Implementing Spectrally Enhanced Lighting

Spectrally enhanced lighting (SEL) is a cost-effective, low-risk design method for achieving significant energy savings. It entails shifting the color of lamps from the warmer to the cooler (whiter) end of the color spectrum, more closely matching daylight. Typically, an SEL installation uses lamps with a correlated color temperature (CCT) of 5000 kelvin (K), while conventional installations are in the range of 3500K.

Studies show that, with this color shift, occupants perceive lighting to be brighter and they are able to see more clearly. Since SEL can provide the same levels of visual acuity with fewer lumens of output, SEL installations can be designed using fewer lamps or lower wattage lamps than traditional lighting.

While the principles of SEL are applicable to any light source, it is predominantly used for fluorescent lighting applications in commercial and industrial settings. The examples and implementation guidance provided here pertain to fluorescent lighting.

Appropriate lamps for SEL are available through many major manufacturers and are generally no more expensive than traditional fluorescent lamps. Energy savings from SEL depend on the incumbent lighting in the candidate space (or the proposed lighting for new construction) and the illumination requirements. Optimal energy efficiency is achieved when lower-ballast-factor, extra-efficient electronic ballasts are used along with SEL lamps.

- **SEL in existing buildings.** Energy savings from SEL lighting retrofits are greatest when the existing system is old and inefficient (e.g., T12 lamps with magnetic ballasts), and when efficient ballasts are installed along with new lamps. However, attractive savings can be realized even in cases where the existing system is relatively new, simply by changing out "yellower" lamps with SEL lamps and adjusting lighting outputs appropriately.
- **SEL in new buildings.** In new construction, energy savings are achieved through SEL lighting designs that require fewer lamps and ballasts and/or fewer lighting fixtures than traditional systems. Because little if any incremental cost is associated with installing SEL rather than more traditional lighting systems, SEL strategies offer immediate payback.

SEL provides permanent reductions of electric load and automatically reduces demand load at peak hours. Returns on investment can be substantial in areas with high peak demand charges.

The following guidelines include a methodology for calculating the reduction in light levels with SEL, as well as samples of energy savings and paybacks under different scenarios. For best results in SEL installations, be sure to hire a professional lighting designer or lighting retrofit contractor familiar with successful SEL systems.

Determining Light Level Reduction

The guiding principle of SEL is to install new lighting that provides an equal level of visual acuity as in the existing facility (or the same level being planned in new construction). The reduction in lumens achieved with SEL translates directly to energy savings. The Equivalent Visual Effectiveness (EVE) method can be used to determine the reduction in light level possible with SEL. The EVE method is fully described in the Illuminating Engineering Society Technical Memorandum, IES TM-24-13.

In the EVE method, the new illuminance, P_2, is equal to the reference illuminance P_1 multiplied by a ratio of S/P values that are raised to the 0.8 power:

$$P_2 = P_1 \left(\frac{S/P_1}{S/P_2}\right)^{0.8}$$

Example:

Reference Illuminance = 400 lux, under 735 fluorescent lamp with S/P Ratio = 1.4

New proposed lamp, 850 fluorescent lamp with S/P = 2.0

New Illuminance calculated as follows:

$$P_2 = 400\ lux \left(\frac{1.4}{2.0}\right)^{0.8} = 300\ lux$$

When using this method, it is important to get the lamp S/P values from the manufacturers.

IES TM-24-13 also stipulates the following:

- The method applies to IES Categories P through Y, for Visually Demanding Tasks.
- The task background luminance should not be less than 50 cd/m^2.
- People utilizing this lighting should have normal ocular health.
- When used to meet IES Illuminance Recommendations, the reference S/P ratio is 1.4.

Examples of Potential Energy Savings

The tables to the right show energy savings under two sample scenarios[1]:

- **New construction scenario.** Here, the assumption is that SEL fluorescent lamps (850) are used in place of "yellower" fluorescent lamps (ranging from 730 to 841) with no difference in the ballasts.
- **T8 retrofit scenario.** In this case, the same lamp substitutions are made while also upgrading to extra-efficient ballasts as compared to standard ballasts commonly used in commercial applications.

The above tables include differences in lumen outputs; for this reason, there are even more energy savings to be gained when using SEL 850 lamps to replace 700-series lamps.

New Construction Scenario	
Baseline F32 T8 lamp with standard electronic instant-start ballast	Energy savings from 850 lamp alone
F32T8/730	37%
F32T8/735	32%
F32T8/741	22%
F32T8/830	25%
F32T8/835	20%
F32T8/841	11%

T8 Retrofit Scenario	
Baseline F32 T8 lamp with standard electronic instant-start ballast	Energy savings from 850 lamp and improved ballast
F32T8/730	44%
F32T8/735	39%
F32T8/741	30%
F32T8/830	32%
F32T8/835	27%
F32T8/841	18%

Potential Payback Scenario

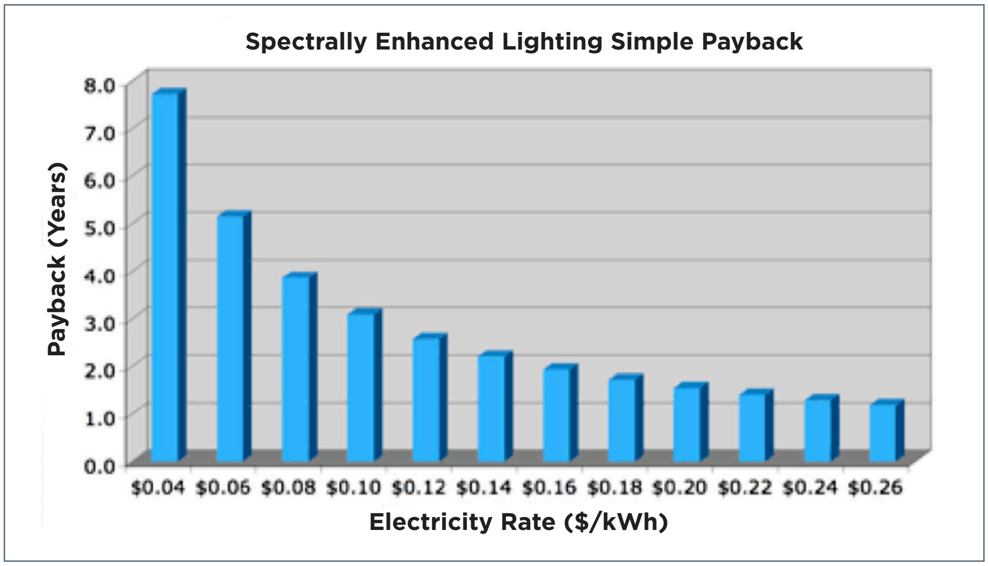
The following potential payback scenario is based on a building tenant with 50,000 square feet of open office space with 2x4-foot lensed luminaires on 8x10-foot spacings (total 625 luminaires). Each luminaire has three 735 T8 lamps and a three-lamp electronic ballast with a normal (0.87) ballast factor. The lighting system was installed approximately 10 years ago. The ballast data show that each luminaire consumes 90 watts, so the total wattage for the lighting system is 56,250 watts. The system is on for an average of 12 hours per day, five days a week plus some weekend hours, for a total assumed 3,500 annual hours of use. The annual energy consumed by the lighting system is therefore 197,000 kWh.

Use of 850 SEL allows the design team to reduce the lumens per luminaire by 32% while achieving the same visual acuity levels. For the purposes of this illustration, the team will de-lamp the luminaire to two lamps and change the ballast to extra-efficient instant-start electronic ballasts with the same ballast factor (.87) to achieve this one-third reduction. The new wattage of the lighting system is now 53 watts per luminaire at a cost of $40.00 each.

The cost to change the lighting system is $25,000 and the annual energy savings are 81,000 kWh. The annual energy cost savings will depend on the utility rates, as shown in the chart below.

The calculations in the chart do not include the additional potential for reduced cooling costs, which result from the lowered heat generation of the new lighting system. In addition, the new lamps have longer life spans, and will provide additional savings over the life of the system by lowering the maintenance costs of lamp replacement. The benefits of installing new ballasts are also significant, since the existing ballasts are approaching the end of their life. The new system life will be approximately 15 years and, based on the life of the new lamps (24,000 hours), the lamps will require changing only twice over the life of the system.

The energy savings from this approach result in a one- to three-year payback for regions where electric utility rates are $0.10 per kWh or higher. At least 80% of these savings are attributable to SEL, with the remainder attributable to the use of higher efficiency electronic ballasts. The energy savings shown here are based on permanent load reductions; paybacks would be better in areas where peak demand charges are higher than the rates used in this example.



1. CRI and CCT are often combined into a three digit number where the first digit represents the CRI and the last two digits represent the CCT; for example, an 850 lamp is one with a CRI in the 80s, and a high CCT of 5000K; a 730 lamp is one with a CRI in the 70s and a low CCT of 3000. 80 CRI lamps in this comparison are high-lumen lamps; 70 CRI lamps are not available as high-lumen lamps.

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