Lighten the Load: Investments in New Lighting Using Tax Incentives

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ABSTRACT

Federal tax incentives for implementing energy conservation measures in commercial buildings have been extended to include equipment placed into service by the end of 2013. This four-year window provides the opportunity to take advantage of significant tax deductions that can easily be attained through energy-saving lighting retrofits. This paper explores how the installation of new lighting technologies advanced by the Department of Energy, coupled with energy conservation standards for buildings and these limited-time tax deductions can have immediate paybacks – in some cases, the deduction pays for the entire lighting project and the building saves as much as 50% of the lighting energy for the foreseeable future.

Specific focus will be on the how to move investment decisions toward implementing energy-saving lighting technologies using the tax deductions included in the Energy Conservation and Efficiency Provisions of the Energy Improvement and Extension Act of 2008. The emphasis on lighting is warranted due to its ease of installation, rapid deployment, and high rate of return on the investment. The paper will discuss new lighting approaches advocated by the US Department of Energy that can achieve significant energy savings and attain the maximum tax benefits allowable under the new legislation in common building installations. The paper furthermore reviews how the widespread implementation of these technologies and methods have the potential to dramatically and permanently reduce demand load and energy use. As a result, the need for new power plants can be eliminated, and the load on the national grid greenhouse emissions will be reduced.

Background

The Energy Policy Act of 2005 (EPAct 2005) included the Energy Efficient Commercial Buildings Deduction (Section 1331), which added Section 179D to existing tax law, allowing specific deductions for installing energy efficient equipment in commercial buildings. The original legislation was somewhat vague and left many details unresolved; the IRS issued their first interpretation in June of 2006 and a further clarification was issued in April 2008, only eight months before the provisions of the legislation were set to expire. As a result, very few projects capitalized on the benefits of this tax law, and the provisions were extended to December 2013 in the Emergency Economic Stabilization Act of 2008.

The tax benefits are generally targeted to reward building owners who reduce the overall total annual energy costs of the aggregate building systems (lighting, HVAC, and hot water systems) by 50% or more as compared to a reference building meeting the minimum requirements of ASHRAE Standard 90.1-2001 (the Standard). These provisions are contained in what is referred to as the "Permanent Rule", which requires that a computer-modeling program be used to demonstrate compliance. There are provisions within the Permanent Rule that allow applicants to install lighting measures only, if the lighting measures attain energy cost savings of 16.667% for the entire building from the Standard; however this also requires a computer program to demonstrate compliance.

A third option within the legislation offers more direct and specific guidelines for energy efficient lighting without having to model the building through a computer simulation. The "Interim Rule" provides simplified rules for lighting in recognition of its ease of installation, rapid deployment potential, and recognized ability to achieve significant energy savings. These guidelines offer a unique opportunity for building owners to install lighting systems that, in many cases, can be immediately deducted and result in a 100% or better Rate of Return. The national benefit of a widespread movement to implement these changes would be the equivalent of removing several power plants worth of demand load from the national grid and eliminating the need for any new coal-burning power plants in the near future.

The tax benefit within EPAct 2005 works as a carrot; for existing buildings with older T12 lamps and magnetic ballasts, the Energy Policy Act of 2005 also includes a stick. The legislation includes provisions that will result in the phased elimination and sale of most magnetic ballasts in new fixtures starting in 2009, and replacement ballasts in 2010. Taken in context, business owners with buildings containing T12 lamps should be advised that their products are being phased out during the next 2 years, meaning that they will eventually be forced to change their lighting to more efficient T8 or T5 lighting systems… and the window of opportunity to receive the Section 179 Deduction is only in effect for the next four years. Timing, indeed, is everything.

Basis for Lighting Tax Deduction –General Rules, Compliance Rules and Standards, and Deduction Allowances

General Rules

In order to qualify for the tax deduction, the building in question must be located in the United States and costs must be associated with depreciable (or amortizable in lieu of depreciable) property that is within the Scope of ASHRAE 90.1-2001. The calculated lighting levels (illuminance measurements) must meet the minimum requirements as set forth in the IESNA Lighting Handbook, Performance and Application, Ninth Edition, 2000. The equipment must be placed into service prior to December 31, 2013.

Compliance Rules

Wattage limitations. The basis of the tax deduction is the Lighting Power Density (LPD) of lighting within the building as compared to ASHRAE Standard 90.1-2001, Tables 9.3.1.1 (Building Area Method), and 9.3.1.2 (Space-by-Space Method). These calculations for LPD reduction do not include additional interior lighting power allowances included in other sections of the Standard. The applicant can utilize either method; the main criterion for obtaining the tax deductions is that the equipment installed must be utilized to reduce the lighting system LPD to a value that is at least 25% lower than the values listed in either of these tables, with the sole exception of warehouses, in which case the lighting equipment under consideration must yield an LPD that is 50% lower than that listed in the Standard.

Lighting Power Densities are a basic building block of lighting energy analysis, and have been used in energy codes since the late 1970's with the advent of California's Title 24 Energy Efficiency Standards. The Standard lists various LPD values for different space and building types in recognition that as lighting requirements change, so must the power levels associated with the lighting design. For instance, a hospital will require higher lighting levels than a warehouse, and thus the LPD allowance for a hospital will be higher. As technologies increase in efficiencies, energy efficiency standards re-evaluate lighting products and applications and continually refine the allowances to reflect the increases in efficiency and affordability for consumers (both commercial and residential) to change to more efficient products.

For most occupancies, the minimum values required to qualify for the Tax Deduction are very close to the newest version of the Standard (ASHRAE 90.1-2007) and the maximum tax benefits are obtained by installing lighting systems that have LPD's that are roughly 20-25% below the current 2007 ASHRAE standard. This means that nearly any lighting installed to meet the current Standard LPD's will qualify for the tax deduction and that many of them can achieve the maximum deduction by simply using the most current energy efficient lighting equipment.

Control requirements. The tax deduction would not be viable government program without having some strings attached, and in this case the strings are held by specific types of lighting control requirements. The control requirements are:

- Buildings with over 5,000 square feet must have automatic shutoff of lighting systems;
- All spaces within a building enclosed by walls or ceiling height partitions must have it's own control – if the space is over 10,000 sq. ft., the requirement is to have an individual control for every 10,000 sq. ft., and if space is less than 10,000 there must be a separate control for every 2,500 sq. ft.
- Bi-level switching is required for all occupancies except for hotel and motel guest rooms, store rooms, restrooms, and public lobbies.

The first two requirements are part of the Standard and are easily met in both new construction and lighting retrofit scenarios. Bi-level switching was introduced as a separate component of the legislation that is not in the Standard, and while easily obtainable in new construction, can be costly in many lighting retrofit cases. This is especially true in applications with many small rooms, such as offices with private offices, and has unfortunately deterred many from applying for this tax benefit.

Administrative requirements. The IRS has issued Notices 2006-52 and 2008-40 that provide clarifications for reporting and certification requirements. The certification process must be performed in order to claim the deduction and the applicant must retain this documentation: however the documentation does not need to be attached to the actual tax return. The certification must be signed by an engineer or contractor that is not related to the applicant with a valid license in the jurisdiction of the building location.

Additional administrative issues are clarified in these documents and include eligibility rules for claiming the deduction. Essentially, the tax deduction can be claimed by the party(ies) responsible for investing in the energy conserving measures in privately owned buildings, and the designer(s) can claim the deduction in government owned facilities. In either case, the deduction can be shared, up to the maximum allowed by the credit, among several participants.

Deduction Allowances

For warehouses, the tax deduction for the maximum amount of $0.60 per sq. ft. is allowed if the resulting LPD is 0.60 Watts per square foot or less (this is 50% below the Standard). For all other commercial building occupancies, the deduction is calculated using a sliding scale as follows:

Table 1. Sliding Scale Tax Deduction for Energy Efficient Lighting Installation

If your LPD is this percentage below ASHRAE 90.1-2001:	You Can Deduct This Percentage of the Lighting System Cost:	Up to a Maximum of, in Dollars per Square Foot of Installation
25% (minimum)	50%	$0.30
"x" , between 25% and 40%	100%-(3.333(40% - x%))*	$0.30 + $0.02(x – 25)*
40% or more	100%	$0.60

Formulas derived from EPAct 2005 Section 1331

* Simplification: For every 1% additional reduction in LPD above 25% (and up to 40%), there is a 3-1/3% increase in allowable investment deduction, and the maximum deduction is raised by 2 cents per square foot.

Note that Table 1 makes no reference to any specific type of building occupancy; the percentages can be applied to any of the occupancies listed in the Standard. Table 2 provides an example of how this applies to some typical commercial building occupancies listed in the Standard:

Table 2. Examples of Occupancies and LPD Requirements to Achieve Tax Deductions

Occupancy Type	ASHRAE Standard 90.1-2001 LPD	LPD to get Deduction (25% LPD Reduction)	Maximum Deduction (40% LPD Reduction)	ASHRAE Standard 90.1-2007 LPD
Office	1.3	0.98	0.78	1.0
Retail	1.9	1.43	1.14	1.5
School / University	1.5	1.13	0.90	1.2
Health Care / Clinic	1.6	1.20	0.96	1.0
Manufacturing Facility	2.2	1.65	1.32	1.3

Derived from ASHRAE 90.1-2001with applied percentages for tax deduction.

Table 2 can be interpreted as follows: If an office lighting system is installed that results in an LPD to 0.78 Watts per square foot or below, and all control requirements are met, the business responsible for making the investment to achieve the energy savings can deduct $0.60 per square foot as an immediate deduction for the year that the investment was put into service.

This table also shows that in the case of Offices, Retail, and Schools, the LPD reduction of 25% relative to the 2001 Standard are essentially the same the current 2007 ASHRAE Standard, and that in the case of Health Care/Clinic and Manufacturing Facility, the current 2007 Standard is essentially the same as the 40% reduction from the 2001 Standard. Finally, we note that the additional 15% energy saving requirement for Offices, Retail, and Schools to attain the full 40% reduction is easily obtainable through design decisions that add no cost to a project, as we will describe in detail in this paper.

Lighting Products and Design Strategies

The Lighting Power Densities noted above are somewhat meaningless without context. The comparison of the reductions of the LPD's in the 2001 Standard to the 2007 Standard shows that the goals of the tax incentive are not overly burdensome or difficult to achieve; in fact, the current ASHRAE 90.1-2007 LPD values are the same as they were in the 2004 version, indicating that the cost-effectiveness of achieving the target values of the tax incentive have been well established for over three years.

The formula for lighting energy efficiency is derived from three principal components: lighting equipment (Lamps and Ballasts), lighting controls, and lighting design. From the point of view of this tax deduction, it is presumed that the lighting controls meet the requirements of the Standard; no additional deductions are given for additional controls, and therefore the means to achieve the LPD's required for the tax incentive are through the use of energy efficient lighting equipment and design.

Basic Lighting Equipment

For the purpose of this paper, we limit this discussion to lamps and non-dimming ballasts (the rationale here is that dimming ballasts require a control system, and these are not required for the purpose of achieving the tax deduction). From the point of view of current technologies, the most energy-efficient lighting systems utilize High Performance T8 lamps and Premium electronic ballasts. These terms, "High Efficiency" and "Premium" are now standards within the lighting industry used to denote newer products that have attained a higher level of energy efficiency and additional enhanced performance benefits, such as prolonged lamp life and stability of performance over the system life. Other technologies such as T5 lamps and compact fluorescent lighting also contribute to the arsenal of lighting products, and LED's for general lighting are on the way to market, however this discussion will center on moving the market with the most efficient and cost effective lighting systems available today – which can be simplified into highly efficient T8 lamps and electronic ballasts.

Design

An often overlooked component of lighting energy efficiency is the aspect of proper lighting design, which capitalizes on placement of lighting fixtures and specific lighting strategies to make the basic components of lamps and ballasts be the most efficient they can be within the spaces being illuminated. This powerful tool for achieving energy efficiency can be the most important component of a lighting installation; spaces have been routinely illuminated using highly efficient products that far exceed the tax incentive targets through utilizing proper placement of fixtures, task/ambient lighting strategies, and understandings of visual factors that can be utilized to gain greater energy efficiency. The tool of design is most prevalent in new construction, but there are often cases in lighting retrofits where the advantages of a changed lighting design can substantially improve the energy efficiency and visual comfort of the work environment.

One of the most cost effective design tools for energy efficient lighting is the use of Spectrally Enhanced Lighting (SEL). The principle behind SEL is that the color of light has an effect on vision that is not taken into account with a standard light meter; if a lamp's color is more like daylight than another, the pupil of the eye gets smaller and people will have better visual acuity. For spaces where visual work is important, such as offices, health care facilities, and educational settings, SEL can provide an additional energy savings of 20-25% beyond normal lighting designs simply by choosing a different color lamp using SEL formulas.

The Spectrally Enhanced Lighting formulas were determined through laboratory studies sponsored by the DOE at Lawrence Berkeley National Laboratory during the 1990's (Berman et al, 1992, 1993, 1996), and are easily applied using modifying factors to standard lighting design calculations. The "Visual Effectiveness" method incorporating SEL has been tested in Field studies by the DOE in 2004 and 2006 (DOE 2004 and 2006). These studies demonstrated occupant acceptance and economic viability of this method in full-scale applications using a commonly available 850 fluorescent lamp (Correlated Color Temperature of 5,000K and Color Rendering Index of 82) to replace more commonly used warmer colored fluorescent lighting. These studies showed 50% energy savings compared to T12 installations and 20% compared to otherwise comparable T8 applications.

The importance of SEL as a design tool is in its simplicity of application. It does not require any different equipment other than specifying a different color of lamp, which for fluorescent lighting has no impact on the overall cost of the project. Therefore, SEL is a no-cost add to a project that is already being considered for installation and has an immediate payback – simply for choosing a different color of lighting and performing the calculations to ensure that the light levels are within the IESNA recommendations. Furthermore, as we noted in Table 2, the current 2007 Standard LPD allowances for Offices, Retail, and Educational Facilities falls 15% short of the required 40% reduction from the 2001 Standard that is required for the full tax deduction, a difference easily made up through the use of Spectrally Enhanced Lighting. The use of SEL is therefore a very important tool that for achieving the maximum tax benefit under the current law.

Table 3. Lighting Power Densities of Typical Commercial Office Space Lighting Systems

System Component Description			Data for 3-Lamp Fixture Spaced 8' x 10' on Center		
Lamp Type	**Lamp Color**	**Ballast Type**	**Watts/ Fixture**	**LPD**	**Percent that LPD is below ASHRAE 90.1-2001 LPD**
Std. 34W T12	735	EE Magnetic	108	1.35	NA
Std. 32W T8	735	Std. Electronic	93	1.16	10.6%
HP 32W T8	835	Premium Electronic	72	0.90	30.8%
HP 32W T8 - SEL	850	Premium Electronic	53*	0.66*	49.0%*

Wattages for the first two systems are default values from the California Energy Commission Building Efficiency Energy Standards, Reference Appendices, 2008. Wattages for the last two systems are derived from the GE Consumer & Industrial Lighting Lamp and Ballast 2008 Product Catalogs

* The use of SEL results in lowering the number of lamps from 3 to 2 in this example.

Table 3 shows the incremental wattage reductions as the technology of a lighting system improves. Using a standard office application as an example, we see that the LPD of lighting installations reduce significantly with each improvement in technology and design.

Lighting Economics and Investment Strategies

Lighting economics calculations can be rather complicated. The Illuminating Engineering Society uses a Life-Cycle Cost-Benefit Analysis that includes many variables based on the time value of money and depreciated assets. The tax deduction, on the other hand, brings the deduction to an immediate Present Value and therefore offsets the installation costs at the time of the installation (first year), in some cases to the full value of the investment. This has beneficial financial consequences for all subsequent years that add to the value of the investment; we emphasize here the word *investment* and will presently make the case that there are very few investments that have as high a return as that of replacing old lighting systems with new ones taking advantage of this tax deduction.

New Construction:

In new construction, the overall material costs for lighting systems that meet the criteria for the tax credit are generally lower than if the installation was designed for higher LPD's. This is implicit with higher energy-efficient lighting products, in that lower wattage consumption per square foot is gained through fewer lamps and ballasts - thus there is already a high potential to *reduce* material and installation costs, even though the cost per unit might be slightly higher for the higher-efficiency products. From this point of view, any new construction should capitalize on these tax incentives and attempt to achieve the 40% reduction in LPD from the Standard to attain the full benefit of $0.60 per square foot, since the *incremental* costs of reaching these goals would actually be negative and therefore yield an immediate payback. In other words, the tax benefits are given as an additional benefit to new construction projects that have already lowered their costs by being energy efficient!

In a holistic sense, new construction would benefit most from trying to achieve the full benefit of the tax deduction for the entire buildings, i.e. run the computer simulation and strive for the full $1.80 per square foot deduction. In this case, lighting contributes significantly to this goal by achieving its proportion of savings and adding to the efficiency of air conditions systems. The main concern for new construction projects is the timing of the installation – will the project meet the deadline of having the products in service prior to 2013?

Lighting Retrofits

The strongest and most profitable case for using the tax incentive is to replace existing lighting installations that have T12 lamps and magnetic ballasts. In these cases, energy savings will generally be 50% or more when converting to High Performance T8 lamps and Premium electronic ballasts and the combined tax incentive and energy savings can essentially pay for the cost of the installation within one year. The ability to attain this kind of return on investment is relatively easy in these installations through the reduction in LPD's, however, the lighting control requirement of 2-level switching may add costs that will extend the payback for one or more years. On the other hand, consideration must be given to the fact that T12 lamps and magnetic ballasts will be phased out, and it makes good sense to remove these inefficient lighting systems while the tax deduction is available.

For lighting installations that were installed in the 1990's, the time for replacing ballasts is due, and the extra efficiency gained with the new lighting components along with the tax deduction can easily offset the installation costs. Many installations using the combinations of spectrally enhanced lighting with highly efficient lamps and ballasts are easily meeting the new LPD requirements, and the economic of these retrofits has proven to be very cost effective.

Table 4. Energy Savings Potential for New Technologies and Design in Office Spaces

Values in the Table are the percentages of wattage reduction per sq. ft. when retrofitting the below Base Systems with either of the Retrofit systems to the right.		And you Retrofit with:	
		Retrofit System 1: High Performance T8 & Premium Electronic Ballast, No SEL	**Retrofit System 2: High Performance T8 & Premium Electronic Ballast, With SEL**
If you have:	LPD's	0.90	0.66
Base System 1: 34W T12 with EE Magnetic Ballast	1.35	33%	50.9%
Base System 2: 32W T18 with Std Electronic Ballast	1.16	22.6%	43.0%

Refer to Table 3 for full descriptions of systems described in Table 4.

The Economic Model for Lighting Retrofits

Simple Payback Model

Lighting retrofits in which we presume that we are reducing load (LPD's) without making changes to the schedule of lighting control fall into a category of economic analysis that allows for a simplified model using a Present Worth per-square-foot method analysis. By breaking down the component costs of installation and using the LPD reduction, the simple payback can be expressed as follows:

$$SimplePayback = \frac{1}{kH \times r} \times \frac{x - y}{LPD_2 - LPD_1}$$

Where:
kH = Annual Hours of operation, in thousands of hours
r = Utility rate, in \$/kWh
x = Installed Cost of lighting retrofit, in dollars per sq. ft.
y = Reductions to the Installed Cost of the lighting retrofit that are allowed in the year of installation, such as tax deductions and utility rebates, in dollars per sq. ft.
LPD_2 = Lighting Power Density, post-retrofit
LPD_1= Lighting Power Density, pre-retrofit

This equation simplifies the payback equation to its simplest form, given that the analysis is for a specific building that has set operating hours that do not change with the lighting retrofit. It should be noted that the first term is a constant that affects the payback as follows – the greater the annual hours or utility rate, the shorter the payback. The second term shows that tax deductions and rebates reduce the payback (numerator), as does lowering the new LPD relative to the old LPD (denominator).

Let's take a simple example: An office building with 34 Watt T12 lamps and ballasts has 3-lamp fluorescent fixtures spaced at 8' x 10' centers. The wattage per fixture is 108 Watts. A lighting retrofit is designed to change the system to (2) 850 T8 high-performance lamps with Premium ballasts, with a resulting wattage of 53 Watts per fixture at a cost of \$60 per fixture.

What is the Payback, given that the annual hours of operation are 3600 hours, and the blended utility rate is \$.12/kWh? The investment is being made by a C Corporation with a 35% tax rate.

The first part of the solution is to establish the constant first term, which is (1/(3.6*.12))=2.315.

To calculate the LPD savings, we take the difference in wattage and divide it by the fixture density (108-53)/80, which is .6875 Watts per sq. ft.; Combining this with the constant noted above, we can calculate a new factor that represents the payback amount per dollar per sq. ft. spent. In our example, the payback will be (2.315/.685) = 3.38 years for every dollar per square foot invested to achieve the result.

In our example, the initial cost is \$60 per fixture/80 sq. ft. per fixture = \$.75 per sq. ft.. The resulting LPD is 53/80 = 0.66 Watts/sq. ft., which, according to Table 2, qualifies for the full tax deduction of \$.60 per sq. ft. This means that the initial cost minus the tax deduction is (\$.75-(\$.60*.35) = \$.54 per sq. ft.. On a simple payback calculation, therefore, simple payback utilizing the tax deduction is (3.38)(.54) = 1.83 years; without the tax deduction, the payback would have been (3.38)(.75) = 2.54 years, so the tax deduction reduces the payback by 3/4 of a year.

Supplemental Economic Factors

The Simple Payback method is a quick, shorthand method for assessing a first order level of economic viability assessment for a lighting retrofit. However, this is a very conservative method and does not account for the additional benefits of new lighting – namely the improved life of the lamps and the possible long-term savings that would be attributable due to increased utility rates. A more realistic study would assess any additional benefits that the retrofit system would provide as compared to the base lighting system throughout the life of the lighting system, which is generally accepted to be the life of the ballast, or 15 years. We therefore need to add three additional factors to our equation to adequately assess the financial impact of installing a lighting system: 1) depreciation of the system for costs in excess of the tax deduction allowance; 2) the difference in lamp replacement costs over the life of the system, and 3) the long-term benefit of the energy savings due to the likely increase in energy costs over the life of the system.

Depreciation. On the first issue, the depreciation remaining after the tax deduction might be taken in several ways, depending on tax strategy and qualifications of the system based on IRS rules. Lighting systems are generally considered to have a 15 year life based on the life of the ballast, and often times a straight-line depreciation schedule is assumed. However, tax codes are constantly changing and some interpretations allow the Modified Accelerated Cost Recovery System (MACRS) to be used to accelerate the depreciation. There are also Cost Segregation consultants that specialize in segregating portions of buildings and building systems specifically for the purpose of determining depreciation schedules for the different building components – in these cases, the IRS makes exceptions and allows shorter depreciation schedules. Whatever the method, there are additional savings in the future years that add up to the remaining balance of the investment (beyond the first year tax deduction)

For our purpose, let us take the most conservative route and presume that we will have a straight-line depreciation over the life of the system for the balance of the remaining system cost. Using our example, we will now be able to deduct the difference of \$.75 - \$.60 = \$.15 per sq. ft. over the next 14 years. Presuming the same corporate tax rate of 35% and a cost of money factor of 5%, this would be equivalent to reducing the initial cost by approximately \$.036 per sq. ft., using Present Worth calculations (calculations are not shown here, as these are standard economic formulas). As a present worth benefit, this cost can be taken from the initial cost, i.e. we can deduct \$.036 per sq. ft. from the initial cost to assess the financial impact based on today's dollars. This makes sense, since the vast majority of the cost was deducted in the first year with the tax deduction. Using our example above, our initial cost term becomes \$.54 - \$.036 = \$.504/SF.

Lamp replacement benefit. If a lighting system is being replaced by a similar system, i.e. changing out one set of fluorescent lamps with another type of fluorescent lighting, we can use another type of simplified method to determine the annual cost difference between a base case and a retrofit case, on the presumption that the labor costs for changing out the fluorescent lamps would be the similar between the two systems. We first calculate this on a per lighting fixture basis, and then once again convert this to a per sq. ft. basis:

$$R = kH \; \frac{(num_{L1} \times price_{L1}) + labor_{F1}}{klife_{L1}} - \frac{(num_{L2} \times price_{L2}) + labor_{F2}}{klife_{L2}}$$

Where:
R = Annual difference in lamp replacement cost, System 1-System 2, per fixture
kH = Annual Hours of operation, in thousands of hours
Subscripts 1 and 2 denotes Base Case Fixture and retrofit fixture, respectively:
num = number of lamps per fixture
price = cost per lamp, in dollars
labor = labor cost of lamp replacement, per fixture
klife = rated lamp life, in thousands of hours

From our previous example, we find that the price of the base T12 lamp is \$1.50 each with a lamp life 20,000 hours and the retrofit T8 has a cost of \$1.75 with a lamp life of 36,000 hours. We first calculate this on a per-fixture basis, then convert to cost per sq. ft.:

$$R = 3.6 \; \frac{(3 \times \$1.50) + \$4.50}{20} - \frac{(2 \times \$1.75) + \$450}{36} \quad = \$.82 \text{ per fixture, or } \$0.01 \text{ per sq. ft.}$$

We now use the Series Present Worth formula to determine the Present Worth savings based on this annual savings, and find that the equivalent present worth savings is \$.104 per Sq. ft. This can now be deducted from the initial cost. Given our previous example where we had \$.504/sq. ft. (including the tax deduction and the depreciation), we now will have an initial cost of (.504-.104) = \$.40/sq. ft., and our effective payback is now 1.35 years.

Inflation adjustment. If there are any truisms that could be tacked on to those certainties in life (death and taxes), it's that the rate of electricity will never go down. The mathematics for adjusting the payback for increasing electricity rates is not simple, but we can take a simplified approach. According to the EIA, the electricity rate increased in 2007 2.3% on average in the United States, with local variations ranging from slight decreases to increases of over 6%; we can be somewhat assured that over the 15 year life of a typical lighting system, however, there will be some increase in electricity costs.

In order to assess the impact of inflation on the utility rate, we use the formula for an annual Future Worth cost of electricity on a per year basis, on the assumption that there is an annual increase of some inflationary index. This formula is $F = P(1+i)n$, where F is the future cost at n years based on the present value P and inflation rate i. Using a spreadsheet, an analysis can be performed to predict the utility costs per year for the life of the system, and the sum of these values would be the Present Worth of the total utility cost for the life of the system. A simplified approach is to average this sum over the number of years in the life of the system, and then we use this rate instead of the value we have assumed using today's rate. In our example, if we presumed an annual increase of 2% in electricity rates, our Present Worth utility rate using this formula changes from $0.12/kwH to $.138W/kWh. Exchanging these values, our new factor becomes 2.94, instead of 3.38, and our payback now becomes (2.94*0.40) = 1.18 years.

Summary of Economic Model

The economics presented above uses a simple Present Worth model for lighting retrofits on the presumption that we are simply replacing fluorescent lamps and ballasts with new lamps and ballast using the most energy efficient equipment and design methods available. The keys to achieving the maximum economic benefit are:

1. Use high efficiency lamps and electronic ballasts. This will generally achieve the LPD required to get the minimum tax credit;
2. Use Spectrally Enhanced Lighting. This will reduce the LPD to achieve the maximum tax deduction;
3. Use the maximum tax credit of $.60 per sq. ft. to achieve the maximum benefit and reduce the initial cost of the system.
4. Use the modified method for payback that allocate real savings from depreciation, lamp replacement cost benefits and adjustments for utility cost inflation

In our example, we started off with a payback of 2.54 years, assuming no tax deduction benefits (i.e. a standard simple payback calculation). With the maximum tax credit, we saw our payback improve to 1.83 years, and the modifications further improved the payback to 1.18 years. The value of this method is in it's ability to discern the value of the lighting benefit on a per square feet basis, which becomes easy to extrapolate for large scale analysis.

Commercial Lighting Retrofits as Mini Banks and Mini Power Plants

The maximum energy benefit from the combination of lighting technologies and tax incentives gives rise to an important value to the national interest in many ways.

For businesses, the impact is greater profitability over the life of the system, as energy costs are by definition an overhead expense. The savings potential for using the high efficiency equipment coupled with spectrally enhanced lighting design can meet the criteria for the maximum tax deduction, and therefore the annual savings from the lighting system change will be felt after the first year of installation for T12 installations (as in our example) and after the second or third year for most T8 lighting retrofits. For a business that fits our T12 example, the annual savings over the life of the system would be roughly (.6875 W/sq. ft. x $.138/kWh x 3.6kH) = $.34 per square foot, so a 100,000 sq. ft. building would have savings of approximately $34,000 *per year*.

Imagine the economic benefit to businesses in the United States based on this kind of increased cash flow. Let's assume, for instance, that we have roughly half of our commercial buildings with T12 lamps and the other half with T8 lamps in a city with $.12/kWh utility rates now and 2 million square feet having been retrofit at an average 3600 hours of operation. The annual increase in pre-tax profitability to these businesses due to reduced lighting energy usage .58 W/sq. ft. on average would be $576,290 per year!

Now let's take this same city and see how this affects the demand load on the local power plants. Remember that lighting reductions of this type are all permanent load reductions, which means that the load is taken directly off of the electrical grid at all times, and most importantly, at peak hours. If our drop in LPD is .58 W/sq. ft. and we have 2 million square feet, we see that our reduction in peak demand load is 1.16 MW.

In the United States, there is approximately 46 Billion square feet of commercial and industrial lighting applications in which this method of lighting retrofits could be installed. Using our average from above and a figure of a 20% market penetration, the potential permanent load shed from our national grid could be 5.3 Gigawatts, the equivalent of (18) 300-MW power plants. The economic benefits of this kind of conversion to energy-efficient lighting would result in increased profitability of $2.6 Billion per year based on an average utility rate of $.12/kWh, adjusted for inflation over the next 15 years.

As a final note, the cost of installing simple lamp/ballast lighting retrofits typically ranges from $.60 to $1.00 per sq. ft. depending on the application. If we assume the worst case at $1.00 per sq. ft. and use our average of .58 W/sq. ft., we find that the cost of this power generation through lighting retrofits is approximately $1,725 per kW. This is half of the cost of what it would take to build a new power plant; coal, geothermal and nuclear power plants cost between $3,500 and $4,000 per kW and these are just the construction costs without measuring the environmental impact and the costs that will be transferred to the utility customers by the utilities to pay for these power plants. The energy saving benefits of lighting retrofits are therefore far more beneficial to commercial customers than what a simple payback calculation presumes – if enough businesses participate, it will help lower the rate of increased utility rates by offsetting the construction costs that would have been added to the bill!

Conclusion

The timing for lighting retrofits has never been more advantageous. The economic stimulus of tax deductions, along with new cost effective new technologies and lighting designs have created an economic basis for changing existing lighting systems that has never been more profitable; furthermore, the use of lighting retrofits can significantly reduce the demand load on the electric grid, giving the country time to upgrade the grid and hold off construction of polluting types of power plant installations while other means of power generation and distribution are developed. This is significant in reducing the effects of global warming; by using the benefits of energy-efficient lighting now in existing buildings, we can build a future electrical system that uses more renewable energy sources in the future.

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