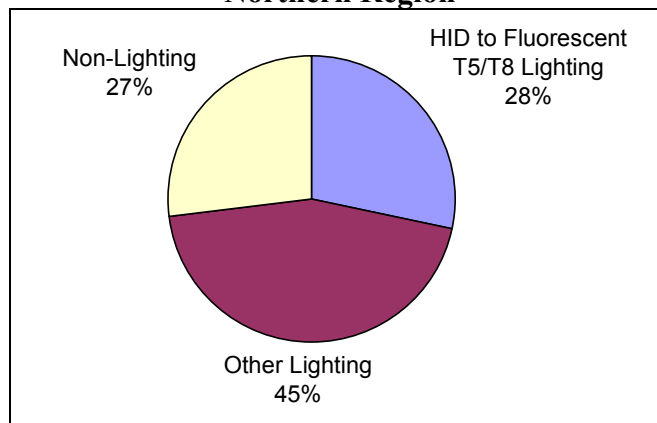
The NV Energy Sure Bet Program has also seen significant energy savings from the HID to fluorescent measures. NV Energy's C&I incentive program has operated in two regions in Nevada for more than 5 years: the Northern region, centered near the Lake Tahoe area in Reno and Carson City, NV, and the Southern region, centered around the Las Vegas area. While the program's duration has allowed the program team to align the HID to fluorescent fixture savings with expectations, this example demonstrates how even within a Utility Company's two service territories, the results can vary widely for this measure. NV Energy's Northern territory has a much higher industrial base than the more service oriented businesses found in the Southern region. Due to the significant difference in customer mix in the two regions, savings are presented in Figures 8 and 9 by region.

Figure 8. Percentage Breakdown of Gross Savings for NV Energy C&I Retrofit – Southern Region



Source: NV Energy SureBet Program
Notes: Total Savings = 68.2 GWh

Figure 9. Percentage Breakdown of Gross Savings for NV Energy C&I Retrofit – Northern Region



Source: NV Energy SureBet Program
Notes: Total Savings = 32.7 GWh

In either case, HID-to-fluorescent retrofits have made a significant impact on the NV Energy program results.

HID Retrofits as Part of a Program Portfolio

A high level of interest in HID retrofits is good for programs as this measure is cost effective, easy to install, and can quickly create energy savings in new markets. In markets where there have been low levels of energy efficiency activity, the incentives provide strong economic motivating force. There are, however, some additional challenges with this measure that are being reviewed through several other studies currently underway. The energy savings that many utilities rely on for this and other measures comes from the Database for Energy Efficient Resources or DEER database. The DEER database was developed in California as a central repository for energy savings and measure cost data for all energy efficiency measures used in programs throughout the state. While the DEER database is very valuable, the numbers are developed for the California market. One issue with the high bay lighting is the operating hour assumptions that DEER uses for this measure. In many cases, the DEER operating hours for warehouses are much lower than warehouse use in other regions of the country based on the type and usage of typical warehouses in the California market; however, many other regions have used the reference to calculate energy savings for this growing measure. Since many prescriptive programs use a deemed-savings value for this measure, they assume standard operating hours. While some programs calculate the savings using a custom program, this approach adds analysis cost to the measure when many applications are identical. Programs can use customer reported operating hours as well, but those too can be erroneous. Furthermore, as new technology provides instant on and off functionality, many post retrofit conditions result in widely different operating hours than were used with the older equipment.

Conclusions

The demonstrated benefits of T5 and T8 technologies, along with the first-cost reduction made possible by incentive programs, have induced major changes in high bay applications. Many DSM programs have seen large portions of savings come from HID to T5 or T8 fixtures and these measures have contributed far more savings than originally expected. This measure has helped DSM program implementers to achieve their fast start goals as new programs are initiated. These higher than expected returns suggest that there are huge potentials to change out HIDs to the more energy efficient, higher light-quality, and more flexible T5 or T8 fluorescent fixtures in many markets. In order to insure that this measure which makes up a huge portion of the energy savings potential is accurately accounted for, further review of the operation hours should be continued including more investigation into those facilities that operate on a 24/7 schedule as they replace lamps as well as install occupancy sensors on those new fixtures.

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